# How to Use the Schedule Book

The information of each talk is encoded as an 8-bit string, **AB-Cd-EF-xy**, meaning that the talk of TYPEAB will be given on DATECd during the TIMESPANEF at ROOMxy. The symbols are explained as follows.

**Code: Type-Date-Time-Room No.**

<table>
<thead>
<tr>
<th>Type</th>
<th>IL=Invited Lectures, SL=Special Lectures, MS=Minisymposia, IM=Industrial Minisymposia, CP=Contributed Papers, PP=Poster Papers</th>
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<tbody>
<tr>
<td>Date</td>
<td>Mo=Monday, Tu=Tuesday, We=Wednesday, Th=Thursday, Fr=Friday</td>
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<tr>
<td>Timespan</td>
<td>A=8:30-9:30, B=10:00-11:00, C=11:10-12:10, BC=10:00-12:10, D=13:30-15:30, E=16:00-18:00, F=19:00-20:00, G=12:10-13:30, H=15:30-16:00</td>
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<td>Room No.</td>
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<td>VIP4-3</td>
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**Examples:**

MS-Tu-BC-13: Minisymposium, Tuesday 10:00-12:00, Room VIP3-2.
CP-Th-E-55: Contributed Papers, Thursday 16:00-18:00, Room 106.

## ICIAM 2015 Classification Codes

- A01 Linear Algebra
- A02 Real and Complex Analysis
- A03 Ordinary Differential Equations
- A04 Partial Differential Equations
- A05 Discrete Mathematics
- A06 Numerical Analysis
- A07 Computational Science
- A08 Computer Science
- A09 Probability and Statistics
- A10 Control and Systems Theory
- A11 Optimization and Operations Research
- A12 Information, Communication, Signals
- A13 Applied, Algebraic, and Computational Geometry
- A14 Imaging Science
- A15 Fluids
- A16 Physics and Statistical Mechanics
- A17 Geophysical, Atmospheric & Oceanographic Science
- A18 Chemistry, Chemical Engineering
- A19 Life Science and Medicine
- A20 Social Science
- A21 Finance and Management Science
- A22 Education in the Mathematical and Computational Science
- A23 Simulation and Modeling
- A24 Materials Science and Solid Mechanics
- A25 Applications of the Mathematical and Computational Sciences in Industry
- A26 Dynamical Systems and Nonlinear Analysis
- A27 Other Mathematical Topics and their Applications
- A28 General
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<th>Time</th>
<th>Sunday August 9</th>
<th>Monday August 10</th>
<th>Tuesday August 11</th>
<th>Wednesday August 12</th>
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<td>8:30-9:30</td>
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<td>Prize Lectures (3 in parallel)</td>
<td>Invited Lectures (3 in parallel)</td>
<td>Public Lecture (Ballroom A at Level 1)</td>
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<td>9:30-10:00</td>
<td>Opening Ceremony &amp; Laudations for Prize Winners (9:00-11:30, Plenary Hall A at Level 4)</td>
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<td>15:30-16:00</td>
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<td>Coffee Break &amp; Poster Session</td>
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<td>Dinner Break</td>
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<td>19:00-20:00</td>
<td>Reception (18:00-20:00 North Lobby at Level 4)</td>
<td>Olga Taussky-Todd Lecture (Ballroom C at Level 1)</td>
<td>Peter Henrici Prize Lecture (Ballroom C at Level 1)</td>
<td>John von Neumann Lecture (Ballroom C at Level 1)</td>
<td>Sonia Kovalevsky Lecture (Ballroom C at Level 1)</td>
<td>Closing Ceremony (18:10-18:40, Ballroom C at Level 1)</td>
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We examine the problem of discovering a sparse polynomial from noisy samples at chosen points. Recent progress in efficient sparse interpolation algorithms over exact domains such as integers and finite fields is based on reducing the problem with potentially large degree to a related one with much lower degree. We will discuss the challenges and successes in adapting these techniques to the numeric setting.

EM-Mo-D-01-1 13:30–14:30
Hybrid Symbolic-numeric Computation: A Marriage Made in Heaven
Kaltofen, Erich
North Carolina State Univ.

Abstract: Hybrid algorithms use floating point arithmetic for speed and symbolic computation for the type of objects: formulas and exact identities and inequalities.

New hybrid algorithms are presented: for solving optimization problems by sum-of-squares proofs; for computing a sparse interpolant in power or Chebychev basis via linear progressions. There, we allow for errors in the inputs, performing error-correction by methods from digital error correcting codes. Join with Andrew Arnold, Clement Pernet, Zhengfeng Yang, LiHong Zhi.

EM-Mo-D-01-2 14:30–15:00
Applying Symbolic Sparse Interpolation Techniques to Numeric Data
Roche, Daniel
U.S. Naval Acad.

Abstract: We examine the problem of discovering a sparse polynomial from noisy samples at chosen points. Recent progress in efficient sparse interpolation algorithms over exact domains such as integers and finite fields is based on reducing the problem with potentially large degree to a related one with much lower degree. We will discuss the challenges and successes in adapting these techniques to the numeric setting.

EM-Mo-D-01-3 15:00–15:30
Sparse Polynomial Interpolation with Arbitrary Orthogonal Polynomial Bases
Yang, Zhengfeng
East China Normal Univ.

Abstract: The problem of sparse interpolation with arbitrary orthogonal bases can be regarded as a generalization of sparse interpolation with the Chebyshev basis. In Lakshman and Saundar [1996], an algorithm, based on Prony/Blahut’s method is provided to interpolate polynomials that are sparse in the Chebyshev basis (of the first kind). In this talk, we will present new algorithms for interpolating a univariate black-box univariate polynomial that has a sparse representation by allowing arbitrary orthogonal bases. This is joint work with Erich L. Kaltofen.
t applications of integrable systems extend to a wide range of pure/applied mathematics and physical sciences, such as algebraic geometry, combinatorics, probability theory, numerical algorithms, cellular automata, (discrete) differential geometry, computer visualizations, statistical physics, nonlinear physics and so on. The purpose of this minisymposium is to bring together researchers to discuss recent advances on various aspects of applied integrable systems.

**Abstract:** We present some results on integrable discrete deformations of space/plane discrete curves in various settings, including: (i) isoperimetric deformation of plane curves (discrete mKdV equation) (ii) conformal deformation of plane curves (discrete Burgers equation) (iii) deformation of space curves described by the discrete nonlinear Schrödinger equation. We also discuss construction of exact solutions to the dynamics of discrete curves, which is a great advantage of applying the theory of discrete integrable systems to geometry.

**MS-Mo-D-03-2**

14:00–14:30

Hirota's Discrete KP Equation and Its Reductions from Geometric Point of View

Doliva, Adam

Univ. of Warmia & Mazury

Abstract: We present geometric theory of Hirota's semidiscrete KP equation and of certain its distinguished reductions. We discuss interplay between root-lattice and incidence geometry aspects of the theory.

**IM-Mo-D-04-1**

13:30–14:15

Manufacturing Systems Controlled by Agents

Weiss-Cohen, Michal

Technion

Spitai, Moshe

Technion

Abstract: A new agent-based adaptive control system has been developed in order to simulate and examine a dynamic, flexible and stochastic job shop problem that considers random events, such as random job arrivals, uncertain processing times, unexpected machine break downs, various shop utilization levels and the possibility of processing flexibility. The system provides advanced decision-making strategies for responsive factories based on agents with local intelligence. We demonstrate, by simulation, and discuss the excellent results achieved.

**IM-Mo-D-04-2**

14:15–15:00

Efficient and Robust Time-Optimal CNC Interpolation under Dynamic Constraints

Gao, Xiao-Shan

Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: To fully utilize the dynamic ability of the CNC machines and enforce a given precision bound and minimum time machining time is a basic problem in CNC Machining. In this talk, we will show that efficient numerical algorithms could be developed for several problems of this type, and in particular, dynamic constraints are considered.

**IM-Mo-D-04-3**

15:00–15:30

The New Requirements of CNC and Development Practice of LT-CNC

Y u, Dong

Shenyang Inst. of Computing Tech., CAS

Abstract: By analysis of the machining data process of CNC system, the new requirements of CNC are proposed, such as influence of the NC data quality, control of contour tolerances, reproducibility of adjacent tool paths, dynamic oscillation free movements, five axis capability, etc. Based on the analysis, the control features for fast, accurate milling with high surface definition are summarized, and the development practice of LT-CNC is described.

**Compressed Sensing, Extensions and Applications - Part I of III**

**MS-Mo-D-05**

13:30–15:30

Compressed Sensing, Extensions and Applications - Part I of III

For Part 2, see MS-Mo-E-05

For Part 3, see MS-Tu-D-05

Organizer: Kulyukin, Olita

Technische Universität Berlin

RWTH Aachen Univ.

Abstract: Compressed sensing has seen an enormous research activity in recent years. The key principle is that (approximately) sparse signals can be recovered efficiently from what was previously believed to be vastly incomplete information. For this reason, compressed sensing and its algorithms (often convex optimization approaches) have a large range of applications such as magnetic resonance imaging, radar, wireless communications, and more. Remarkably, all provably optimal measurement schemes are based on randomness and therefore, compressed sensing connects various mathematical fields such as random matrix theory, optimization, approximation theory, and harmonic analysis. Recent developments have extended the theory and its algorithms to the recovery of low rank matrices from incomplete information, to the phaseless estimation problem, and to low tensor recovery. The minisymposium aims at bringing together experts in the field and to provide an overview of its most recent results.

**MS-Mo-D-05-1**

13:30–14:00

Almost Lossless and Stable Analog Signal Separation

Stotz, David

Boelskei, Helmut

ETH Zurich

Abstract: We develop an information-theoretic framework to study almost lossless and stable analog signal separation. Our results reveal Minkowski dimension as the foundational element of the theory. As a byproduct, we dis-
cover a new technique for showing that the intersection of generic subspaces with subsets of sufficiently small Minkowski dimension is empty. This result can be viewed as a measure-theoretic version of the celebrated null-space property in compressed sensing theory.

- **Function Approximation via Infinite-dimensional Weighted $L^1$ Minimization**
  - **Adcock, Ben**  
  - Simon Fraser Univ.

  **Abstract:** The reconstruction of multivariate functions from a limited sets of pointwise samples is an important problem in a number of applications. In this talk I will present an infinite-dimensional framework for this problem based on weighted $L^1$ minimization. This framework generalizes, and applies to arbitrary point sets and expansion systems. I will explain why working in infinite dimensions is important, describe the critical role that weights play in the formulation, and address recovery guarantees.

- **Phase Retrieval via Wirtinger Flow: Theory and Algorithms**
  - **Li, Xiaodong**  
  - Univ. of Pennsylvania

  **Abstract:** In phase retrieval, one aims to recover a signal from magnitude measurements. In this talk, we show how to recover the signal by a non-convex optimization method. The initialization scheme is based on a spectral method; then a specific type of gradient descent is applied iteratively. This algorithm is guaranteed to converge to the original signal with fast convergence rate. Large scale simulations are also employed to verify the effectiveness of our method.

- **Fast Phase Retrieval for High-Dimensions**
  - **Iwen, Mark**  
  - Michigan State Univ.

  **Abstract:** We develop a fast phase retrieval method which is near-linear time, making it computationally feasible for large data. Both theoretical and experimental results demonstrate the method’s speed, accuracy, and robustness. We then use this new phase retrieval method to help establish the first known sublinear-time compressive phase retrieval algorithm capable of recovering a given sparse signal $x \in \mathbb{C}^n$ (up to an unknown phase factor) in $\mathcal{O}(\log^3 n \cdot \log d)$-time.

- **On Stability of Equations and Systems with A Distributed Delay**
  - **Braverman, Elena**  
  - Univ. of Calgary

  **Abstract:** We consider either an equation of population dynamics or a system with a monotone increasing production term including a distributed delay and, generally, nonlinear mortality term. Delay-independent stability results are obtained including multistability in the case of a single equation. This is joint work with L. Berezansky.

- **Asymptotic Behavior of Solutions for A Class of Higher Order Delay Differential Equations**
  - **Rogovchenko, Yuriy**  
  - Univ. of Agder

  **Abstract:** In this paper, we study the asymptotic behavior of solutions to a class of higher order Emden–Fowler differential equations with delayed argument. Sufficient conditions for all solutions to be either oscillatory or to converge to zero are obtained. Oscillation criterion is also derived. Two examples are provided to demonstrate that new theorems improve and extend a number of results reported in the literature.

- **Continuous Separation for Non-autonomous Delay Differential Equations: Theoretical Results and Numerical Applications**
  - **Obaya, Rafael**  
  - Univ. de Valladolid

  **Abstract:** We investigate dynamical properties of nonautonomous linear cooperative families of ODEs and FDEs based on the existence of a continuous separation. We provide numerical algorithms for the computation of the dominant one-dimensional subbundle of the continuous separation and the upper Lyapunov exponent of the semiflow. These methods are used in study of nonlinear families of neural networks of Hopfield type. The talk is based in joint works with S. Novo, A. Sanz and J. Calzaada.

- **Delay Systems and Application - Part I of II**

  **Panel Organizer:** Braverman, Elena  
  - Univ. of Calgary

  **Abstract:** The topic of the minisymposium is to provide a wide forum for presentations and detailed discussions on the recent trends in the theory of differential and difference equations with deviating arguments. The topic includes delayed and advanced systems, as well as various applications of such models, for example, in mathematical biology.

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- **Global Warming: How Can Mathematics Help People to Know if it’s Real?**
  - **Shen, Samuel**  
  - San Diego State Univ.

  **Abstract:** Various kinds of climate data from land, ocean, satellite and numerical models can be optimally analyzed using innovative mathematical and statistical methods to demonstrate climate change and highlight natural climate variability, such as El Nino. This lecture will describe how global warming is defined and how the historical global average temperature curves beginning in 1860 from the Intergovernmental Panel on Climate Change were obtained and used as a gauge of global warming.

- **Progress Towards Improving Seasonal Climate Prediction by Mathematical Methods**
  - **Tang, Youmin**  
  - Univ. of Northern British Columbia

  **Abstract:** In this talk, we will discuss some conceptual models that explain the characteristic features of the glacial-interglacial cycles in the Earth’s climate system over the past two million years (the Pleistocene).

- **Asymptotic Behavior of Solutions for A Class of Higher Order Delay Differential Equations**
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Abstract: Preventing Numerical Oscillations in the Flux-split Based Finite Difference symmetrical schemes.

Cal flux is realized in numerical simulation of 1D symmetrical problem in 3D mana et al. [2], a symmetry preserving support-operators diffusion discretization for 2D or three-dimensional (3D), Cartesian geometry to preserve numerical difficulties and may even terminate the simulations. Three representative numerical methods are being developed and improved. In this mini-symposium, novel numerical methods will be presented to show the progress in the area of compressible multi-phase flows, including interface capturing/tracking methods, phase change calculations, mixing methods, fluid-structure interaction methods, multi-physics calculations, adaptive mesh refinement, and high performance computing.

Abstract: In this paper, an improved SPH model for multiphase flows with complex interfaces and large density differences is developed. The multiphase SPH model is based on the assumption of pressure continuity over the interfaces and avoids directly using the information of neighboring particles’ densities or masses in solving governing equations. In order to improve computational accuracy and to obtain smooth pressure fields, a corrected density is implemented both to reduce numerical oscillations and to prevent unphysical particle penetration in the boundary area. The density correction and coupled dynamics SBT algorithms are modified to adapt to the density discontinuity on fluid interfaces in multiphase simulation. A cut-off value of the particle density is set to avoid negative pressure, which can lead to severe numerical difficulties and may even terminate the simulations. Three representative numerical examples, including a Rayleigh-Taylor instability test, a non-Boussinesq problem and a dam breaking simulation, are presented and compared with analytical results or experimental data. It is demonstrated that the present SPH model is capable of modeling complex multiphase flows with large interfacial deformations and density ratios.

Abstract: It is one of the important issues in high-dimensional, two-dimensional (2D) or three-dimensional (3D), Cartesian geometry to preserve perfect one-dimensional (1D) spherical symmetry. Following the idea of Carman et al. [2], a symmetry preserving support-operators diffusion discretization scheme in 3D Cartesian geometry is developed. Spherically symmetrical flux is realized in numerical simulation of 1D symmetrical problem in 3D Cartesian geometry. Some numerical tests are given to prove the developed symmetrical schemes.

Abstract: Numerical oscillations by point-wise flux vector splitting (FVS) and component-wise nonlinear difference discretization of convection terms are revealed and prevented in compressible flows with discontinuities, where pressure and velocity oscillations can be induced by either one of the two operations. Two practicable principles are proposed to prevent the oscillations. Numerical tests confirm the effectiveness, robustness and low computational cost of our proposed method.

Abstract: Among the methods with cell-centered unknowns on large distortion meshes, most adopt the vertex unknowns indirectly to discretize diffusion equations such that their accuracy is ultimately determined by the approximation to the vertex unknowns. In this paper, taking advantage of the high-order accuracy of the “twin-fitting” method especially on discontinuous diffusion coefficients, a new treatment for the vertex unknowns is developed to apply to a nine-point scheme. Numerical experiments show that the new nine-point scheme is effective, robust and low computation cost of our proposed method.

Abstract: A High-Order Accurate Algorithm for Diffusion Equations with Discontinuous Diffusion Coefficients on Distorted Meshes Shuhong, Song Inst. of Applied Physics & Computational Mathematics

Abstract: For a Poisson-Boltzmann (PB) model, solute and solvent regions are separated by a dielectric interface and we are interested in tracing its location and conformational change. We numerically solved the PB model under a well-posed boundary integral formulation. The fast treecode algorithms and GPU computing combined make it realistic to apply the PB model to biomolecular dynamics simulation. We derived and implemented the numerical schemes for computing the dominant and computationally demanding electrostatic solution force.

Abstract: A realistically-solvated biomolecular dynamics simulation for the moving dielectric interface will be presented. We develop a novel meshless method for reaction-advection-diffusion equations on distorted surfaces. The method has a priori error bounds in terms of percentage of the norm of the solution and has extensions to more general flows and surfaces. A number of numerical experiments are provided. This is joint work with K.-C. Cheung, and L. Ling.

Abstract: We present a fully practical residual-based adaptive simulation framework for two-phase flows with variable densities governed by a Cahn-Hilliard Navier-Stokes model with double obstacle potential. The method is based on a new stable time integration scheme, which conserves the energy decay. In the adaptive framework the generation of discrete energy contributions stemming from coarsening is avoided by an appropriate modification of the coarsening strategy. Authors: Harald Garcke, Michael Hinze, Christian Kahle

Abstract: We will present a new model that is robust to three-dimensional effects, based upon a previous planar model. The sperm flagellum is modeled using an immersed elastic boundary and the method of regularized Stokeslets. Authors: Shuhong Song Inst. of Applied Physics & Computational Mathematics, Shuhong, Song Inst. of Applied Physics & Computational Mathematics, Shuhong, Song Inst. of Applied Physics & Computational Mathematics, Shuhong, Song Inst. of Applied Physics & Computational Mathematics, Shuhong, Song Inst. of Applied Physics & Computational Mathematics

Abstract: We numerically solved the PB model under a well-posed boundary integral formulation. The fast treecode algorithms and GPU computing combined make it realistic to apply the PB model to biomolecular dynamics simulation. We derived and implemented the numerical schemes for computing the dominant and computationally demanding electrostatic solution force.
Abstract: A cellular automaton (CA) is a discrete dynamical system composed of an array of cells that only take a finite number of states. CAs can exhibit complex time evolution patterns and are used as mathematical models for a variety of natural and social phenomena. Ultradiscretization is a mathematical tool for constructing CAs from continuous systems. It has been successfully used to obtain CA models that share important features with continuous phenomena. The purpose of this organized session is to offer researchers the opportunity to discuss recent advances in ultradiscretize and in particular their application to fundamental biology.

Combinatorial and Solvable Structures of Random Domino Automaton
Bialecki, Mariusz
Inst. of Geophysics, Polish Acad. of Sci.
Abstract: We introduce Random Domino Automaton - recently proposed slowly driven system being a stochastic toy model of earthquakes and also a generalisation of 1D Drossel - Schwabl forest-fire model. A solution of the set of discrete equations describing stationary state of Random Domino Automaton in inverse-power case is presented. We describe also a link to Motzkin numbers.

The Topology of a DNA String and Its Gene Expression
Bao, Yuanyuan
Tohoku Forum for Creativity, Tohoku Univ.
Abstract: Spatial structure and gene expression of a DNA interact with each other in various ways. In this talk, we discuss some topological (structural) properties of a DNA string, regarded as an embedded curve in the 3-space. We then talk about how these properties support the process of gene expression, such as transcription and alternative splicing.

Statistical Method for Constructing Cellular Automata
Kawaharada, Akane
Univ. of Shizuoka
Abstract: We propose a statistical construction method of cellular automata based on observation data. Cellular automaton are discrete dynamical systems whose configurations are determined by local rules acting on each cell in synchronous. Since cellular automata generate rich and complex behaviors, we can expect they are good models for simulating phenomena. In this talk, we introduce the method and apply to some physical phenomena. Cellular automata with three neighbors and 2\to 8 states are obtained.

Modeling Cell-cell Interactions in Gliomas
Badoual, Mathilde
Paris Diderot Univ.
Abstract: Diffuse low-grade gliomas are brain tumors that grow slowly, but that are incurable because some glioma cells migrate within the parenchyma surrounding the tumor. Here, we will present a stochastic approach, based on a cellular automaton, where the interactions between migrating cells are taken into account and the properties of the correlations between cells are studied in order to characterise the leading edge of the tumor. We also calculated the continuous limit.

Recent advances in matrix computations for extreme-scale computers - Part I of II
For Part II, see MS-Mo-E-10
Organizer: Li, Xiaoye
Lawrence Berkeley National Laboratory
Organizer: Duff, Iain
STFC Rutherford Appleton Laboratory
Abstract: Numerical linear algebra is at the heart of scientific and industrial discoveries. The forthcoming arrival of the exascale era provides tremendous opportunities and challenges for further development of algorithms and software extreme-scale computing. This minisymposium emphasizes problem formulations, algorithm redesigns and code refactorings for the efficient use of high performance computers. Topics range from direct methods, iterative methods, preconditioning, and the emerging fast algorithms for both dense and sparse algebraic systems. The speakers will present various techniques to reduce communication, synchronization and memory footprint. The performance of the new algorithms will be demonstrated on modern manycore parallel machines.

Combining Direct and Iterative Methods to Solve Very Large Sparse Equations on Massively Parallel Architectures
Duff, Iain
STFC Rutherford Appleton Laboratory
Abstract: We have developed a hybrid solver for large sparse systems. The basis for our approach is block Cimmino where the rectangular blocks are solved by a direct method on an augmented system. The partitioning can determine whether we use a direct method or purely iterative one. We can augment the system to force orthogonality between the blocks. We show the performance of our approach on a range of large problems on several different parallel platforms.

On the Design of Parallel Linear Solvers for Large Scale Problems
Pierre, RAMET
Bordeaux Univ. & Inria
Abstract: In this talk we will discuss our research activities on the design of parallel linear solvers for large scale problems that range from dense linear algebra, to parallel sparse direct solver and hybrid iterative-direct approaches. In particular we will describe the implementations designed on top of runtime systems that should provide both code and performance portabilities. Finally, we will present some preliminary results on the integration of h-matrices kernels in our sparse direct solver framework.

Asynchronous Optimized Schwarz Methods
Szyl, Daniel
Temple Univ.
Abstract: Optimized Schwarz Methods are domain decomposition methods, where one imposes Robin conditions on the artificial interfaces. The Robin parameter can be optimized to obtain very fast convergence. We present an asynchronous version of this method, where the problem in each subdomain is solved using whatever boundary data is locally available and with no synchronizations with other processes. We prove convergence of the method, and illustrate its efficiency on large three-dimensional problems. (Joint with Frederic Magoulès).

Solving Linear Equations with HSS Structure: Theory and Practice
Li, Xiaoye
Lawrence Berkeley National Laboratory
Rouet, Francois-Henry
Lawrence Berkeley National Laboratory
Ghysels, Pieter
Lawrence Berkeley National Lab
Abstract: Low-rank block structures arise in matrices from integral equations, boundary element methods, and discretized PDEs. We will show that, both in theory and in practice, the hierarchically semi-separable (HSS) structured factorization is an effective way of exploiting the low-rankness. It provides a powerful tool for solving linear equations, both dense and sparse, with arithmetic and memory complexity asymptotically lower than the standard methods. It can be parallelized well on modern manycore parallel machines.

Combining Direct and Iterative Methods to Solve Very Large Sparse Equations on Massively Parallel Architectures
Duff, Iain
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Extremal Combinatorics, Probabilistic Combinatorics, and their applications - Part I of III
For Part II, see MS-Mo-D-12
Organizer: Chen, Guantao
Georgia State Univ.
Organizer: Ma, Jie
Univ. of Sci. & Tech. of China
Abstract: Combinatorics is a fundamental discipline of modern mathematics which studies discrete objects and their properties. This minisymposium we propose will focus on the subfield of extremal and probabilistic combinatorics, which has witnessed an exciting development over the past decades, and also has many striking practical applications in mathematical optimization, computer science, statistical physics and voting sociology. We aim to bring the top researchers to the minisymposium, where they will present the recent progress, discuss open challenges, exchange research ideas, and initiate new collaborations. We expect a minisymposium of this nature to have a lasting impact on the future of the subject.

Maximizing Proper Colorings on Graphs
Ma, Jie
Univ. of Sci. & Tech. of China
Naves, Humberto
IMA - Inst. for Mathematics & its Applications
Abstract: Linial and Wilf asked for the graphs with fixed numbers of vertices and edges which maximize the number of proper q-colorings. We characterize the asymptotic structure of extremal graphs for fixed edge density and...
The biclique partition number \( b_p(G) \) is the minimum number of complete bipartite graphs needed to partition the edges of a graph \( G \). Erdős conjectured that for the random graph \( G = G(n, p) \), \( b_p(G) = n - \alpha(G) \) with high probability, where \( \alpha(G) \) is the independence number. In this talk I will discuss some recent progress and remaining challenges in this area, and construct a counterexample to this conjecture. Joint work with Noga Alon and Tom Bohman.

**Counting Cliques in Graphs with Forbidden Subdivision**

Oum, Sang-il

KAIST

Abstract: We prove that for all positive integers \( t \), every \( n \)-vertex graph with no \( K_t \)-subdivision has at most \( 2^{t-1}n \) cliques. We also prove that asymptotically, such graphs contain at most \( (2^{t+1}+1)n \) cliques, where \( o(1) \) tends to zero as \( t \) tends to infinity. This strongly answers a question of D. Wood asking if the number of cliques in \( n \)-vertex graphs with no \( K_t \)-minor is at most \( 2^t n \) for some constant \( c \). Joint work with C. Lee.

**Decomposition of Sparse Graphs into Forests: the Nine Dragon Tree Conjecture for \( k \leq 2 \)**

Kim, Seog-Jin

Konkuk Univ.

Abstract: The fractional arboricity \( Arb(G) \) is the maximum of \( \frac{|E(H)|}{|V(H)|} \) over all subgraphs \( H \) with at least two vertices. Generalizing the Nash-Williams Arboricity Theorem, the Nine Dragon Tree Conjecture asserts that if \( Arb(G) \leq k + \frac{1}{k+1} \), then \( G \) decomposes into \( k+1 \) forests with one having maximum degree at most \( d \). We prove it for all \( d \) when \( k \leq 2 \). This is joint work with M. Chen, A.V. Kostochka, D.B. West, and X. Zhu.

**Analysis and algorithm for coupling of kinetic and fluid equations - Part I of III**

For Part 2, see MS-Mo-E-13

For Part 3, see MS-Tu-D-14

Organizer: Sun, Weiran Simon Fraser Univ.

Organizer: Lu, Jianfeng Duke Univ.

Organizer: Sun, Weiran Simon Fraser Univ.

Organizer: Li, Chun Penn State Univ.

Organizer: Lin, Fanghua Courant Inst./NYU

Abstract: A hierarchy of hybrid numerical methods for the Boltzmann equation, based on moment realizability. We present hybrid schemes where the hydrodynamic part is given either by the compressible Euler or Navier-Stokes equations, or even with more general models, such as the Burnett system. We present numerical simulations in both 1 and 2 dimensions of physical space, and of velocity.

**A Hierarchy of Hybrid Numerical Methods for the Boltzmann Equation**

Rey, Thomas

Lille 1 Univ.

Abstract: In this work in collaboration with F. Filbet, we construct a hierarchy of hybrid numerical methods for the Boltzmann equation, based on moment realizability. We present hybrid schemes where the hydrodynamic part is given either by the compressible Euler or Navier-Stokes equations, or even with more general models, such as the Burnett system. We present numerical simulations in both 1 and 2 dimensions of physical space, and of velocity.

**Measure Valued Solutions to the Boltzmann Equation**

Yang, Tong

City Univ. of Hong Kong

Abstract: Some recent results on the existence, regularity and large time behavior for the Boltzmann equation with measure valued initial data will be presented.

**Nonlinear Acoustic Wave Propagation in A Rarefied Gas: Numerical Analysis Based on Kinetic and Fluid Equations**

Aoki, Kazuo

Kyoto Univ.

Abstract: Nonlinear acoustic waves caused by an infinitely wide plate oscillating in its normal direction and propagating into a semi-infinite expanse of a rarefied gas are investigated numerically on the basis of a model Boltzmann equation and of the compressible Navier-Stokes equations with the correct temperature jump condition on the oscillating plate. The long-time behavior of the solution, including the attenuation of the waves and the creation of the acoustic stream, is obtained accurately.
Data-driven mathematical models for production and traffic flow - Part I of II

13:30–15:30 205A

MS-Mo-D-15

MS-Mo-D-15-1

13:30–14:00

The Euler–Lagrange Equation for the Anisotropic Least Gradient Problem

Mazon, Jose
University of Valencia

Abstract: We find the Euler–Lagrange equation for the anisotropic least gradient problem

\[
\inf \left\{ \int_{\Omega} \phi(x, Du) : u \in BV(\Omega), \ u|_{\partial \Omega} = f \right\}
\]

being \(\phi\) a metric integrand and \(f \in L^1(\Omega)\). We also characterize the functions of \(\phi\)-least gradient as those whose boundary of the level set are \(\phi\)-area minimizing in \(\Omega\).

MS-Mo-D-15-2

14:00–14:30

Algorithms for Anisotropic Mean Curvature Flow of Networks

Esedoglu, Selim
University of Michigan

Abstract: We describe how to extend the threshold dynamics algorithm of Merriman, Bence, and Osther to weighted mean curvature flow of networks, where the surface tension of each interface in the network may be different and may depend on the direction of the normal. Joint work with Felix Otto and Matt Elsey.

MS-Mo-D-15-3

14:30–15:00

Depinning for Geometric Flows

Braides, Andrea
University of Rome Tor Vergata

Abstract: We consider inhomogeneous surface energies whose homogenized (static) limits are described by crystalline perimeters. The corresponding flows present pinning and depinning phenomena due to the presence of many local minima, so that their limit description varies from the geometric flow of the Gamma-limit. We compute the effective flow and show how the Gamma-limit description must be corrected. We highlight how such phenomena can be framed within the theory of minimizing movements along a sequence.

MS-Mo-D-15-4

15:00–15:30

Surface Evolution and Grain Boundary Migration: Some Theory and Applications

Novick-Cohen, Amy
Technion IIT

Abstract: In applications, grain boundary migration by mean curvature motion and surface evolution by surface diffusion often couple dynamically yielding a complex combination of evolving surfaces where both these two types of motion occur. In my lecture, a variety of physical problems will be described which may be modeled by such models. While some of these problems appear to require an anisotropic formulation, often isotropic description are useful to consider.

MS-Mo-D-16

13:30–15:30 205A

Data-driven mathematical models for production and traffic flow - Part I of II

For Part 2, see MS-Mo-E-16

MS-Mo-D-16-1

13:30–14:00

Second-order Models for Traffic Flow and Estimation of Fuel Consumption

Goettlich, Simone
RWTH Aachen University

Abstract: We consider the motion of the air with condensation of water vapor in a high cylindrical domain. The motion is described by classical hydrodynamical equations (see e.g. Landau-Lifchitz), to which we add convection term with latent heat and dynamical effect of water droplets. Numerical solution shows the very quick growth of ascending motion and its stabilization by
Abstract:
In this talk we will discuss the stability of the three dimensional Prandtl boundary layer equations, which shows that monotonic shear flows are linearly and nonlinearly unstable in the three dimensional Prandtl boundary layers in general.

Stability for the Incompressible 2-D Boussinesq System for Magnetohydrodynamics Convection
Gui, Guilong School of Mathematics, Northwest Univ., China
Abstract: Consideration in this talk is the stability analysis of the 2-D magnetohydrodynamics-Boussinesq system with the temperature-dependent viscosity, thermal diffusivity and electrical conductivity. It's established that, the steady-state is globally stable when the steady linear mean temperature profile is increasing in terms of height. Moreover, the decay estimate of the solution to the perturbed system is investigated. It is also shown that, if the mean state decreases with height, the steady state is nonlinearly unstable.

2D Navier-Stokes Equations with Large Reynolds Number
Guo, Yan Division of Applied Mathematics, Box F, Brown Univ., Providence, RI 02912, USA
Abstract: Instability of channel flows and steady Prandtl layer expansions for large Reynolds number will be discussed.

Instability of Shear Flows in 3-d Prandtl Boundary Layer Equations
Wang, Yaguang Shanghai Jiaotong Univ.
Abstract: In this talk, we shall study the stability of the three dimensional Prandtl boundary layer equations, which shows that monotonic shear flows are linearly and nonlinearly unstable in the three dimensional Prandtl boundary layers in general.

MS-Mo-D-17-4 15:00–15:30
Stability for the Incompressible 2-D Boussinesq System for Magnetohydrodynamics Convection
Gui, Guilong School of Mathematics, Northwest Univ., China
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Multiscale methods with applications in fluid mechanics and materials modeling
For Part 2, see MS-Mo-E-18

2D Navier-Stokes Equations with Large Reynolds Number
Guo, Yan Division of Applied Mathematics, Box F, Brown Univ., Providence, RI 02912, USA
Abstract: Instability of channel flows and steady Prandtl layer expansions for large Reynolds number will be discussed.

Nonlinear Dispersive Wave Equations - Part I of II
For Part 2, see MS-Mo-D-18

Organizer: Yanzh, Zhang Missouri Univ. of Sci. & Tech.
Organizer: Cai, Yonglong Beijing Computational Sci. Research Center
Organizer: Lakoba, Taras Univ. of Vermont
Abstract: Nonlinear dispersive wave equations have applications in various fields, such as quantum mechanics, nonlinear optics, fluid dynamics, electromagnetic theory and so on. This mini-symposium focuses on both theoretical and numerical studies on various nonlinear dispersive wave equations. The topics include, but not limited to, existence of traveling wave solutions, orbital stability of solitary waves, numerical algorithms to solve nonlinear wave equations, and numerical computations.

Instability of channel flows and steady Prandtl layer expansions for large Reynolds number will be discussed.

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MS-Mo-D-18 13:30–15:30
Nonlinear Dispersive Wave Equations - Part I of II
For Part 2, see MS-Mo-D-18

Nonlinear Wave and Schrodinger Equation on Non-trapping Asymptotic Conic Manifold
Zhang, Junyong Beijing Inst. of Tech. & Beijing Computational Sci. Research Center
Abstract: We will look at the establishment of the global-in-time Strichartz estimates for the wave and Schrödinger equation on non-trapping asymptotically conic manifold. By using the Strichartz estimates, we study the well-posedeness and long-time behavior of the solutions to some nonlinear wave and Schrödinger equations. Some of results are from a joint work with Andrew Hassell.

Inverse Problems for the Schrödinger Equation via Carleman Estimate
Zhang, Chuang Beijing Normal Univ.
Abstract: In this talk we will discuss the Semilinear fourth order Schrödinger operator and its Carleman Estimate. The Carleman estimate is used to prove the Lipschitz stability for an inverse problem consisting in retrieving the stationary potential from boundary measurements.

Pseudo-arclength Continuation Algorithms for Symmetry-breaking Solutions of Spin-1 Bose-Einstein Condensates
Chien, Cheng-Sheng Chien-Hsin Univ. of Sci. & Tech.
Abstract: We study pseudo-arclength continuation algorithms for computing the ground state and excited-state solutions of two-dimensional spin-1 BEC. Here the chemical potential, the magnetic potential, and magnetization are used as the three components for the continuation variable. We implement the pseudo-arclength continuation algorithm until the magnetization condition is satisfied. Of particular interest here is the investigation of symmetry-breaking solutions. Some numerical experiments on Na-23 and Rb-87 are reported.

Ground States of Two-Dimensional Attractive Bose-Einstein Condensates
Chien, Cheng-Sheng Chien-Hsin Univ. of Sci. & Tech.
Abstract: We study pseudo-arclength continuation algorithms for computing the ground state and excited-state solutions of two-dimensional spin-1 BEC. Here the chemical potential, the magnetic potential, and magnetization are used as the three components for the continuation variable. We implement the pseudo-arclength continuation algorithm until the magnetization condition is satisfied. Of particular interest here is the investigation of symmetry-breaking solutions. Some numerical experiments on Na-23 and Rb-87 are reported.
Low-rank Tensor Approximation in Multi-parametric and Stochastic PDEs - Part I of II
For Part 2, see MS-Mo-E-20
Organizer: Litvinenko, Alexander KAUST, UQ & ECRC Centers
Organizer: Matthies, Hermann TU Braunschweig, Inst. of Scientific Computing
Organizer: Nouy, Anthony Ecole Centrale Nantes

Abstract: Approximations of stochastic and multi-parametric differential equations may lead to extremely high dimensional problems that suffer from the so called curse of dimensionality. Computational tractability may be recovered by relying on adaptive low-rank/sparse approximation. The tasks are 1) to keep a low-rank approximation of the high-dimensional input data through the whole computing process, 2) compute the solution and perform a post-processing in a low-rank tensor format. The post-processing may include computation of different statistics, visualization of a small portion of large data, large data analysis. The aim is to develop numerical methods which will reduce the computational cost as well as the storage requirement from $O(n^d)$ to $O(knd)$, where $k$ is a small integer (related with the rank). The purpose of this minisymposium is to bring together experts in adaptive discretization/solution of stochastic/multi-parametric problems, experts in multi-linear algebra and experts in uncertainty quantification methods.

Time-dependent Low-rank Approximation Method for Solving Parametric Dynamical Systems
Billaud-Friess, Marie Ecole Centrale de Nantes
Nouy, Anthony Ecole Centrale Nantes

Abstract: This talk concerns a low-rank approximation method for the model reduction of non-linear parametric dynamical systems. The proposed approach combines the construction of a time dependent reduced space in which the full model is projected to derive the reduced dynamical system. This talk concerns a low-rank approximation method for the model reduction of non-linear parametric dynamical systems. The proposed approach combines the construction of a time dependent reduced space in which the full model is projected to derive the reduced dynamical system.

Approximating Stochastic Galerkin Operator in the Tensor Train Data Format
Litvinenko, Alexander KAUST, UQ & ECRC Centers
Matthies, Hermann TU Braunschweig, Inst. of Scientific Computing

Abstract: We apply Tensor Train approximation to solve stochastic elliptic PDE with stochastic Galerkin discretization. We compare two strategies of the polynomial chaos expansion: sparse and full polynomial sets. In full set, the polynomial orders are chosen independently in each variable, which provides higher flexibility and accuracy. We demonstrate that full expansion set encapsulated in TT format is indeed preferable in cases when high accuracy and high polynomial orders are required. Many numerical experiments are provided.

Kolmogorov Widths and Low-rank Approximations of Parametric Elliptic PDEs
Bachmayr, Markus UPMC Paris 06

Abstract: This talk is concerned with low-rank approximations of solution manifolds of parametric diffusion equations, with a particular focus on the case of piecewise constant parametrized diffusion coefficients. Decay estimates for the Kolmogorov widths of solution manifolds are established, which are close to the derived in the previous talk, which focusses on improved theory, the GasLab sampling-free Bayesian inference approach.

Adaptive-fiber Tensor-trains with Application to Bayesian Inference
Gorodetsky, Alex Massachusetts Inst. of Tech.
Marzouk, Youssef Massachusetts Inst. of Tech.

Abstract: Tensor-train (TT) decompositions can enable dramatic compression of arrays arising from discretizations of high dimensional functions. In many applications, however, it is unclear how to specify the discretization level. We propose an extension to TT decomposition that yields virtual discretization-invariance by taking advantage of additional structure (e.g., smoothness, periodicity, along with derivative information) to adaptively approximate each tensor fiber. We apply the new adaptive-fiber TT decomposition to build a sampling-free Bayesian inference approach.

Mathematical Optimization of Gas Transport
Koch, Thorsten TU Berlin / Zuse-Institute Berlin

Abstract: About 25
Talk 1: Evaluating gas network capacities Prof. Dr. Thorsten Koch, TU-Berlin, koch@zib.de In 2008 Open Grid Europe, Germany’s largest gas transport system operator, initiated the Research Cooperation Network Optimization (FoNe) due to the challenges imposed by new regulations on gas transport planning. Researcher from six intuitions worked on modelling and solving mid- and long-term capacity planning problems in gas transport networks. Building on the mathematical results of the project a prototype system was built using a new paradigm in capacity planning. We will report on the results of this seven year project.

Talk 2: Complex European gas supply leads to ever new challenges Dr. Jessica Rövekamp, Open Grid Europe GmbH, jessica.roevekamp@googlemail.com The European gas supply is characterized by a variety of sources of supply, high import dependency, numerous market actors along the value chain and different gas compositions and pressure levels in the pipeline system. Member States have different requirements for gas properties as well as different measurement and regulation systems. Therefore, the focus is always on the security of supply. The discourse shows how these challenges are dealt with and what future developments the European gas supply will have to adapt to.

Talk 3: Mathematical modeling, simulation, and optimization using the example of gas networks Prof. Dr. Alexander Martin, Universität Erlangen-Nürnberg, Alexander.Martin@math.uni-erlangen.de Beginning Oct. 1st 2014, the German national science foundation’s collaborative research center/transregio 154 Mathematical modeling, simulation, and optimization using the example of gas networks will start with more than 20 projects at 5 locations over a 4 to 12 year timeframe. The focus is to study the underlying and inherent mathematical problems including the design of a consistent hierarchy of models, from PDE driven up to combinatorial, the studying of appropriate error controls at each level as well as the development of global optimal solutions methods. We will report on these goals, challenges, and present first results.

Talk 4: MODAL: GasLab Dr. Janina Köper, Zuse-Institute Berlin (ZIB), koerber@zib.de Supported by the German Federal Ministry of Education and Research the Research Campus MODAL (Mathematical Optimization and Data Laboratories) started its operation in 2014. A major part of it is the GasLab where ZIB together with Open Grid Europe will research new methods for improved real time control of the gas transport network. Complementing the previous talk, which focusses on improved theory, the GasLab’s mission is to bring the latest in mathematical optimization into practical use.

Evaluating Gas Network Capacities
Koch, Thorsten TU Berlin / Zuse-Institute Berlin

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Mathematical Modeling, Simulation, and Optimization Using the Example of Gas Networks
Martin, Alexander Friedrich-Alexander-Univ. Erlangen-Nuremberg

Abstract: The focus of the collaborative research center TRR154, supported by the German science foundation, is to study the optimization of gas transport networks and its underlying and inherent mathematical problems including the design of a consistent hierarchy of models, from PDE driven up to combinatorial, the studying of appropriate error controls at each level as well as the development of global optimal solutions methods. We will report on these goals, challenges, and present first results.

Complex European Gas Supply Leads to Ever New Challenges
Roevekamp, Jessica CYRCo GmbH

Abstract: The European gas supply is characterized by a variety of sources of supply, high import dependency, numerous market actors along the value chain and different gas compositions and pressure levels in the pipeline system. The goal is to create one European market while securing future supply, although Member States have different regulatory regimes. The discourse

Schedules: Monday Sessions
IM-Mo-D-21 13:30–15:30 309B
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Abstract: Self-adaptive numerical methods provide a powerful and automatic formulation as well as first heuristic solution approaches based on game theory. To prevent this, a new contract has been designed to guarantee their gas supply by predefined entries. Here, we present a model formula as well as first heuristic solution approaches based on game theory.


For Part 2, see MS-Mo-E-22

Organizer: Zhang, Shun City Univ. of Hong Kong
Organizer: Cai, Zhiqiang Purdue Univ.

Abstract: Self-adaptive numerical methods provide a powerful and automatic approach in scientific computing. In particular, Adaptive Mesh Refinement (AMR) algorithms have been widely used in computational science and engineering and have become a necessary tool in computer simulations of complex natural and engineering problems. The key ingredient for success of self-adaptive numerical methods is a posteriori error estimates that are able to accurately locate sources of global and local error in the current approximation. Talks in this mini-symposium will cover some recent advances in the development and analysis of both a posteriori estimators and (convergent) adaptive schemes, as well as indicate directions of future research.

MS-Mo-D-22-1 13:30–14:00 Robust and Optimal A Priori and A Posteriori Error Estimates for Diffusion Equations with Discontinuous Coefficients

Zhang, Shun City Univ. of Hong Kong

Abstract: For diffusion problems of discontinuous coefficients, the quasimonotonicity assumption (QMA) is a very important condition to guarantee the robustness of the problem independent of the coefficients. In this talk, new results of robust and optimal a priori and a posteriori error estimates for various finite element approximations of diffusion problems with discontinuous coefficients without QMA are discussed.

MS-Mo-D-22-2 14:00–14:30 Robust A Posteriori Error Estimates for HDG Method for Convection-Diffusion Equations

Qiu, Weifeng City Univ. of Hong Kong
Chen, Huangxin Xiamen Univ.

Abstract: We propose a robust a posteriori error estimator for the hybridizable discontinuous Galerkin (HDG) method for convection-diffusion equations with dominant convection. The reliability and efficiency of the estimator are established for the error measured in an energy norm. The energy norm is uniformly bounded even when the diffusion coefficient tends to zero.

MS-Mo-D-22-3 14:30–15:00 A Posteriori Error Estimation Using Auxiliary Subspace Techniques

Ovall, Jeffrey Portland State Univ.

Abstract: The discretization error for conforming simplicial finite elements is estimated by computing a function in an auxiliary subspace. The corresponding error estimates are proven to be efficient and reliable (up to an oscillation term), and numerical experiments demonstrate its robustness with respect to singularities, variation in the coefficients of the differential operator, and polynomial degree used in the discretization.

MS-Mo-D-22-4 15:00–15:30 Optimality of Adaptive Finite Element Methods for Controlling Local Energy Errors

Demlow, Alan Texas A&M Univ.

Abstract: While proof of convergence and optimality of adaptive FEM (AFEM) for controlling standard energy errors is now relatively standard, there are few corresponding results concerning optimality of AFEM for controlling other norms of the error. In this talk we discuss optimality of an AFEM for controlling local energy norms of the error.

MS-Mo-D-23 13:30–15:30 208A Recent Developments in Finite Element Methods for Variational Inequalities - Part I of II

For Part 2, see MS-Mo-E-23

Organizer: Nataraj, Neela Indian Inst. of Tech. Bombay
Organizer: Gudi, Thirupathi Indian Inst. of Sci., Bangalore

Abstract: Variational inequalities have been playing a key role in the modern scientific world. The theory of variational inequalities provides a generalization of the theory of boundary value problems and has applications in many fields like Applied Mathematics, Mechanics, Theory of Control and so on. Unlike variational equations, inequalities exhibit additional singularities due to occurrence of free boundaries, which limit the regularity of the solution. The study of computational methods for variational inequalities thus offers more challenges. The error analysis for the finite element methods of these problems should also be derived under the limited regularity assumptions. Adaptive finite element techniques are quite desirable for these class of problems. We would like to discuss and exchange some of the latest developments in the error analysis of finite element methods for variational inequalities.

MS-Mo-D-23-1 13:30–14:00 A Reliable Residual Based A Posteriori Error Estimator for a Quadratic FEM for the Obstacle Problem

Gudi, Thirupathi Indian Inst. of Sci., Bangalore

Abstract: In this talk, we discuss on derivation of a reliable residual based a posteriori error estimator for the quadratic finite element method for the obstacle problem. The crux of the error analysis is involved in defining an appropriate Lagrange multiplier due to obstacle constraint. The numerical experiments of adaptive algorithm with Dorfler marking strategy shows optimal order convergence and illustrates that the quadratic adaptive fem is not suboptimal.

MS-Mo-D-23-2 14:00–14:30 A Nonconforming Finite Element Approximation for Optimal Control of the Obstacle Problem

Nataraj, Neela Indian Inst. of Tech. Bombay

Abstract: The talk deals with the analysis of a nonconforming finite element method for the discretization of optimization problems governed by variational inequalities. The state and adjoint variables are discretized using Crouziex-Raviart (CR) nonconforming finite elements and the control is discretized using a variational discretization approach. Error estimates have been established for the state and control variables. The theoretical results are justified by numerical experiments.

MS-Mo-D-23-3 14:30–15:00 Optimality and Convergence of A Standard Adaptive Conforming Linear Element Method for An Obstacle Problem

Hu, Jun Peking Univ.

Abstract: In this talk we present the first optimality and convergence analysis of a standard adaptive conforming linear element method for an obstacle problem. The main ingredients for the analysis are the usual Scott-Zhang quasi-interpolation operator and a refined a posteriori error estimator. This is a joint work with Carsten Carstensen.

MS-Mo-D-23-4 15:00–15:30 A Posteriori Error Analysis for Finite Element Methods for Fourth Order Variational Inequalities

Sung, Li-yeng Louisiana State Univ.

Abstract: In this talk we discuss a posteriori error estimates for finite element methods for fourth order variational inequalities, with applications to obstacle problems for Kirchhoff plates and optimal control problems with pointwise state constraints. This is joint work with Susanne C. Brenner, Joscha Gedicke and Yi Zhang.


For Part 2, see MS-Mo-E-24

Organizer: Haack, Jeff Los Alamos National Laboratory
Organizer: Hu, Jingwei Purdue Univ.
Organizer: Tang, Min Shanghai Jiao Tong Univ.

Abstract: Kinetic equations and related models play an important role in many science and engineering branches. Examples include: gas/plasma dynamics, radiative transfer, semiconductor modeling, complex systems in biological

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or social sciences, etc. Designing numerical methods in these applications present similar challenges, ranging from multiscale modeling, nonlinear analysis, to large computational expense requiring high performance computing. This minisymposium aims to report the recent progress in the development of numerical methods for various kinetic equations, and by bringing researchers from diverse fields, to stimulate new problems and methods.

### MS-Mo-D-24-4 13:30–14:00

**Mathematical Description of Bacterial Motion by Chemotaxis : Kinetic Description and Hydrodynamic Limit**

**Vuachelet, Nicolas**
Univ. Paris 6

**Abstract:** Since experimental observations have shown that the motion of bacteria (e.g. Escherichia Coli) is due to the alternation of ‘runs’ and ‘tumbles’, mathematical modelling of this motion thanks to a kinetic description has been proposed. From this mesoscopic description, macroscopic models have been derived whose study and numerical simulations are challenging, since blow up phenomena appears at the limit.

### MS-Mo-D-24-2 14:00–14:30

**A Fast Spectral Method for the Boltzmann Equation of Monatomic Gas Mixtures**

**Wu, Lei**
Univ. of Strathclyde

**Abstract:** A fast spectral method is proposed to solve the Boltzmann equation for gas mixtures, with a computational cost $O(N^2 \log N)$, where $N$ is the number of frequency nodes in each frequency direction, $M$ is the number of solid angle discretization, and $m_t$ is the molecular mass ratio. The algorithm is validated by comparing the numerical results with analytical Bobylev-Krook-Wu (DSMC) solutions in the spatial-inhomogeneous problems, for $m_t$ up to 36.

### MS-Mo-D-24-3 14:30–15:00

**Analysis of the Stationary Wigner Equation with Inflow Boundary Conditions**

**Lu, Tiao**
Peking Univ.

**Abstract:** The stationary Wigner equation with inflow boundary conditions (BVP) has been widely applied in numerical simulation of nano semiconductor devices. It will introduce our recent work on analysis of the mathematical properties of the BVP and then present a semi-discrete version of the Wigner equation and prove that the constructed numerical solution by using the Shannon-Whittaker interpolation formula converges to the solution of the continuous BVP as the velocity mesh size goes to zero.

### MS-Mo-D-24-4 15:00–15:30

**Conservative Discrete Velocity Method for Non-equilibrium Flows**

**Zhang, Yonghao**
Univ. of Strathclyde

**Abstract:** Rapid advances have been made for micro/nano-fluidic technology, which demands computationally efficient design simulation tools that can capture non-equilibrium flow phenomena. Our recent development of a conservative discrete velocity method for modelling gas flows beyond the Navier-Stokes hydrodynamics will be discussed. With a moderate discrete velocity set, we find our model can accurately recover steady and transient solutions of the kinetic equation in the slip-flow and early transition regimes.

### MS-Mo-D-25 13:30–15:30

**Isogeometric methods and design-through-analysis tools in CAD/CAE - Part I of III**

**For Part 2, see MS-Mo-E-25**
**For Part 3, see MS-Mo-D-25**

**Organizer:** Anibal Carlos, INdAM c/o Univ. of Florence

**Abstract:** The development process of industrial digital products relies on geometrical and numerical technologies provided by computer aided applications. The computational models are usually designed through commercial Computer Aided Design (CAD) systems and subsequently processed and approximated with Computer Aided Engineering (CAE) software tools. In order to drastically improve the efficiency and robustness of this process, a deep interaction among scientists from geometric modeling and numerical analysis is needed. An active area of research in this context is related to isogeometric analysis, an emerging paradigm for the solution of partial differential equations which combines and extends finite element techniques with CAD methods related to spline technologies. The isogeometric perspective outlines new paths of research for the identification of geometric representations suitable for numerical simulation. Indeed, isogeometric analysis is based on the idea that the exact geometry of the model should be preserved throughout the overall design-through-analysis process and numerical methods should be able to simulate physical phenomena directly on the CAD model. This is possible only if new, spline based, numerical techniques are designed and innovative schemes for geometric design are developed. The minisymposium will address theoretical and computational issues that arise in the identification, characterization and use of advanced geometric and analytical methods that share the goal of promoting new paradigms for a better CAD/CAE integration.

### MS-Mo-D-25-1 13:30–14:00

**Algebraic Methods in NURBs Representations, Toward Isogeometric Analysis**

**Elber, Gershon**
Technion, Israel Inst. of Tech.

**Abstract:** IGA brought geometric design and analysis (D&A) close. We will discuss several geometric challenges in light of IGA needs. The first will consider precise integration over trimmed surfaces, by untrimming them. Another topic that will be considered is the problem of contact analysis. Several methods to detect contacts and collisions and to precisely integrate over non-compatible surfaces will be considered.

* In collaboration with Fady Massarwi, Myung Soo Kim and Annalisa Buffa.

### MS-Mo-D-25-2 14:00–14:30

**A New Basis Construction for the PHT-Splines**

**Kang, Hongmei**
Univ. of Sci. & Tech. of China

**Chen, Falai**
Univ. of Sci. & Tech. of China

**Deng, Jiansong**
Univ. of Sci. & Tech. of China

**Abstract:** In this talk, we will first point out some limitations of PHT-spline basis, i.e., some of the basis functions decay rapidly for certain mesh refinement, which leads to numerical instability in data fitting and finite element analysis. We then propose a new basis construction for the PHT-splines which overcome the above limitations.

### MS-Mo-D-25-3 14:30–15:00

**Overlapping Schwarz Preconditioners for Isogeometric Collocation Methods**

**Cho, Durkbin**
Dongguk Univ.

**Pavarino, Luca F.**
Univ. of Milan

**Scacchi, Simone**
Univ. of Milan

**Beirao Da Veiga, Lourenco**
Univ. of Milan

**Abstract:** In this talk, an additive overlapping Schwarz method for isogeometric collocation discretizations is introduced and tested. The resulting preconditioner, accelerated by GMRES, is shown to be scalable with respect to the number of subdomains and very robust with respect to the isogeometric discretization parameters such as the mesh size and polynomial degree, as well as with respect to the presence of discontinuous elliptic coefficients and domain deformations.

### MS-Mo-D-25-4 15:00–15:30

**Scalable BDDC Preconditioners for Isogeometric Analysis of Elliptic Problems**

**Pavarino, Luca F.**
Univ. of Milan

**Cho, Durkbin**
Dongguk Univ.

**Scacchi, Simone**
Univ. of Milan

**Zampini, Stefano**
KAUST

**Beirao Da Veiga, Lourenco**
Univ. of Milan

**Widlund, Olof B.**
Courant Inst. of Mathematical Sci., New York Univ.

**Abstract:** We will present and study BDDC (Balancing Domain Decomposition by Constraints) preconditioners with different scalings for isogeometric Analysis discretizations of scalar elliptic problems. We show that the condition number of the resulting BDDC preconditioner is scalable with a quasi-optimal polynomial bound, independently of coefficient discontinuities across subdomain interfaces. Extensive numerical experiments support the theory and show the BDDC strong performance, in particular when a novel deluxe scaling is employed.

### MS-Mo-D-26 13:30–15:30

**Perturbation theory for linear/nonlinear eigenvalue problems in action - Part I of II**

**For Part 2, see MS-Mo-E-26**

**Organizer:** Miedlar, Agnieszka EPF Lausanne

**Abstract:** In numerical analysis, perturbation theory has earned its fame as primarily theoretical contributions, but nonetheless their role in practical computations is crucial. Perturbation results are used extensively for analyzing stability of numerical algorithms or the accuracy of numerical approximation, and sometimes to inspire new algorithm design. Applications include solving PDEs, simulating dynamical systems and model reduction. With the goal to show the beauty and practical importance to a broader audience, this minisymposium reviews classical and recent outstanding results and open problems in eigenvalue perturbation theory, treating both matrices (linear, polynomial...
and general nonlinear eigenvalue problems) and linear operators.

**Relative Perturbation Theory for Diagonally Dominant Matrices**

Dopico, Froilan M.

Universidad Carlos III de Madrid

**Abstract:** Diagonally dominant matrices are very important in applications and have been extensively studied in the last 50 years. Therefore, it is difficult to believe that something really new can be said on these matrices. However, in the last four years a number of highly structured perturbation results have been proved for these matrices and used to prove that many accurate computations are possible for these matrices. This talk presents an overview of these perturbation results.

**Convergence Proof for Some Iterative Projection Methods from A Perturbation Bound for Symmetric Eigenvalue Problems**

Aishima, Kensuke

The Univ. of Tokyo

**Abstract:** We study the convergence of certain efficient projection methods using restarting and shift-invert technique for solving symmetric eigenvalue problems. More precisely, we show that the Ritz pairs converge to exact eigenpairs, although they are not necessarily the target eigenpairs. The key tool for the proof is a perturbation bound obtained by Crouzeix, Philippe, and Sadkane. Our result covers the Jacobi – Davidson and the rational Krylov methods with restarting and preconditioning.

**Perturbation of Partitioned Linear Response Eigenvalue Problems**

Teng, Zhongming

Fujian Agriculture & Forestry Univ.

Li, Ren-Cang

Univ. of Texas at Arlington

**Abstract:** This talk is concerned with the perturbation of the partitioned linear response eigenvalue problem. A bound on how the eigenvalues change is obtained. It is of linear order with respect to the diagonal blocks perturbation but of quadratic order with respect to the off-diagonal perturbations. The result is helpful in understanding how the Ritz values move towards eigenvale in some efficient numerical algorithms for the linear response eigenvalue problem.

**Generic Low-Rank Perturbations of Alternating Matrix Pencils**

Batzke, Leonhard

Technical Univ. Berlin

**Abstract:** Many applications, in particular ones from control, lead to T-alternating (i.e., symmetric / skew-symmetric) matrix pencils and important characteristics can be read off from the canonical form of this pencil. In this talk, we will discuss how the canonical form is altered when a T-alternating regular matrix pencil is subjected to a low-rank perturbation. Surprisingly, compared to arbitrary perturbations, the effect we observe is very different when the perturbation is T-alternating as well.

**Numerical Simulations in Poromechanics - Part I of III**

For Part 2, see MS-Mo-E-27

For Part 3, see MS-Mo-D-27

Organizer: Gaspar, Francisco

Univ. of Zaragoza

Organizer: Rodriguez, Carmen

Univ. of Zaragoza

Organizer: Zikatanov, Ludmil

The Pennsylvania State Univ.

**Abstract:** Poromechanics studies the interactions between fluid motion and deformation in porous media. It has important applications including consolidation, subsidence due to fluid withdrawal, and hydraulic fracturing. Many discretizations and solver schemes have been developed for poromechanics but the design of effective simulation techniques for handling the coupling between fluid motion and solid deformation is still a challenging task. The main theme of the mini-symposium is on the advanced numerical algorithms for simulating poromechanics. The focus is on robust discretizations, adaptivity and efficient nonlinear and linear solvers for various poroelastic models and their applications.

**Numerical Issues in the Simulation of Coupled Poromechanics by Mixed Finite Elements**

Ferronato, Massimiliano

Univ. of Padova

**Abstract:** The numerical solution to coupled poromechanics is still a challenging task because of several issues: (1) pore pressure instability, (2) large number of unknowns, and (3) ill-conditioning of the discretized system. The use of Mixed Finite Elements can alleviate the numerical oscillations in the pressure solution, but give rise to very large and ill-conditioned systems of algebraic equations. The use of efficient block preconditioners is presented and discussed to accelerate convergence in complex real-world applications.

**Uzawa Smoother in Multigrid for Poroelasticity Equations**

Luo, Peiyao

TU Delft

Rodrigo, Carmen

Univ. of Zaragoza

Gaspar, Francisco

Univ. of Zaragoza

Oosterlee, Cornelis

CWI -center for mathematics & computer Sci.

**Abstract:** A multigrid method is employed for the poroelastic equations with an Uzawa-type iteration as the smoother. Our analysis of the smoother is based on the framework of local Fourier analysis. An analytic bound can be obtained on the smoothing factor associated with the proposed smoother. Numerical experiments show that the smoothing factor reflects well the two-grid convergence factor obtained from local Fourier analysis, as well as the actual convergence factor from the real multigrid cycles.

**A Robust Multigrid Method for Discontinuous Galerkin Discretizations of S-tokes and Linear Elasticity Equations**

Hong, Qinqiao

Johann Radon Inst. for Computational & Applied Mathematics (RICAM), Austrian Acad. of Sci. (AT&214,AW)

Kraus, Johannes

Univ. of Duisburg-Essen

Xu, Jinchao

PKU and The Pennsylvania State Univ.

Zikatanov, Ludmil

The Pennsylvania State Univ.

**Abstract:** We consider multigrid methods for discontinuous Galerkin (dvg) conforming discretizations of the Stokes and linear elasticity equations. We abstract that the variable v-cycle and W-cycle multigrid methods with nonnested bilinear forms are optimal and robust, with convergence rates independent of the mesh size and also of the material parameters such as the Poisson ratio. We further report on the extension of the convergence results to the Brinkman problem.

**Weak Galerkin Method and Its Applications - Part I of III**

For Part 2, see MS-Mo-E-28

For Part 3, see MS-Mo-D-28

Organizer: Chen, Long

Univ. of California at Irvine

Organizer: Ye, Xiuf

Univ. of Arkansas at Little Rock

Organizer: Zhang, Ran

Jilin Univ.

**Abstract:** We study some recent developments of the standard Galerkin finite element method where classical derivatives were substituted by weakly defined derivatives on functions with discontinuity. As such, the WG methods have the flexibility in handling complex geometry and low regularity solutions, the simplicity in analyzing real-world physical problems, and the symmetry in reformulating the original PDEs. The aim of this mini-symposium is to bring together specialists in order to exchange ideas regarding the development of WG-FEMs and its industry and research applications. Since women is an underrepresented group in mathematics and engineering, we pay a particular attention to attract female participants.

**Weak Galerkin Finite Element Methods: Basic Principles and Recent Developments**

Wang, Junping

National Sci. Foundation

**Abstract:** In this talk, the speaker will first describe the basic principles for weak Galerkin (WG) finite element methods by using some model PDEs. The speaker will then present some recent developments of WG on three class of problems: (1) PDEs in non-divergent form, (2) PDEs that are generally characterized by inf-sup conditions, and (3) div-curl systems.

**Innovative Weak Galerkin Finite Element Methods with Application in Fluorescence Tomography**

Wang, Chunmei

Georgia Inst. of Tech.

**Abstract:** Fluorescence Tomography (FT) is an emerging, in vivo non-invasive 3-D imaging technique which reconstructs images that characterize the distribution of molecules that are tagged by fluorophores. We present a new and efficient numerical algorithm for FT model by using weak Galerkin (WG) finite element methods. Error estimates in an $H^1$-equivalent norm and the usual L^2 norm are established. Some numerical experiments are presented to illustrate the efficiency and accuracy of the numerical scheme.

**Recent Development of Weak Galerkin Methods**

13:30 – 15:00

**Abstract:** The Weak Galerkin method is an extension of the standard Galerkin finite element method where classical derivatives were substituted by weakly defined derivatives on functions with discontinuity. As such, the WG methods have the flexibility in handling complex geometry and low regularity solutions, the simplicity in analyzing real-world physical problems, and the symmetry in reformulating the original PDEs. The aim of this mini-symposium is to bring together specialists in order to exchange ideas regarding the development of WG-FEMs and its industry and research applications. Since women is an underrepresented group in mathematics and engineering, we pay particular attention to attract female participants.
Abstract: Newly developed weak Galerkin finite element methods will be introduced for solving partial differential equations. Weak Galerkin methods have the flexibility of employing discontinuous elements and share the simple formulations of continuous finite element methods at the same time. The Weak Galerkin method is an extension of the standard Galerkin finite element method where classical derivatives were substituted by weakly defined derivatives on functions with discontinuity. Recent development of weak Galerkin methods will be discussed.

MS-Mo-D-28-4 15:00–15:30
Weak Galerkin Finite Element Methods and Numerical Applications
Mu, Lin
Michigan State Univ.
Abstract: Weak Galerkin FEMs are new numerical methods that were first introduced by Wang and Ye for solving general second order elliptic PDEs. The differential operators are replaced by their weak discrete derivatives, which endows high flexibility. This new method is a discontinuous finite element algorithm, which is parameter free, symmetric, symmetric, and absolutely stable. Furthermore, through the Schur-complement technique, an effective implementation of the WG is developed. Several numerical applications will be discussed.

MS-Mo-D-29 13:30–15:30 305
Multilevel Monte Carlo methods and applications - Part I of III
For Part 2, see MS-Mo-E-29
For Part 3, see MS-Tu-D-29
Organizer: TEMPEONE, RAUL
KING ABDULLAH Univ. Of Sci. & Tech.
Organizer: Giles, Michael
Univ. of Oxford
Organizer: Nobile, Fabio
MATHICSE - EPFL
Abstract: Monte Carlo methods are general, flexible sampling methods for the computation of expected values of observables arising in stochastic systems. Monte Carlo methods are very attractive since they are simple to implement and their rate of convergence is very robust. Still, in the context of random evolution of large systems arising from the discretization of differential equations subject to randomness, their cost can be too large for practical purposes. The recently created Multilevel Monte Carlo method extended, to multiple levels, the idea of using a coarse numerical approximation as a method for control variate to a finer one, reducing the variance and the required number of samples on the finer grid. Multilevel Monte Carlo changed the computational landscape of stochastic problems described in terms of differential equations, which are commonplace, for instance, when carrying out Uncertainty Quantification in applications. In this minisymposium we intend to present the latest algorithmic and theoretical contributions to Multilevel Monte Carlo methods, focusing also on novel applications arising in, among others, stochastic social, chemical and biological modeling, wireless communication networks, computational finance, stochastic particle systems and engineering modeling with random PDEs.

MS-Mo-D-29-1 13:30–14:00
Stabilization of Multilevel Monte-Carlo Methods for Stochastic Differential Equations with Multiple Scales
Abdulle, Assyr
EPFL

MS-Mo-D-29-2 14:00–14:30
Multilevel Ensemble Kalman Filter
Law, Kody
ORNL
TEMPEONE, RAUL
KING ABDULLAH Univ. Of Sci. & Tech.
Hoel, Haakon
Univ. of Oslo
Abstract: This work embeds a multilevel Monte Carlo (MLMC) sampling strategy into the Monte Carlo step of the ensemble Kalman filter (ENKF), thereby yielding a multilevel ensemble Kalman filter (MLENKF) which has provably superior asymptotic cost to a given accuracy level. The theoretical results are illustrated numerically.

MS-Mo-D-29-3 14:30–15:00
MLMC for PDE Solutions Based on Feynman-Kac Theorem
Giles, Michael
Univ. of Oxford
Bernal, Francisco
Instituto Superior Tecnico
Abstract: The Feynman-Kac theorem expresses solutions to high-dimensional parabolic PDEs as expectations of functionals of Brownian diffusions. Existing methods using the Euler-Maruyama discretisation achieve O(eps) RMS accuracy at a cost which is O(eps^{-3}). We present a new MLMC method with a reduced cost which is O(eps^{-2/3}) if log terms are neglected. This relies heavily on theoretical results derived by E. Gobet and others, and is supported by numerical experiments.

MS-Mo-D-29-4 15:00–15:30
The Forward-reverse Method for Conditional Markov Processes
Bayer, Christian
Weierstrass Inst., Berlin
Abstract: In this paper we derive stochastic representations for the finite-dimensional distributions of a multidimensional Markov process on a fixed time interval, conditioned on the terminal state. The conditioning can be with respect to a fixed point or more generally with respect to some subset. The corresponding Monte Carlo estimators have essentially root-N accuracy, and hence they do not suffer from the curse of dimensionality. We also present applications in statistical inference of stochastic reaction networks.

MS-Mo-D-30 13:30–15:30 VIP2-2
Mathematics, statistics and computation in metrology
Organizer: Cox, Maurice
National Physical Laboratory
Organizer: Giles, Michael
Numerical Algorithms Group Ltd
Abstract: Mathematics, statistics and computation in metrology encompass any area where observations are made or gathered and, together with available contextual information, are analysed using mathematical, statistical or numerical procedures. The minisymposium includes the mathematical and statistical modelling of measuring systems, the numerical solution of those models and, given observational uncertainties, the quantification of uncertainties associated with the solution. Numerical methods applied cover the use of existing capability such as provided by software libraries and novel solution techniques that are yet to find their way into mainstream use. Application areas are diverse including physics, chemistry, biology and medicine.

MS-Mo-D-30-1 13:30–14:00
Data Analysis for Chemical Microscopy
Dewar, Mike
National Physical Laboratory
Abstract: Spectroscopic microscopy is used for the detection of molecular compounds within the micro and nano-scale structures of cells, tissues and materials. Analysis of the very large hyperspectral image stacks acquired is computationally challenging, and accurate interpretation often depends on combining multiple complementary imaging modes. This talk will describe the development of tools to allow non-ICT experts to combine multiple types of imaging data and efficiently explore these data sets to create novel insights.

MS-Mo-D-30-2 14:00–14:30
Tipping Point Analysis: A Computational Framework for Studying Transitions and Bifurcations in Time Series
Livina, Valerie
National Physical Laboratory
Abstract: We develop a methodology for anticipating (pre-tipping), detecting (tipping) and forecasting of tipping points in dynamical systems. Early warning signals are analyzed using lag-1 autocorrelations in sliding windows; detection is performed using potential analysis with potential contour plot; forecast is performed by extrapolation of dynamically derived Chebyshev coefficients of the approximation of the probability density. We distinguish transitional and bifurcational tipping points by the structure of the underlying potential in the stochastic modelling equation.

MS-Mo-D-30-3 14:30–15:00
Chebyshev Polynomials in Metrology
Cox, Maurice
National Physical Laboratory
Abstract: Formulation of many problems in metrology involve optimization, approximation, differential equations, and other mathematical disciplines. Numerical software libraries exist to help solve such problems. In recent years the Chebfun software facility appeared that offered high-accuracy numerical computation with functions, but with “symbolic feel and numerical speed”. This talk will indicate how metrology can benefit from Chebfun and give examples of application such as uncertainty propagation and calculations involving probability distributions.

MS-Mo-D-30-4 15:00–15:30
Regularization for High-speed Waveform Metrology
Dienstfrey, Andrew
National Inst. of Standards & Tech.
Abstract: We study multiple algorithms to select regularization parameters to stabilize deconvolution in high-speed communication measurement applications, investigating these algorithms in the presence of unspecified noise cor-

Organizer: Cox, Maurice
National Physical Laboratory
Organizer: Giles, Michael
Numerical Algorithms Group Ltd
Abstract: Mathematics, statistics and computation in metrology encompass any area where observations are made or gathered and, together with available contextual information, are analysed using mathematical, statistical or numerical procedures. The minisymposium includes the mathematical and statistical modelling of measuring systems, the numerical solution of those models and, given observational uncertainties, the quantification of uncertainties associated with the solution. Numerical methods applied cover the use of existing capability such as provided by software libraries and novel solution techniques that are yet to find their way into mainstream use. Application areas are diverse including physics, chemistry, biology and medicine.

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Abstract: Spectroscopic microscopy is used for the detection of molecular compounds within the micro and nano-scale structures of cells, tissues and materials. Analysis of the very large hyperspectral image stacks acquired is computationally challenging, and accurate interpretation often depends on combining multiple complementary imaging modes. This talk will describe the development of tools to allow non-ICT experts to combine multiple types of imaging data and efficiently explore these data sets to create novel insights.

MS-Mo-D-30-2 14:00–14:30
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MS-Mo-D-30-3 14:30–15:00
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Abstract: Formulation of many problems in metrology involve optimization, approximation, differential equations, and other mathematical disciplines. Numerical software libraries exist to help solve such problems. In recent years the Chebfun software facility appeared that offered high-accuracy numerical computation with functions, but with “symbolic feel and numerical speed”. This talk will indicate how metrology can benefit from Chebfun and give examples of application such as uncertainty propagation and calculations involving probability distributions.

MS-Mo-D-30-4 15:00–15:30
Regularization for High-speed Waveform Metrology
Dienstfrey, Andrew
National Inst. of Standards & Tech.
Abstract: We study multiple algorithms to select regularization parameters to stabilize deconvolution in high-speed communication measurement applications, investigating these algorithms in the presence of unspecified noise cor-
relation, analyzing their joint multivariate performance distribution by Monte Carlo. We find that several parameter selection algorithms are not robust to unspecified noise correlations. While directly relevant to metrology for high-speed communication systems, our analysis suggests that these results apply to dynamic metrology applications more broadly.

MS-Mo-D-31: Numerical Computation with Functions and Chebfun - Part I of III

For Part 2, see MS-Mo-E-31
For Part 3, see MS-Tu-D-31

Organizer: Treethen, Lloyd N. Univ. of Oxford
Organizer: Guettel, Stefan The Univ. of Manchester

Abstract: A recent theme in algorithms and software is efficient numerical computation with functions in a manner that “feels symbolic” since the accuracy is high and underlying discretizations (Chebyshev, Fourier,...) are hidden from the user. Projects of this kind include Chebfun, pychebfun, ApproxFun, and PaCAL. A pervasive theme in this work is the use of continuous analogues of familiar discrete mathematical objects and algorithms. This minisymposium will present new developments in the areas of (1) differential and integral equations, (2) working with functions, and (3) rootfinding and linear algebra.

- ▶ MS-Mo-D-31-1: Solving ODEs with Chebfun and Chebgui
  Treethen, Lloyd N. Univ. of Oxford
  Abstract: Chebfun is the most convenient system in existence for numerical solution of ODEs and systems of ODEs. We describe its design, the combined effort by, among others, Driscoll, Birkisson, Bornemann, and Hale. Everything is done in a continuous setting using Frechet derivative operators instead of Jacobian matrices. We highlight newer features including ultraspherical discretizations and Chebfun solution of IVPs. All this can be accessed with no programming at all through the graphical user interface CHEBGUI.

- ▶ MS-Mo-D-31-2: Remez and CF Digital Filtering and Approximation in Chebfun
  Javed, Mohsin Univ. of Oxford
  Abstract: The Remez algorithm, also known as the Parks-McClellan algorithm, is used for designing finite impulse response digital filters. In this talk we will discuss how Chebfun's trigonometric interpolation and root finding algorithms allow us to design digital filters robustly and accurately. We compare our design algorithm with MATLAB's implementation. We also show how a new filter design algorithm based on the Cartheodory-Fejer approximation is the natural near-best filter design procedure of practical importance.

- ▶ MS-Mo-D-31-3: Toward Chebfun in 3D
  Hashemi, Bahram Univ. of Oxford
  Abstract: We present experiments with three techniques to represent 3D functions in Chebfun. The first technique is a purely trivariate tensor product method which computes an order-3 tensor containing coefficients of the Chebyshev expansion of the given function \( f \). The other two approaches are based on low-rank approximations and use ACA-type ideas to create a slice decomposition of \( f \), being different in whether or not they explicitly use the full tensor of values of \( f \).

- ▶ MS-Mo-D-31-4: Bayesian Inference for Multiphase Darcy Flow Models
  Icardi, Matteo KAUST
  Abstract: When Darcy's equation is extended to multiphase flows, it is often used in conjunction with empirical models, whose parameters lump many complex physical phenomena and have to be estimated case by case. In this work we implement with Chebfun one-dimensional Darcy flow models and a Bayesian algorithm to estimate posterior PDFs of flow parameters.

- ▶ MS-Mo-D-32: Reduced-order modeling in uncertainty quantification and computational fluid dynamics - Part I of III
  For Part 2, see MS-Mo-E-32
  For Part 3, see MS-We-E-03

Organizer: Chen, Peng ETH Zurich (Swiss Federal Inst. of Tech. in Zurich)
Organizer: Quarteroni, Alfio EPFL
Organizer: Rozza, Gianluigi SISSA, International School for Advanced Studies

Abstract: This proposed minisymposium is about the development and application of reduced-order modeling techniques in the fields of uncertainty quantification and computational fluid dynamics for control, optimization and design. Large-scale computing is commonly faced in these fields due to the high computational complexity of solving parametric and/or stochastic systems described by, e.g., partial differential equations, which may lead to unaffordable computational burden for real-world application. In order to tackle this challenge, reduced-order modeling (e.g., RB, POD, EIM, PGD) techniques with the aim of capturing and utilizing the most important features of these systems are particularly in need for real-time and/or many-query computations.

This minisymposium focuses on the development and application of reduced-order modeling techniques in following themes: 1. efficient and reliable a posteriori error estimates for reduced solution and output; 2. forward uncertainty quantification problems, e.g., sensitivity analysis, risk prediction or reliability analysis with scientific and engineering applications; 3. stochastic inverse problems (model calibration, parameter identification) by variational or Bayesian approach; 4. control, optimization and design in computational fluid dynamics possibility under uncertainties.

Reduced-order modeling techniques have undergone fast development during the last decade and become a new frontier in scientific computing. Their increasing popularity is witnessed by many minisymposia at congress and conferences around the world, such as ICIAM, ICOSAHOM, WCCM, SIAM CSE, SIAM UQ, ECCOMAS, ENUMATH. The aim of this minisymposium is to discuss the most recent development of these techniques with emphasis in the field of UQ and CFD and identify new directions and perspectives. For this purpose we have invited 12 speakers with great expertise from several universities around the world, e.g., (MIT, Stanford, Paris VI, EPFL, TU Munich, CAS, Sandia National Laboratories, etc.).

- ▶ MS-Mo-D-32-1: Introduction of Reduced-order Modeling for UQ and CFD
  Rozza, Gianluigi SISSA, International School for Advanced Studies
  Chen, Peng ETH Zurich (Swiss Federal Inst. of Tech. in Zurich)
  Abstract: We present some recent development of reduced-order modeling techniques in the fields of uncertainty quantification and computational fluid dynamics. We consider multilevel and weighted algorithms in the context of reduced-order modeling to capture and utilize the most important features of the underlying systems. Examples of high-dimensional variational data assimilation for blood flow in carotid artery will be shown to demonstrate the efficiency and accuracy of our proposed algorithms.

- ▶ MS-Mo-D-32-2: Dynamical Low Rank Approximation of Incompressible Navier Stokes Equations with Random Parameters
  Musharbash, Eleonora EPFL
  Noble, Fabio MATHICSE - EPFL
  Abstract: We propose a Reduced Basis approach for time dependent incompressible Navier Stokes equations with random parameters, based on a time evolving, Dynamically Orthogonal, basis. The solution is approximated in a low dimensional, time dependent manifold MS. This is achieved by projecting at each time step the residual of the governing equation onto the tangent space to MS. Numerical tests at moderate Reynolds number will be presented, with emphasis on the case of stochastic boundary conditions.

- ▶ MS-Mo-D-32-3: Adaptive Model Reduction for Large-scale Inverse Problems with High Dimensional Unknowns.
  Cui, Tiangang MIT
  Marzouk, Youssef Wilcox, Karen Massachusetts Inst. of Tech.
  Abstract: Algorithmic scalability to high dimensional parameters and computational efficiency of numerical solvers are two significant challenges in large-scale data-constrained inverse problems. Here we will explore the intrinsic dimensionality in both state space and parameter space of inverse problems by analyzing the interplay between noisy data, ill-posed forward model and smoothing prior. The resulting reduced subspaces naturally lead to a scalable and fast model reduction framework for solving large-scale inverse problems with high dimensional parameters.

- ▶ MS-Mo-D-32-4: Hybridized Reduced Basis Method and Generalized Polynomial Chaos for Solving Partial Differential Equations
  Jiang, Jiahua Univ. of Massachusetts Dartmouth
  Abstract: The generalized Polynomial Chaos (gPC) method is a popular method for solving partial differential equations (PDEs) with random parameters. However, when the probability space has high dimensionality, the solution ensemble size required for an accurate gPC approximation can be large. We show that this process can be made more efficient by closely hybridizing
gPC with Reduced Basis Method (RBM). Since the reduced model is more efficient, costs are significantly reduced.

**MS-Mo-D-33**

**Random Graphs and Complex Networks - Part I of II**

**13:30–15:30**

**Organizer:** Han, Dong

**School:** Shanghai Jiao Tong Univ.

**Abstract:** We focus on the following questions of random graph and complex networks. How to classify the structure of different random growing networks? How do the dynamical processes taking place on a random network shape the network topology? Spectral theory of random graphs. Random matrix and its application. Stochastic processes on random graphs and complex networks.

- **MS-Mo-D-33-1**
  - 13:30–14:00
  - Some Questions Concerning Random Walks on Trees in A Random Environment
  - Chen, Dayue
  - Peking Univ.
  - Abstract: Consider the speed of the \( \lambda \)-biased random walk on Galton-Watson trees. It was proved by Lyons, Permanente & Peres that the speed exists, and was conjectured that the speed is monotone on \( \lambda \) for \( 0 < \lambda < \infty \). In the same spirit we consider the simple random walk on the infinite cluster of the Bernoulli bond percolation of trees, and investigate the relation between the speed of the simple random walk and the retaining probability.

- **MS-Mo-D-33-2**
  - 14:00–14:30
  - Nodal Domain Partition and Community Structure in Networks
  - Zhang, Xiaodong
  - Shanghai Jiao Tong Univ.
  - Abstract: Discrete nodal domain theory is used to provide a criterion to determine how many communities a network has and how to partition these communities by means of topological structure and geometric characterization. By capturing the signs of the Laplacian eigenvectors, we separate the network into several reasonable clusters. The method leads to a fast and effective algorithm with application to a variety of real network data sets.

- **MS-Mo-D-33-3**
  - 14:30–15:00
  - Mixing Time of Random Walk on Poisson Geometry Small World
  - Wu, Xianyuan
  - School of Math. Sci., Capital normal Univ.
  - Abstract: Let's consider the supercritical Poisson continuous percolation on \( \ell^d \)-dimensional torus \( T^n_{\ell^d} \) with volume \( n^d \). By adding “long edges,” randomly to the largest percolation cluster, we obtain a random graph \( G_n \). We first prove that the diameter of \( G_n \) grows at most polynomially fast in \( n \). Secondly, we prove that the random walk on \( G_n \) possesses the rapid mixing property, namely, the random walk mixes in time at most polynomially large in \( n \).

- **MS-Mo-D-33-4**
  - 15:00–15:30
  - Laplacian Spectra of Random Hypergraphs
  - Lu, Linyuan
  - Univ. of South Carolina
  - Peng, Xing
  - Univ. of California, San Diego
  - Abstract: The Laplacian eigenvalue of a graph plays an important role in controlling other graph parameters. It is closed related to random walks. In this talk, we introduce a set of Laplacian eigenvalues of a uniform hypergraph by considering high-order random walks and we also calculate the Laplacian eigenvalues of random hypergraphs.

**MS-Mo-D-34**

**13:30–15:30**

**Organizer:** Wang, Yani

**Inst. of Applied Physics & Computational Mathematics**

**Abstract:** The Boltzmann equation is very important in a number of high-tech fields such as the space exploration, plasma and the semiconductor simulations. However, the numerical cost of solving the Boltzmann equation directly in large systems is still unaffordable. The highly efficient numerical solvers are needed to solve this problem. Or, people may build the simplified models instead of directly solving the Boltzmann equation, where the moment method is the main method. The numerical difficulties in different application areas also vary greatly and are always hard to solve. Numerical methods to solve the Boltzmann equation are also widely used in these related application areas. Recently, the research on direct Boltzmann solvers and moment methods together with their applications are very active. The purpose of this mini-symposium is to gather most representative researchers and report their progress. It invites speakers from different parts of the world and provides a good opportunity to exchange ideas.

- **MS-Mo-D-34-1**
  - 13:30–14:00
  - An Asymptotic-preserving Numerical Scheme for the Electronic M1 Model in the Diffusive Limit.
  - Brull, Stephane
  - Inst. Polytechnique de Bordeaux
  - Abstract: This work is devoted to the derivation of an asymptotic-preserving scheme for the electronic M1 model in the diffusive regime. A Godunov type scheme, based on approximated Riemann solvers and satisfying the admissibility conditions is proposed. Numerical tests cases will be presented in the classical and in the diffusive regime.

- **MS-Mo-D-34-2**
  - 14:00–14:30
  - Multigrid Acceleration for Steady-state Boltzmann Equation Based on Moment Method
  - HU, Zhicheng
  - The Hong Kong Polytechnic Univ.
  - Abstract: The stationary solution of Boltzmann equation has a special significance in various modern kinetic fields. While the steady state is unavailable in general via an analytical way, numerical simulation for it is also very challenging. We concentrate in this talk on efficient solution strategies for the stationary Boltzmann equation with BGK-type collision term, based on multi-grid method and unified formulation of numerical regularized moment method of arbitrary order.

- **MS-Mo-D-34-3**
  - 14:30–15:00
  - A Moment Method with \( L^2 \) Convergence in the Gas Kinetic Theory
  - Cai, Zhenning
  - RWTH Aachen Univ.
  - Abstract: In Grad's moment method, the distribution function is expanded into a series in a weighted \( L^2 \) space. However, in some problems like heat transfer between two parallel plates, the exact solution may be outside this space, which causes divergence of the moment method. To overcome this, we expand the distribution function in the unweighted \( L^2 \) space, and add a conservation fix to keep the conservation laws. Numerical simulation shows the convergence of this new method.

- **MS-Mo-D-34-4**
  - 15:00–15:30
  - Applications of NRxx Method in Plasma and Semiconductor
  - Wang, Yani
  - Inst. of Applied Physics & Computational Mathematics
  - Abstract: Asino-Poisson and Wigner equations are fundamental equations in Plasma and Semiconductor, respectively. We focus on numerically solving these two equations using the regularized moment method. Distribution functions are approximated by Hermite polynomial expansion, which is shifted by local macroscopic velocity and scaled by the square root of local temperature. A new regularization method is adopted to get globally hyperbolic moment equations. Numerical simulations demonstrate that NRxx method shows a high efficiency when solving both equations.

**MS-Mo-D-35**

**13:30–15:30**

**Organizer:** Xu, Jin

**Inst. of Software Engineering**

**Liu, Jinjie**

**Delaware State Univ.**

**Abstract:** In order to simulate complicated EM phenomena, such as inhomogeneous medium, curve interface and boundary, complicated BCs, many new techniques need to be developed and old ones be extended, such as DG, Matched Interface and Boundary (MIB) method, high-order algorithms, Method of Moment (MOM), Fast Algorithms, etc. These methods are efficient and powerful in current EM simulations, but there are also many new challenges need to be solve. Therefore, new developments and extensions are needed. Furthermore, in order to use large-scale supercomputers, original algorithms need to be modified and efficient parallel models need to be developed. Combination of above techniques can dramatically improve the capability of electromagnetic simulations. This mini-symposium focuses on these new methods improvements, including high-order methods, algorithm and large-scale computing techniques, which can improve EM simulations dramatically.

- **MS-Mo-D-35-1**
  - 13:30–14:00
  - Rigorous 3D Photolithography Simulation
  - Cui, Tao
  - ICMSEC, AMSS, CAS
  - Chen, Zhiming
  - AMSS, Chinese Acad. of Sci.
  - Abstract: The complexity of modern photolithography makes extensive simulations indispensable. In this talk, based on the parallel adaptive finite element method with DG, an extremely fast time-harmonic finite element solver was developed to simulation of light scattering from DUV/EUV masks. Source transfer domain decomposition method will be used as preconditioner for solving
We consider Frenkel-Kontorova models corresponding to one-periodic media always have either uniform or bipodal structure, in some cases with singularities. We find that large graphs, cousins of exponential random graph models, in which edges and certain other subgraphs have certain densities of edges and/or outward p-stars. Our models are close to the discontinuous electromagnetic waves. We present study on some EM solvers in time domain and frequency domain using different numerical methods. The numerical methods and their parallel models are explained in brief, and comparisons and benchmark results are present next. Furthermore, the difference of these methods in large-scale computing will be emphasized, and some efforts on improving will be present. At last simulation results with different methods will be shown for more understanding of these methods.

Asymptotic limits of discrete structures
Organizer: Yin, Mei
Univ. of Denver
Abstract: This mini-symposium will center on asymptotic limits of various discrete structures and their associated phase transitions from a statistical mechanics perspective. The organizer (who is also the first speaker) will provide an overview of this exciting area of study, elaborate on its broad connections to other areas of mathematics, and suggest new venues for continued research and applications.

In this talk, I will discuss simulations of the benchmark problem arising from shock clustering. The computation of coarsely self-similar flow turbulence can be modeled by Smoluchowski’s dynamics with additive kernel $K(x,y)\times x+y$. Long time numerical integration approach fails for getting the self-similar solutions due to the accumulated errors. In contrast, dynamic renormalization and fixed point algorithms are applied to the results of shortly evolved dynamics, and successfully overcome these difficulties. These methods not only capture the asymptotic behaviour of the exact self-similar solutions, but also approximate the first moments with errors in satisfaction.

A Multilevel Radial-Basis-Function Method for Computer Experiments
Tuo, Rui
Chinese Acad. of Sci.
Abstract: This minisymposium consists of three sessions. Each co-organizer will organize one session. They will address the three aspects of the title: design, modeling, and computations. The focus will be on these problems from the statistical perspective but will also bring in interface with work in applied mathematics on UQ. In design, both space-filling designs and sparse grids are considered. In modeling, both stochastic kriging and generalized polynomial chaos approximation are considered. Comparisons and contrasts between work in applied math and statistics will be emphasized. Computational challenges for high dimensions and big data are the third theme.

Optimization of Nested Latin Hypercube Designs
Xiong, Shiheng
Chinese Acad. of Sci.
Abstract: This paper introduces a multi-layer enhanced stochastic evolution- ary algorithm to improve the space-filling property of nested Latin hypercube designs (NLHDs). The proposed algorithm first considers the sub-designs in the lower layers, and optimizes the NLHD layer by layer. Three basic element-exchanging operations are proposed to search better NLHDs. The whole design always keeps the structure of the NLHD after each operation. Numerical examples indicate that the proposed algorithm is applicable for uncertainty quantification, prediction and optimization problems.
An application to building energy is given. The approach is economical in run size and computationally efficient. With the advent of new data capturing technologies in imaging, the number of input parameters can be large and existing methods for UA and SA become infeasible. We propose a unified framework by using a hierarchical variable selection approach to connect UA and SA with the use of one design. The approach is economical in run size and computationally efficient. An application to building energy is given.

A Unified Framework for Uncertainty and Sensitivity Analysis of Computational Models with Many Input Parameters

Gyu, Li
Georgia Inst. of Tech.
Wu, Jeff
Georgia Inst. of Tech.

Abstract: Uncertainty Analysis (UA) and Sensitivity Analysis (SA) study uncertainties in physical systems. As the system becomes more complex, the number of input parameters can be large and existing methods for UA and SA become infeasible. We propose a unified framework by using a hierarchical variable selection approach to connect UA and SA with the use of one design. The approach is economical in run size and computationally efficient. An application to building energy is given.

MS-Mo-D-38-4 15:00–15:30
Minisymposium on Statistical Inference for Constrained Stochastic Dynamical Systems - Part I of II
For Part 2, see MS-Mo-E-38
Organizer: Rempala, Grzegorz
The Ohio State Univ.
Organizer: Kurtek, Sebastian
The Ohio State Univ.

Abstract: In this paper, we consider the epidemic model estimation problem using classical SIR epidemic model. We utilized maximum posterior estimator based on Bayesian approach for parameter estimation. In addition, when the collected number of infected is smaller than the true number at the early time period among the pandemic, we proposed a method in order to improve model accuracy. We applied proposed method to the H1N1 epidemic in a small area and performed a simple simulation

Stochastic Epidemic Modeling with Early Stage Approximation
Choi, Boseung
Daegu Univ.
Rempala, Grzegorz
The Ohio State Univ.

Abstract: In this paper, we consider the epidemic model estimation problem using classical SIR epidemic model. We utilized maximum posterior estimator based on Bayesian approach for parameter estimation. In addition, when the collected number of infected is smaller than the true number at the early time period among the pandemic, we proposed a method in order to improve model accuracy. We applied proposed method to the H1N1 epidemic in a small area and performed a simple simulation

Network Geometry and Inference in Biochemical Reaction Systems
Casian, Pantea
West Virginia Univ.

Abstract: Identifiability of mass-action reaction networks from experimental data is limited by the fact that distinct networks may give rise to the same ODE system. However, we show that the inherent variability of reaction rate parameters from one experiment to another may be used in conjunction with the geometry of the network to devise an algebraic statistical method for identifying the most likely network structure. This is joint work with G. Rempala and G. Craciun.

Geometric Approach to Pairwise Bayesian Alignment of Functional Data Using Importance Sampling
Kurtek, Sebastian
The Ohio State Univ.

Abstract: We present a Bayesian model for pairwise nonlinear registration of functional data. We utilize the geometry of the space of warping functions to define priors and sample from the posterior using importance sampling. A square-root transformation is used to simplify the geometry of the space of warping functions allowing for computation of sample statistics and efficient posterior inference where multiple modes of the posterior distribution corresponding to multiple plausible registrations are found.

Rate-Invariant Analysis of Trajectories on Riemannian Manifolds
Su, Jingyong
Texas Tech Univ.

Abstract: We investigate statistical analysis of trajectories on Riemannian manifolds that are observed under arbitrary temporal evolutions. We introduce a quantity that provides both a cost function for temporal registration and a proper distance for comparison of trajectories. This distance, in turn, is used to define statistical summaries, such as the mean and covariances of the synchronized trajectories. We will illustrate this framework using several representative manifolds in multiple applications.

Recent advances on inverse scattering problems - Part I of III
For Part 2, see MS-Mo-E-39
For Part 3, see MS-Tu-D-39
Organizer: Liu, Xiaodong
Inst. of Applied Mathematics, Chinese Acad. of Sci.
Organizer: Liu, Hongyu
Hong Kong Baptist University
Organizer: Zhang, Bo
Acad. of Mathematics & Sys. Sci., CAS

Abstract: The minisymposium intends to bring together leading experts working on inverse scattering problems and their applications to discuss recent advances and new challenges in this fascinating field.

Detection and Classification from Electromagnetic Induction Data
Chen, Junqing
Department of Mathematical Sci., Tsinghua Univ.

Abstract: I will introduce an efficient algorithm for identifying conductive objects using induced induction data derived from eddy currents. Our method consists of first extracting geometric features from the induction data and then matching them to precomputed data for known objects from a given dictionary. The matching step relies on fundamental properties of conductive polarization tensors and new invariants introduced in this paper. A new shape identification scheme is introduced and studied.

The Direct and Inverse Scattering Problems with Generalized Oblique Derivative Boundary Condition
Wang, Haibing
Southeast Univ.
Liu, Jiabin
Southeast Univ.

Abstract: Consider the exterior problem for the Helmholtz equation with a generalized oblique derivative boundary condition, which arises in some new scattering problems such as the scattering of tidal waves by islands. Compared with the classical scattering models, the tangential derivative on the obstacle boundary leads to some essential differences such as the symmetric property of the Green function and the reciprocity principle of the scattering data. Both the direct and inverse scattering problems are considered.

An Efficient Finite Element Method for Grating Profile Reconstruction
Zhang, Ruming
Michigan Technological Univ.
Sun, Jiaguang
Michigan Technological Univ.

Abstract: We consider the reconstruction of grating profiles from near-field data. The inverse problem is formulated as an optimization problem with a regularization term. We employ a quasi-Newton method to solve it, for which we devise an efficient finite element method. The stiffness matrix and mass matrix are assembled only once at the beginning of the numerical procedure. Then only minimal changes are made to the mass matrix at each iteration.

Shape Derivatives in Differential Forms with Applications to Acoustic and Electromagnetic Scattering Problems
Li, Jingghi
South Univ. of Sci. & Tech. of China

Abstract: This talk provides a unified approach to computing arbitrary order shape derivatives of domain and boundary integrals in differential forms. Hitherto unknown expressions for shape Hessians can be derived with little effort. We illustrate this powerful machinery by deriving the shape derivatives of solutions to second-order elliptic boundary value problems with different boundary/interface conditions. Moreover, applications to acoustic and electromagnetic scattering problems will also be addressed.

Dynamics Analysis and Intervention of Social Networks
Organizer: Hong, Yiguang
Acad. of Mathematics & Sys. Sci.
Organizer: Hu, Xiaodong
Acad. of Math & Sys. Sci., CAS

Abstract: Social networks and dynamics has attracted interests of wide range from various areas. There are several important and challenging problems about social networks. The evolution of beliefs or opinions is a fundamental problem in the study of social networks. Here we provide a quite genera suf- ficient connectivity conditions for the social network to reach an agreement of dispersed beliefs. Another important issue is to locate the source of diffu-
Understanding dynamics for a pedestrian crowd is of great theoretical and practical significance, in particular for strategy design of emergency interventions. Pedestrian dynamics are extremely important for the purposes of planning and verification of strategies. Active intervention, such as optimal direction of agents, seems to be of great importance in such situations.

In this paper, we investigate a simple intervention scheme of opinion dynamics to reduce the opinion disagreement only by injecting noise within a finite time. A small random injection mechanism is provided by injecting uniformly distributed noise in the opinion dynamics. It is shown that the seemingly useless noises, which also influence the individual opinions randomly, are effective in reducing the opinion difference and increasing the agreement possibility of opinions in the social networks.

**Agreement Seeking of Social Networks: the Influence of Antagonistic Interactions and the Role of Centralized Information**

Ziyang Meng
Technische Universität München, Germany

**Abstract:** The evolution of beliefs or opinions is a fundamental problem in the study of social networks. A basic understanding is that sufficient connectivity of the network will lead to an agreement of dispersed beliefs. In the commonly considered networks, the relationships between different agents are considered to be cooperative and the exchanged information is assumed to be local. However, in certain, or even most of network settings, there are also antagonistic interactions that may affect the belief evolution and centralized information that can be used for agreement seeking. In this talk, we try to understand how antagonistic interactions will influence belief evolution of the social networks and what is the role of centralized information in the classical social network model. In particular, we reveal that both cooperative and antagonistic interactions contribute to belief convergence of cooperative-antagonistic network and strong connectivity, instead of quasi-strong connectivity, is critical.

**Active Intervention of Opinion Dynamics by Noise Injection**

Su Wei
Acad. of Math & Sys. Sci.
Hong Yinguang
Acad. of Mathematics & Sys. Sci.

**Abstract:** This paper investigates a simple intervention scheme of opinion dynamics to reduce the opinion disagreement only by injecting noise within a finite time. A small random injection mechanism is provided by injecting uniformly distributed noise in the opinion dynamics. It is shown that the seemingly useless noises, which also influence the individual opinions randomly, are effective in reducing the opinion difference and increasing the agreement possibility of opinions in the social networks.

**Locating source of diffusion in network for controlling and preventing epidemic risks.** It has been studied under various probabilistic models. In this paper, we study source location from a deterministic point of view by modeling it as the minimum weighted doubly resolving set (DRS) problem, which is a strengthening of the well-known metric dimension problem. We establish q-inn-approximability of the minimum DRS problem on general graphs for both weighted and unweighted versions. This is the first work providing explicit approximation lower and upper bounds for minimum (weighted) DRS problem, which are near-optimality.

**Crowd Dynamics and Optimal Intervention**

Hu Xiaoming
Royal Inst. of Tech.

**Abstract:** Understanding dynamics for a pedestrian crowd is of great theoretical and practical significance, in particular for strategy design of emergency evacuation in public places. However, experiments in genuine escape panic situations are difficult, especially with human beings due to ethical and legal concerns, which indicates that mathematical modeling and analysis of the pedestrian dynamics are extremely important for the purposes of planning and verification. In this presentation, we will report some results using approaches in multi-agent systems and optimal control.

**Evolutions for a Cohesive Interface**

Toader, Rodica
Universita’ degli studi di Udine

**Abstract:** We prove a homogenization result for the energy-functional associated with a purely brittle composite whose microstructure is characterized by soft periodic inclusions embedded in a stiffer matrix. We show that there exists an elementary microscopic arrangement of the two constituents as above that gives rise, in the limit, to homogeneous macroscopic energy-functional of cohesive type.

**MS-Mo-D-41-3**

14:30–15:00

**On Quasistatic Cohesive Fracture Evolution**

Larsen, Christopher
WPI

**Abstract:** We will discuss why proving existence for quasistatic fracture evolution has been elusive, and report on some recent progress with a PhD student, Ying Li. In particular, we will describe how to handle some of the difficulties, some with the help of a technical assumption on the growth of the cohesive energy density.

**MS-Mo-D-41-4**

15:00–15:30

**Full Characterization of Quasistatic $H^1$ Evolutions for a Cohesive Interface Model**

Negri, Matteo
Univ. of Pavia

**Abstract:** We consider the quasistatic evolution of a prescribed cohesive interface: dissipative under loading and elastic under unloading. We provide existence (by energy approximation and time discretization) in terms of parameterized BV solutions w.r.t. the $H^1$ norm. Technically, the evolution is fully characterized by equations: equilibrium, energy balance and Kuhn-Tucker conditions. Catastrophic regimes (jumps) are described by gradient flows of visco-elastic type.

**MS-Mo-D-42**

13:30–15:30

**Real world phenomena explained by microscopic particle models**

Organizer: Renger, Michael
WIAS
Organizer: Patterson, Robert
Weierstrass Inst.

**Abstract:** Many natural phenomena are best understood as emergent effects of underlying microscopic systems. For design and engineering purposes, it is important to know exactly how microscopic properties influence the macroscopic phenomena. Centred around this common theme, problems ranging from ferromagnetism to ecology will be addressed. Methods will be drawn from several areas of mathematics including asymptotic analysis, PDEs and stochastic processes.

**MS-Mo-D-42-1**

13:30–14:00

**Non-equilibrium via Current Reservoirs**

Carinci, Gioia
Univ. of Modena & Reggio Emilia

**Abstract:** Stationary non-equilibrium states are characterized by steady currents flowing through the system. Usually current density is produced by fixing different densities at the boundaries. We instead implement mass transport by introducing current reservoirs producing a given current by injecting particles from the left and removing particles from the rightmost occupied site. We discuss recent results obtained in the study of this topic, whose purpose is to provide a microscopic model for free boundary problems.
**Abstract:** We consider a class of stochastically reacting particle systems for which the empirical process converges to deterministic concentrations with mass-action kinetics. The empirical process of independent copies of the empirical process (the "ensemble process") then converges to the corresponding Liouville transport equation. For both limit passages, we prove dynamic large deviation principles, and discuss how thermodynamic principles, like entropy-driven gradient flows, can be derived from these large deviations.

**MS-Mo-D-42-1 13:30–15:30**

**Existence and Uniqueness on Smoluchowski Coagulation Equations**

Li, Guolong

University of Cambridge

**Abstract:** Smoluchowski coagulation equations are a system of partial differential equations that describes the behaviour of a cluster of diffusing particles which coagulate together after colliding. We will construct an iteration scheme to show the well-posedness of these equations under certain physical reasonable conditions.

**MS-Mo-D-43 13:30–15:30**

**Stochastic Equilibrium Problems: Economic Modeling, Analysis and Computation**

Organizer: Su, Che-Lin

University of Chicago

**Abstract:** Motivated by empirical demand estimation problems in economics, the objective of this mini-symposium is to discuss and address both theoretical and numerical challenges of stochastic equilibrium problems, arisen from estimation and pricing of pure characteristics demand models. The four presentations aim to first provide an overview of stochastic equilibrium problems and their economic applications, to discuss a regularization method for analyzng and solving stochastic equilibrium problems, to examine the analysis of sample average approximation for a pricing problem formulated as a stochastic equilibrium problem, and finally, to present alternative formulations for studying estimation and pricing problems.

**MS-Mo-D-43-1 13:30–14:00**

**Regularized Mathematical Programs with Stochastic Equilibrium Constraints: Estimating Structural Demand Models**

Chen, Xiaojun

Department of Applied Mathematics, The Hong Kong Polytechnic University

**Abstract:** The article considers a particular class of optimization problems involving set-valued stochastic equilibrium constraints. We develop a solution procedure that relies on an approximation scheme for the equilibrium constraints. Based on regularization, we replace the approximated equilibrium constraints by those involving only single-valued Lipschitz continuous functions. In addition, sampling has the further effect of replacing the 'simplified' equilibrium constraints by more manageable ones obtained by implicitly discretizing the (given) probability measure so as to render the problem computationally tractable. Convergence is obtained by relying, in particular, on the graphical convergence of the approximated equilibrium constraints. The problem of estimating the characteristics of a demand model, a widely studied problem in micro-econometrics, serves both as motivation and illustration of the regularization and sampling procedure.

**MS-Mo-D-43-2 14:00–14:30**

**Sample Average Approximation Regularized Method for Products Pricing Problem Based on Pure Characteristics Demand Models**

Hailin, Sun

Department of Applied Mathematics, The Hong Kong Polytechnic University

**Abstract:** Utility-based choice models are often used to determine a consumer’s purchase decision among a list of available products. By a pure characteristics model, we consider a firm’s multi-product pricing problem. A sample average approximation (SAA) method is used to approximate the expected market share of products considered and the firm’s profit. We then apply a regularized method to compute a solution of the SAA problem and study the convergence of the SAA solutions.

**MS-Mo-D-43-3 14:30–15:00**

**Topics in Computing Nash Equilibria**

Pang, Jong-Shi

University of Southern California

**Abstract:** This talk presents results on two topics pertaining to the computation of Nash equilibria in non-cooperative games. These are: (a) equilibrium constrained optimization, and (b) games with minmax players. The former topic is treated more broadly under the framework of variational-inequality constrained hemivariational inequality. Interestingly, a particular pull-out approach for solving the latter class of games can be applied to a sampled version of games with stochastic recourse functions.

**MS-Mo-D-43-4 15:00–15:30**

**A Constructive Approach to Estimating Pure Characteristics Demand Models with Pricing**

Su, Che-Lin

University of Chicago

**Abstract:** We consider estimating pure characteristics demand models. The main difficulty in solving this problem is that market share equations are nonsmooth. To overcome this difficulty, we first characterize consumers’ purchase decisions by a system of complementarity constraints. This new characterization leads to smooth approximated market share equations and allows us to cast the estimation problem as a mathematical program with complementarity constraints. We present numerical results to demonstrate the computational effectiveness of our approach.

**MS-Mo-D-44 13:30–15:30**

**Nonsmooth Numerics via Piecewise Linearization**

Organizer: Gnewuch, Andreas

Humboldt University

**Abstract:** Most nonsmooth problems are piecewise smooth. Then they have a piecewise linear approximation. We consider the results of successive piecewise linearization applied to various computational tasks, in particular equation solving, (un)constrained optimization and the numerical integration of Lipschitzian dynamical systems.

**MS-Mo-D-44-1 13:30–14:00**

**On Exact Solution of Piecewise Linear ODEs and Use for General Lipschitz ODEs**

Kabidoldanova, Assem

al-Farabi Kazakh National University

Griewank, Andreas

Humboldt University

**Abstract:** Piecewise linear dynamical systems can be solved up to working accuracy as a sequence of linear systems. In each open polyhedron the solution is defined by the relevant Jacobian and the initial point, which is typically on the boundary. We compute the explicit solutions in the open polyhedron and glue them together at the boundaries between the polyhedrons. Piecewise linear systems with smooth forcing can be solved as the sequence of inhomogeneous linear systems.

**MS-Mo-D-44-2 14:00–14:30**

**Evaluating Sensitivities for Dynamic Systems via Piecewise Linearization**

Khan, Kamal

Argonne National Laboratory

**Abstract:** This presentation combines recent theoretical developments in non-smooth dynamic sensitivity analysis with new integration methods involving piecewise linearization, to evaluate directional derivatives and Lie-derivatives for non-smooth dynamical systems. The developed methods are illustrated by application to various systems involving collisions and shape boundaries.

**MS-Mo-D-44-3 14:30–15:00**

**Solution of Piecewise Linear Equations**

Monson, Todd

Argonne National Laboratory

Bosse, Torsten

Argonne National Laboratory

**Abstract:** Piecewise linear systems of equations arise as approximations of nonsmooth functions and are derived by a minor modification of techniques from Algorithmic differentiation. The resulting models contain local information about the nonsmoothness of the original function and can be used within nonlinear equation solving and optimization algorithms. Within this talk we will provide an overview on several approaches to solve piecewise linear equations and their connection with other existing methods.

**MS-Mo-D-44-4 15:00–15:30**

**An Optimization Method for Lipschitzian Piecewise Smooth Minimization**

Chen, Xiaojun

Department of Applied Mathematics, The Hong Kong Polytechnic University

**Abstract:** We consider estimating pure characteristics demand models. The main difficulty in solving this problem is that market share equations are nonsmooth. To overcome this difficulty, we first characterize consumers’ purchase decisions by a system of complementarity constraints. This new characterization leads to smooth approximated market share equations and allows us to cast the estimation problem as a mathematical program with complementarity constraints. We present numerical results to demonstrate the computational effectiveness of our approach.
New Effective Differential Nullstellensatz

Jeronimo, and Solern

Abstract:

This is based on joint work with Xing Gao, Li Guo, and Shanghua Zheng.

The results are applied to a class of algebras known as Rota-Baxter Type al-

proved some general results on confluence, termination and convergence.

We introduce a class of term-rewriting systems on free modules and

ware such as the RegularChains library (see http://www.regularchains.org)

polynomial system decomposition by means of characteristic sets.

Moreover, three other sessions of ICMS 2014 had talks on this subject of

session but were not able to do so at that time or in that location.

About another 30 researchers had expressed interest in participating to this

Decomposition˙Session.html

Abstract:

Organizer: Chen, Changbo

Chinese Acad. of Sci.

Organizer: Moreno Maza, Marc

The Univ. of Western Ontario

Organizer: Moreno Maza, Marc

Chinese Acad. of Sci.

Abstract:
The Characteristic Set Method of Wen Tsun Wu has freed Ritt's decom-

position from polynomial factorization, opening the door to a variety of
discoveries in polynomial system solving. In the past three decades the work
of Wu has been extended to more powerful decomposition algorithms and ap-
plications to different types of polynomial systems or decompositions: differential
systems, difference systems, real parametric systems, primary decompo-
sition, cylindrical algebraic decomposition. Today, triangular decomposi-
tion algorithms provide back-ends for computer algebra system front-end solver-
s, such as Maple’s solve command and have been applied in various areas
both in the academia and in the industry.

In this proposed workshop, we hope to gather researchers who have applied
and extended the works of Joseph Fels Ritt and Wen Tsun Wu. Our goals are,
first, to disseminate the techniques and software tools which have been de-
veloped by this vibrant community and, second, to stimulate further devel-
opments and applications of polynomial system decomposition by means of
characteristic sets.

At the International Congress on Mathematical Software (ICMS 2014), a
satellite conference of the International Congress on Mathematics, in Seoul
(South Korea), a session on the same topics as the proposed one had gathered 9 talks, see http://www.ced.uvo.ca/~moreno/ICMS_Triangular

Decomposition_Session.html

About another 30 researchers had expressed interest in participating to this
session but were not able to do so at that time or in that location.
Moreover, three other sessions of ICMS 2014 had talks on this subject of
polynomial system decomposition by means of characteristic sets.

In a sum, the proposed workshop for ICIAM 2015 is expected to be well at-
tended to and generate new interactions. At the same time, the available soft-
ware such as the RegularChains library (see http://www.regularchains.org)
will support software demonstration of the applications of the Characteristic
Set Method.

Organizer: Shi, Cong

Univ. of Vienna

Organizer: Ammari, Habib

Ecole Normale Superieure

Abstract: Quantitative photoacoustic tomography is an emerging imaging

method that visualizes biological material parameters. In a typical PAT
session, the object is exposed to a short pulse of an electromagnetic wave. The object absorbs
a fraction of the induced energy, heats up, and reacts with thermoelastic expan-
sion. This in turn produces acoustic waves, which can be recorded outside the
specimen. The mathematical formulation of PAT is an inverse problem related
to the wave equation - to reconstruct the source term of the wave equation
from measurements of the acoustic wave. PAT combines the high resolution
of ultrasound waves and high contrast of EM waves.

The classical mathematical models of PAT ignore the attenuation effects and
dispersion within the object, which leads to inaccurate images. There are two
main challenges in the topic: one is to model the attenuation effect mathe-
matically, the other is to compensate for the effect in image reconstruction.
To correctly model the attenuation effect in a given media, we need to investi-
gate the relation between attenuation, dispersion, and causality. It is known
that attenuation and dispersion are connected by the Kramers-Kronig rela-
tion. Several attenuation models are documented in the literature, and most
of them are derived from power laws. On the other hand, the research on
compensation for the attenuation effect has only begun recently, and much
remains to be done on both of the problems. This minisyposium focuses on
recent advances in this field.

Bayesian Approach to Image Reconstruction in Quantitative Photoacoustic

Tomography

Tarvainen, Tanja

Univ. of Eastern Finland

Abstract: Quantitative photoacoustic tomography is an emerging imaging
technique aiming at estimating quantitative values of optical parameters insid-
e tissues from photoacoustic images which are formed by combining optical
information and ultrasound propagation. This is an ill-posed problem and it
needs to be approached within the framework of inverse problems. In this
work, the image reconstruction problem of quantitative photoacoustic tomog-
raphy is considered in a Bayesian framework.

Asymptotic Techniques for Photoacoustic Imaging in Attenuating Media

Kalmieri, Konstantinos

RICAM

Abstract: We present some of the existing models, taking into account a-
coustic attenuation under the different physical properties of the biological
issue. A family of time reversal imaging functionals is presented, based on
the techniques are based on recently proposed ideas of Ammari et al for the
thermo-viscous wave equation. In particular, an asymptotic analysis provides
reconstruction functionalities from first order corrections for the attenuating ef-
A Stable Algorithm for Attenuation Correction in Photo-acoustic Imaging

Wahab, Abdul
COMSATS Inst. of Information Tech.

Abstract: In this talk, a brief description of the time reversal algorithms in attenuating media is provided. Considering simple attenuated wave models, two algorithms are discussed. First an adjoint wave time reversal algorithm is established wherein the adjoint lossy wave is re-emitted into the medium. However, since the adjoint lossy wave is explosive in nature, indeed due to the exponentially growing nature of back-propagating waves with frequency, a regularization using frequency suppression of the attenuation maps is expected due to sampling noise. We close with numerical examples demonstrating the efficiency of NOWPAC.

On Time Reversal in Photoacoustic Tomography for Tissue Similar to Water

Kowar, Richard
Univ. of Innsbruck

Abstract: This talk is concerned with time reversal in photoacoustic tomography (PAT) of dissipative media that are similar to water. We consider an approach based on the non-causal thermo-viscous wave equation and another based on the dissipative wave equation of Nachman, Smith and Waag.

Analytical and algorithmic advances in the immersed boundary method - Part I of II

For Part 2, see MS-Mo-E-47

Organizer: Stockie, John
Simon Fraser Univ.

Overview of the Immersed Boundary Method and Recent Developments in Algorithms, Analysis and Applications

Stockie, John
Simon Fraser Univ.

Abstract: This talk will begin with an overview of the immersed boundary method for solving complex fluid-structure interaction problems, including recent developments in algorithms and model extensions that handle a much wider class of applications. I will then describe a novel computational approach based on a pseudo-compressible fluid solver that yields a simple and efficient parallel implementation. The capabilities of the method are illustrated with applications including spherical membranes, flexible particle suspensions and jellyfish swimming dynamics.

An Immersed Boundary Method for Rigid Bodies

Bhalla, Amneet Pal Singh
Univ. of North Carolina - Chapel Hill

Griffith, Boyce
Univ. of North Carolina at Chapel Hill

Donev, Aleksandar
Courant Inst. of Mathematical Sci., New York Univ.

Abstract: In this work we develop an IB method that exactly enforces rigidity constraint for immersed solid bodies by solving a linear system coupling a standard semi-implicit discretization of the fluid equations with a rigidity constraint. An effective preconditioned iterative solver that combines an approximate multigrid solver for the fluid problem with an approximate direct solver for the Schur complement system is developed which works for both zero and moderate Reynolds number flows.

An Immersed Boundary Method for Mass Transfer Across Permeable Moving Interfaces

Huang, Huaxiong
York Univ.

Abstract: We present an immersed boundary method for mass transfer across permeable deformable moving interfaces interacting with the surrounding fluids. One of the key features of our method is the introduction of the mass flux as an independent variable, governed by a non-standard vector transport equation.

Interactions of Micro-organisms Near A Wall in Stokes Flow Using A Regularized Image System

Huang, Jianjun
Worcester Polytechnic Inst.

Olson, Sarah
WPI

Abstract: We present an extension of the regularized image system for Stokeslets, where regularization functions and parameters are chosen to satisfy zero flow at the wall for several different fundamental solutions. Interactions of different representative microorganisms near a wall are studied. Sperm and bacteria flagella are described by a version of the Kirchhoff rod model, where intrinsic curvature and twist are prescribed. Results are presented for swimming speeds and attraction to a wall.
In this talk, I will use the shortest path problem, finding the shortest path problems, and proves the local convergence. Numerical analysis shows the action can measure how far from one path to MEP method can then be applied in the ASS to speed up the computation. Optimization is based on joint work with Shui-Nee Chow (Math, Georgia Tech), Yanzi Li (Math, Georgia Tech), Jun Lu (Wells Fargo).

## MS-Mo-D-49-1
**13:30–14:00**

### Metastability, Spectra and Eigencurrents of Networks Representing Energy Landscapes
**Cameron, Maria**
Univ. of Maryland

Abstract: Computational tools for spectral analysis of large stochastic networks representing energy landscapes of atomic and molecular clusters are proposed: (i) an efficient algorithm for computing zero-temperature asymptotics for eigenvalues and eigenvectors of the generator matrices, and (ii) a continuation technique for computing selected eigenpairs of interest at finite temperatures and corresponding eigencurrents. Applications to Wales group’s networks representing Lennard-Jones clusters of 38 and 75 atoms whose energy landscapes have double-funnel structures will be presented.

## MS-Mo-D-49-2
**14:00–14:30**

### An Adaptive Step-size String Method and Its Convergence to the Minimum Energy Path
**Zhang, Lei**
Peking Univ.

Abstract: Finding minimum energy path (MEP) on a potential energy surface is of great interest in understanding the barrier-crossing events. We develop an adaptive step-size string (ASS) method by treating classical string method as a minimization process of the Friedlin-Wentzell functional. Optimization method can then be applied in the ASS to speed up the computation. Numerical analysis shows the action can measure how far from one path to MEP and proves the local convergence.

## MS-Mo-D-49-3
**14:30–15:00**

### Evolving Junctions on Obstacle Boundaries (E-JOB) Method for the Shortest Path Problems
**Zhou, Haomin**
Georgia Inst. of Tech.

Abstract: In this talk, I will use the shortest path problem, finding the shortest path connecting two points while avoiding obstacles in a region, as an example to illustrate how one can use stochastic differential equations (SDEs) to solve some challenging real world problems. On the other hand, the algorithm introduces new, but challenging, mathematical problems in dynamical systems and PDEs that have not been studied in the past. This presentation is based on joint work with Shui-Nee Chow (Math, Georgia Tech), Yanzi Diao-Mercado (ECE, Georgia Tech), Magnus Egerstedt (ECE, Georgia Tech), Wuchen Li (Math, Georgia Tech) and Jun Lu (Wells Fargo).

## MS-Mo-D-49-4
**15:00–15:30**

### The String Method for Saddle Point Search
**REN, WEIQING**
National Univ. of Singapore & IPIC

Abstract: In this talk, we show how the string method, which was originally developed to compute minimum energy paths between two meta-stable states, can be used to compute saddle points for a given potential of the free energy. These saddle points act as bottlenecks (i.e. transition states) for barrier-crossing events. Application to the wetting transition on patterned surfaces will be presented.

## MS-Mo-D-50
**13:30–15:30**

### Mathematics for Industry 1: Analytical, geometrical and statistical methods to solids, fluids and plasmas
**Organizer: Fukumoto, Yasuhide**
Inst. of Mathematics for Industry, Kyushu Univ.

Abstract: Mathematics for Industry (MI) has been born by amalgamating and developing future technologies. Institute of Mathematics for Industry (IMI), Kyushu University, was founded in 2011 to develop MI, including fundamental research. This minisymposium starts with introduction of IMI’s activities. Mathematics finds its effective applications in manufacturing industry and global environmental problems. The symposium is followed by outstanding examples: modeling of interfacial phenomena of complex fluids, novel minimal surfaces, with their distinctive properties, of a solid body, and advanced statistical approach to predict magnetic storms caused by solar flares.
new models, coming from the game theory have been introduced. This talk will give an introduction to such models.

**MS-Mo-D-51-2**

**Analysis and Control of Epidemic Models with Information Dependent Vaccination**

Buonomo, Bruno

Univ. of Naples Federico II

Abstract: In recent years, there have been significant developments in the field of mathematical theory of the spread of infectious diseases. These developments concern the so called behavioral-epidemic models. Such models include feedbacks that the information and rumours about the spread of an infectious disease have on the spreading itself. In this talk, we will focus on the analysis and control of some behavioral-epidemic models. In particular, we will deal with the effects of information feedbacks.

**MS-Mo-D-51-3**

**Mean Field Games Equilibrium in A SIR Vaccination Model**

Laguzet, Laetitia

Univ. Paris-Dauphine

Abstract: Recent debates concerning the innocuity of vaccines with respect to the risk of the epidemic itself lead to vaccination campaign failures. We analyze, in a SIR model, whether individuals driven by self interest can reach an equilibrium with the society. We show, in a Mean Field Games context, that an equilibrium exists and discuss the price of anarchy. Finally, we apply the theory to the 2009-2010 Influenza A (H1N1) vaccination campaign in France.

**MS-Mo-D-51-4**

**Dual Dilemma of Vaccination**

Fu, Feng

ETH Zurich

Abstract: Massive vaccination is beneficial on the population level to suppress the overall epidemic prevalence, but in the mean time, the presence of high vaccination level intensifies the selective pressure favoring the emergence of vaccine-resistant pathogen strains. This gives rise to the notion of “dual dilemma of vaccination”. Here we address this problem with a combined game theory and an evolutionary epidemiological model.

**MS-Mo-D-52**

**Mathematics in population genetics and evolution - Part I of II**

For Part 2, see MS-Mo-E-52

Organizer: Yang, Zheng

Univ. of North Carolina

Organizer: Ma, Zhiming

AMSS, CAS

Abstract: Population genetics provides mechanistic interpretations of Charles Darwin’s theory of evolution by natural selection. It is a discipline in the life sciences that has a strong interplay with statistics, computer science and applied mathematics, founded by R.A. Fisher, S. Wright, and J. B. S. Haldane. It is essential both for understanding biological evolution and for interpreting the ever-increasing genomic datasets, and has thus gained momentum in the last few decades because of the rapid accumulation of genetic data, driven by the various genome projects. This symposium will focus on probabilistic modeling and statistical analysis of modern genetic and genomic data, and the statistical and computational challenges that we face. The symposium will provide a forum for statisticians and computer scientists interested in this exciting field of biology to exchange ideas and experiences with evolutionary biologists, and to discuss various problems at the cutting edge of the field.

**MS-Mo-D-52-1**

**The Multiples Species Coalescent Model and Its Applications in Analysis of Genomic Sequence Data**

Yang, Zheng

Univ. College London

Abstract: The multiple species model is a natural extension of the single-population coalescent to the case of multiple species. It accounts for the polymorphism and coalescent within each population as well as the phylogenetic relationships among the species. It provides a natural framework for the analysis of genomic sequence data to address a number of important questions in evolutionary biology, such as estimation of population sizes and species divergence times, species tree estimation, and species delimitation. Computation is achieved using Bayesian Markov chain Monte Carlo (MCMC) algorithms. In this talk, we will provide an overview of the multispecies coalescent model and discuss its many applications.

**MS-Mo-D-52-2**

**Bayesian Species Delimitation Using DNA Sequences**

Rannala, Bruce

Univ. of California Davis

Abstract: A Bayesian inference method for joint species delimitation and species tree estimation using multilocus sequence data under the multi-species coalescent model is described. It eliminates the need for a user-specified guide tree. Computation is achieved through MCMC which moves between different species trees and MCMC which moves between different delimitation models. The method is found to have good statistical properties. Real datasets are often found to be informative about delimitation but not about phylogeny.

**MS-Mo-D-52-3**

**Voodoo or Real Inference? ABC Meets Machine Learning**

Corander, Jukka

Univ. of Helsinki

Abstract: We consider machine learning techniques for significantly accelerating simulator-based approximate inference. The first strategy introduces classification for discrimination between representative and poor simulated data sets, such that consistent estimators can be obtained. The second strategy uses Bayesian optimization to guide a search in the parameter space, which can result in several orders of magnitude faster convergence to a point estimate. We illustrate both concepts using several types of dynamic models involving genetic data.

**MS-Mo-D-52-4**

**Stochastic Modeling and Analysis of DNA Sequence Data from Follicular Lymphoma**

Wu, Carstens

Univ. of Copenhagen

Abstract: In this talk I present a coalescent model with stochastic population size, growing from a single individual/cell in the past to a random number of individuals at the present time. The model is based on a birth-death process. The model will be applied to samples of DNA sequences from Follicular Lymphoma, a cancer disease, with the aim of estimating the time of origin of the disease.

**MS-Mo-D-53**

**Challenges in Financial Modelling: Numerics, Statistics, and Calibration**

Li, Bin

Univ. of Waterloo

Abstract: We consider a financial market with a risk-free asset and a risky asset, with the latter’s price following a diffusion with stochastic volatility. Under the robust time-consistent dynamic utility introduced by Bion-Nadal and Delbaen, utilizing time-consistency and g-expectation, a closed-form optimal strategy is obtained for the incomplete market with either full uncertainty or partial uncertainty. The convergence of the associated optimal strategy is also proved when the market is approaching from partial uncertainty to full uncertainty.

**MS-Mo-D-53-1**

**Robust Time-consistent Dynamic Utility Maximization under Stochastic Volatility**

Alban, Vincius

Univ. of Vienna

Abstract: We adapt Dupire’s local volatility model to price European options on commodity futures, applying Tikhonov regularization to the corresponding calibration problem, under a discrete setting. We also present two simplifications. The first one is a parametric local volatility surface. In the second one, we make use of the Bayes theorem to find a simplified pricing technique, reducing the dimension of the inverse problem. We perform numerical tests with synthetic as well as market data.

**MS-Mo-D-53-2**

**Local Volatility Calibration in Commodity Markets and Practical Simplifications**

Zubelli, Jorge

IMPA

Abstract: We adapt Dupire’s local volatility model to price European options on commodity futures, applying Tikhonov regularization to the corresponding calibration problem, under a discrete setting. We also present two simplifications. The first one is a parametric local volatility surface. In the second one, we make use of the Bayes theorem to find a simplified pricing technique, reducing the dimension of the inverse problem. We perform numerical tests with synthetic as well as market data.
Abstract: We shall start with a brief overview of the importance of calibration methods in mathematical finance in general and risk management in particular. After that we shall focus on the problem of recovering the local volatility (not the implied one) from observed market prices. Here we shall compare competing approaches to handle such problem, including iterative methods and state space methods. This will set the stage for the other talks in this mini-symposium.

**MS-Mo-D-53-4**

**15:00–15:30**

**Data Completion**

Ascher, Uri

Univ. of British Columbia

Abstract: The lagged steepest descent (LSD) method for convex quadratics challenges basic notions in PDE discretization and general orderly convergence. It is chaotic; it occasionally takes steps that cannot be too small, and its convergence rate remains unproved. More in the talk.

**MS-Mo-D-54**

13:30–15:30

VPH-2

Minisymposium Computational Finance - Part I of III

For Part 2, see **MS-Mo-E-54**

For Part 3, see **MS-Tu-D-54**

Organizer: Teng, Long

Bergische Universität Wuppertal

Organizer: Guenther, Michael

Bergische Universität Wuppertal

Organizer: Ehrhardt, Matthias

Univ. of Wuppertal

Abstract: In recent years the variety and complexity of financial mathematics models has witnessed a tremendous growth. For the resulting computational complexity, advanced numerical techniques are imperative for the applications in financial industry. The aim is to deepen understand complex financial models and to develop effective and robust numerical schemes for solving linear and nonlinear problems arising from the mathematical theory of pricing financial derivatives and related financial products. The motivation for this minisymposium is to exchange and discuss current insights and ideas, and to lay groundwork for future collaborations. Finally, it should serve as a kickoff for the special interest group (SIG) Computational Finance within ECM (European Consortium for Mathematics in Industry).

**MS-Mo-D-54-1**

13:30–14:00

Rare Event Simulation Using Reversible Shaking Transformations

LIU, GANG

École Polytechnique

Gobet, Emmanuel

École Polytechnique

Abstract: We introduce random transformations called reversible shaking transformations which are used to design two schemes for estimating rare event probability. One is based on interacting particle systems (IPS) and the other on time-average on a single path (POP) using ergodic theorem. We discuss their convergence rates and provide numerical experiments including continuous stochastic processes and jump processes. Both schemes have good performance with a seemingly better one for POP.

**MS-Mo-D-54-2**

14:00–14:30

High-order Compact Finite Difference Methods for Parabolic Problems with Mixed Derivative Terms and Applications in Computational Finance

During, Bertram

Univ. of Sussex

Abstract: We present a high-order compact finite difference approach to parabolic partial differential equations with mixed second-order derivative terms and space-dependent coefficients in arbitrary spatial dimension. Problems of this type arise frequently in computational fluid dynamics and computational finance. We give some results on the stability of the scheme and present numerical examples for pricing of European basket options. Analytical and numerical results suggest unconditional stability of the scheme.

**MS-Mo-D-54-3**

14:30–15:00

ADEX Methods - Numerical Analysis and Application to Linear and Nonlinear Black-Scholes Models

Buckova, Zuzana

Bergische Universität Wuppertal

Ehrhardt, Matthias

Univ. of Wuppertal

Guenther, Michael

Bergische Universität Wuppertal

Abstract: We are dealing with numerical methods for linear and nonlinear Black-Scholes model. We apply finite difference method, esp. Alternating direction explicit methods (ADEX), which were suggested in 1957 by Saul'ev. Our work includes detailed numerical analysis consisting of stability and consistency proofs.

Numerical results of the ADEX method for nonlinear Black-Scholes models, where the nonlinearity is caused by illiquid markets, are provided.

We compare our method to alternative numerical approaches for solving the nonlinear Black-Scholes.

**MS-Mo-D-54-4**

15:00–15:30

An Accurate Simulation-based Approach to the Dynamic Portfolio Management Problem

Cong, Fei

TU Delft

Oosterlee, Cornelis

CWI-center for mathematics & computer Sci.

Abstract: We enhance a well-known dynamic portfolio management algorithm, the BGGS algorithm, proposed by Brandt, Goyal, Santa-Clara and Stroud (Review of Financial Studies, 18, 831-873, 2005). We equip this algorithm with the components from a recently developed method, the Stochastic Grid Bundling Method, for calculating conditional expectations. When solving the first-order conditions for an optimum, we implement a Taylor series expansion based on a nonlinear decomposition to approximate the utility functions.

**MS-Mo-D-55**

13:30–15:30

Multi-Physical modeling and multi-scale methods for nano-optics

Organizer: Liu, Di

Michigan State Univ.

Abstract: The main objective of the proposed minisymposium is update recent progress on robust, efficient and accurate numerical methods for multiphysical models of nanoscale optical devices that are able to bridge multiple time and space scales. Application will be focused on photon driven nano devices and attosecond pulse physics.

**MS-Mo-D-55-1**

13:30–14:00

A Multiscale Method for Study of Metal-enhanced Fluorescence

Cui, Tao

ICMSEC, AMSS, CAS

Zhang, Hai

ENS, Paris

Abstract: We first introduce some background of super-resolution. We then focus on the particular super-resolution technique where resonant media are used. Two cases are analyzed: one is Heilmoltz resonators and the other is high contrast material. In both cases, we developed rigorous mathematical theory to explain the mechanism of super-resolution achieved.

**MS-Mo-D-55-2**

14:00–14:30

Mathematics of Super-resolution in Resonant Media

Bao, Gang

Zhejiang Univ.

Hu, Guanghui

Univ. of Macau

Liu, Di

Michigan State Univ.

Abstract: The spurious oscillation of the total energy can be observed when using finite element methods to simulate the translational and/or rotational move of an electronic structure. Such oscillation can negatively affect the calculation of the ion force acting on the nucleus. We will present the results of using adaptive finite element methods to keep the translational invariance of the total energy, and related applications on geometry relaxation of molecules with Born-Oppenheimer molecular dynamics.

**MS-Mo-D-55-4**

15:00–15:30

A Maxwell-Ehrenfest Model for Optical Responses of Nano-structures

Luo, Songting

Iowa State Univ.

Organizer: Rotundo, Nella

Weierstrass Inst.

Organizer: Schilders, Wil

TU Eindhoven

Abstract: The mathematical modeling of semiconductor devices plays a fundamental role both in studying the effects of decreasing the dimension of the devices with respect to their efficiency and in pushing forward the research on new materials as well as improving the behavior and efficiency of well-known materials. On the one hand, mathematical modeling should be investigated and validated from the analytical point of view. On the other hand, numerical simulations are becoming a fundamental tool to validate the models and re-
duc the time of the design creation. This minisymposium aims at providing a vision on recent advances on semiconductor theory and simulations and to encourage the communication between experts in fields of applied analysis and numerics of aspects of semiconductor theory.

**MS-Mo-D-56-1** 13:30–14:00

*Generalisations of the Scharfetter-Gummel Scheme to Non-Boltzmann Statistics*

Farrell, Patricio  
Weierstrass Inst. (WIAS)

**Abstract:** We discuss how the Scharfetter-Gummel scheme can be adapted to more complicated distribution functions (in particular to non-Boltzmann statistics). Our main goal is to discretely preserve important properties from the continuous system such as existence and uniqueness of the solution, consistency with the thermodynamical equilibrium and unconditional stability. We also show how these numerical methods can be efficiently implemented for 2D and 3D applications.

**MS-Mo-D-56-2** 14:00–14:30

*Analytical Methods for Doping Optimization for Semiconductor Devices*

Rotundo, Nella  
Weierstrass Inst.

**Abstract:** We present an optimal design problem for semiconductor devices. We consider the van Roosbroeck’s system of equations which comprises different kinds of generation and recombination terms. It includes radiative, spontaneous and stimulated recombinations. The optimal doping problem can be seen as a PDE-constrained optimization problem in which we minimize an objective functional depending upon the electron and hole densities, the electrostatic potential and the doping profile. We discuss the case where the doping profile serves as the control.

**MS-Mo-D-56-3** 14:30–15:00

*Analysis for Edge-emitting Semiconductor Heterostructures*

Thomas, Marita  
Weierstrass Inst. for Applied Analysis & Stochastics (WIAS Berlin)

**Abstract:** This contribution discusses results on the existence of local-in-time classical solutions for edge-emitting semiconductor heterostructures both in 2D and 3D. Electrics of the semiconductor is governed by the Poisson equation for the electrostatic potential and a system of drift-diffusion equations for the carrier transport, nonlinearly coupled with the equations of optics, given by a Helmholtz-type eigenvalue problem and an ODE for the photon balance. 2D-simulations based on this coupled system will be presented.

**MS-Mo-D-56-4** 15:00–15:30

*Numerical Methods for the Simulation of Semiconductor Devices*

Schilders, Wil  
TU Eindhoven

**Abstract:** In this talk, an overview will be given of numerical methods that have been developed specifically for the simulation of semiconductor devices. Special methods for the discretization and nonlinear solution will be discussed, and it will be shown why standard methods fail. The methods developed can be formulated in an abstract mathematical way. The methodology can also be used for organic devices like OLEDs.

**MS-Mo-D-57** 13:30–15:35 402A

**Recent advances in modeling, analysis, and methodology for interface and free boundary problems and applications - Part I of V**

For Part 2, see MS-Mo-E-57  
For Part 3, see MS-We-D-26  
For Part 4, see MS-We-E-26  
For Part 5, see MS-Th-BC-26

**Organizer:** Li, ZhiLin  
North Carolina State Univ.

**Organizer:** Lai, Ming-Chih  
National Chiao Tung Univ.

**Abstract:** In recent years, there is increasing interest in the development and application of advanced computational techniques for interface problem-s, problem with free boundary and moving interface, fluid-structure interactions driven by applications in biology, fluid mechanics, material sciences, porous media flow, and biology. There are also many numerical approaches developed in recent years. The aim of this mini-symposium is to bring together scientists in the field to exchange their recent research discoveries and future directions, to stimulate novel ideas, and to nurture collaborations. The focus would be on Cartesian grid method such as the immersed boundary/interfacet methods, the level set methods, fluid-structure interactions, and applications.

**MS-Mo-D-57-1** 13:30–13:55

*A Treecode-Accelerated Boundary Integral Poisson-Boltzmann Solver for Solvated Proteins*

Krasny, Robert  
Univ. of Michigan

Geng, Weihua  
Southern Methodist Univ.

**Abstract:** We present a treecode-accelerated boundary integral (TABI) solver for electrostatics of solvated proteins described by the linear Poisson-Boltzmann equation. We compare TABI results with those obtained using the grid-based APBS code. The TABI solver exhibits good serial and parallel performance combined with relatively simple implementation, efficient memory usage, and geometric adaptability.

**MS-Mo-D-57-2** 13:55–14:20

*Simple Eulerian Methods for Compressible Fluids in Domains with Moving Boundaries*

Alina, Chertock  
North Carolina State Univ.

**Abstract:** We introduce a simple Eulerian method for treatment of moving boundaries in compressible fluid computations. The fluid domain is placed in a computational domain, which is divided into internal, boundary, and external cells. The numerical solution is evolved in internal cells only. The numerical fluxes at other cells are computed using a ghost-cell extrapolation and an interpolation in the phase space. The computational framework may be used in conjunction with one’s favorite finite-volume method.

**MS-Mo-D-57-3** 14:20–14:45

*A Weak Formulation for Solving Elliptic and Elasticity Interface Problems*

Hou, Songming  
Louisiana Tech Univ.

**Abstract:** Interface problems occur in many multi-physics and multi-phase applications in science and engineering. An accurate and efficient method is desired. We proposed a non-traditional finite element method for solving elliptic and elasticity interface problems using non-body-fitted mesh. Some theoretical discussions and numerical studies are presented in both 2D and 3D.

**MS-Mo-D-57-4** 14:45–15:10

*Mathematical Modeling and Computational Methods for the Tumor Microenvironment*

Dillon, Robert  
Washington State Univ.

**Abstract:** We describe a hybrid/cells-based model for the emergence of ductal carcinoma in situ and the transition to invasive ductal carcinoma both in vivo and in microfluidic cell-culture devices. We present preliminary results using simplified models of metabolism as well as the cellular response and production of diffusible growth factors such as TGF-beta. In this model, the cells are represented as discrete entities in which the fluid mechanical component is represented in an immersed boundary framework, the transport of ions and proteins by an immersed interface methods, coupled with systems of ODEs for the intracellular processes.

**MS-Mo-D-57-5** 15:10–15:35

*A Numerical Method for A Quasi-incompressible Variable Density Phase-field Model with A Discrete Energy Law*

Lin, Ping  
Univ. of Dundee

**Abstract:** We consider two-phase flows with variable densities. The Quasi-Incompressible NSCH model with the gravitational force being incorporated in the thermodynamically consistent framework will be investigated. We design a continuous finite element method and a special temporal scheme such that the energy law is accurately preserved at the discrete level. Such a discrete energy law for a variable density two-phase flow model has not been established - a joint work with Z.L.Guo and J. Lowengrub.

**MS-Mo-D-58** 13:30–15:30 401

**Surface diffusion and related problems and flows. - Part I of III**

For Part 2, see MS-Mo-E-58  
For Part 3, see MS-Tu-D-58

**Organizer:** Novick-Cohen, Amy  
Technion IIT

**Abstract:** Motion by surface diffusion, in which the normal velocity of an evolving surface is proportional to minus the surface Laplacian of its mean curvature, constitutes a geometric motion which plays a critical role in many technological applications, from thin film drug delivery, optical coatings, printing, and spray technology. While surface diffusion has been discussed in the material science literature to 1950s, much concerning its mathematical theory remains to be developed. The aim of the proposed minisymposium is consider surface diffusion and related problems from a variety of aspects, including existence, uniqueness, self-similarity, numerical methods, and issues related to applications. SIAG-MS sponsored.

(Comment: the actual area might best reflect A04 as well as A24, and the organizer is a member of two siags: SIAG-APDE as well as SIAG-MS)

**MS-Mo-D-58-1** 13:30–14:00

*Quadruple Junctions and Hole Formation in Thin Films: A Numerical Study*

Derkach, Vadim  
Technion IIT
Abstract: In my lecture I shall report on 3D numerical studies of the motion of quadruple junctions and thermal grooves in thin polycrystalline films, where the mean curvature motion of the grain boundaries and the surface diffusion evolution of the exterior surfaces couple along the thermal grooves. Our algorithms could also be used to study hole evolution in thin monocrystalline and polycrystalline films, where only the motion of the exterior surface needs to be considered.

Abstract: Our study is the problem of the existence of the self-similar solution for the surface diffusion flow in one-dimensional case with nonlinear boundary conditions. This problem was proposed by W. W. Mullins in 1957 to describe the thermal grooving. In this talk, we show the existence of self-similar solution of the differential form of the surface diffusion flow with linearized boundary conditions.

Abstract: Until now, theoretical treatments of chemical interdiffusion along short and long island films, pinch-off, hole dynamics, semi-infinite film, etc.

Abstract: Our study is the problem of the existence of the self-similar solution for the surface diffusion flow in one-dimensional case with nonlinear boundary conditions. This problem was proposed by W. W. Mullins in 1957 to describe the thermal grooving. In this talk, we show the existence of self-similar solution of the differential form of the surface diffusion flow with linearized boundary conditions.

Abstract: We consider a basic zero temperature model for screw dislocations in discrete lattices. Using a discrete-in-time variational scheme, we study the motion of dislocations in the dilute regime, towards low energy configurations. Letting the spacing and time parameters go to zero, we deduce an effective, fully overdamped dynamics predicting motion along the glide directions of the crystal. The results are obtained in collaboration with Adriana Garroni, Rober- to Alicandro and Marcello Ponsiglione.

Abstract: The variational multi-scale analysis of dislocations is a first very important step in order to better understand the continuum models for material defects and plasticity. I will present some of the main issues arising in this analysis (e.g., the difficulty of formulating a discrete model and the need for regularization in the linearized semi-discrete theories) and some of the mathematical tools used to formulate the problem.

Abstract: Dislocations are line defects in crystals. Their motion and interaction is considered the fundamental mechanism for plastic deformation in metals. Effective models for plasticity have to take into account the collective behavior of many dislocations whose response is influenced by their microscopic arrangement. Considerable effort has been recently devoted to observing, modelling, analyzing and simulating large ensembles of dislocations. This effort involves multiple communities, including applied physics, materials science, solid mechanics and applied mathematics. We propose a minisymposium in three sessions, with the aim of bringing together experts from those diverse communities to share their understanding of the problem from their respective perspectives.

Abstract: We consider a basic zero temperature model for screw dislocations in discrete lattices. Using a discrete-in-time variational scheme, we study the motion of dislocations in the dilute regime, towards low energy configurations. Letting the spacing and time parameters go to zero, we deduce an effective, fully overdamped dynamics predicting motion along the glide directions of the crystal. The results are obtained in collaboration with Adriana Garroni, Roberto Alicandro and Marcello Ponsiglione.
Huang, Huaxiong
York Univ.

Abstract: I have been to several Chinese Study Groups with Industry, including the ones in Hong Kong. In this talk I will discuss some of the problems I have worked on. The first problem was presented by Bao Steel, on the temperature control inside a steel sheet during the hot rolling process. The second problem was submitted by the Royal Bank of Canada on estimating counterparty risks.

IM-Mo-D-60-3
14:30–15:00
Application of Mathematical Models in the Steel Making Process
Guo, Zhaoxu
Baosteel
Gao, Wenwu
Anhui Univ.

Abstract: Mathematical models have been widely used in the steel making process. This talk will present developments of its application in steel making process. Some new trends and challenges of building mathematical models for steel making process will be also covered. Moreover, we shall demonstrate some ideas of how to couple together metallurgical mechanism and big data to develop simulation models for new steel grade development.

IM-Mo-D-60-4
15:00–15:30
Power Allocation Strategy of Hybrid Electric Bus
Zhonggeng, Han
Zhengzhou Information Engineering Univ.
Du, Jianping
Zhengzhou Information Engineering Univ.

Abstract: The strategy of power allocation is one of the key techniques in designing a Hybrid Electric Bus (HEB). In this article, a Bayesian forecasting model is firstly proposed to predict the future power demand based on the historical data of driving circles. Then a two-phase model is developed so that the original large-scale Stochastic Dynamic Program (SDP) can be decomposed to several small-scale SDPs and a Deterministic Dynamic Program (DDP). Since it is time-consuming to solve an SDP by the traditional iterative method, the sparse representation of an SDP solution and the Stochastic Simulation Optimization (SSO) are implemented to accelerate the SDP solver. Further, an Estimation of Distribution Algorithm (EDA) is applied to stochastic Simulation Optimization (SSO) are implemented to accelerate the SDP solver. Finally, a table-based strategy is given as the solution of the online power allocation problem.

CP-Mo-D-61
13:30–15:30
Ordinary Differential Equations
Chair: Guezane-Lakoud, Assia
Univ. Badji Mokhtar Annaba

Abstract:

> CP-Mo-D-61-1
13:30–13:50
Solution for the Initial-Value Problem of A Nonlinear Differential Equation
Guezane-Lakoud, Assia
Univ. Badji Mokhtar Annaba
Khaldi, Rabah
Badji Mokhtar Annaba Univ.

Abstract: This talk concerns the existence and uniqueness of solution of an initial value problem for a fractional differential equation involving Riemann–Liouville fractional derivatives. Many problems in sciences are described by initial value problems for nonlinear fractional differential equations such as in the study of models of viscoelasticity, electrochemistry, control, porous media, electromagnetic, etc. Under Krasnoselskii-Krein type conditions, successive approximations, some existence and uniqueness results are established.

> CP-Mo-D-61-2
13:50–14:10
Existence Results for Fractional Boundary Value Differential Equations in Non-reflexive Banach Space via Petits Integral
Ur Rahman, Ghaus
Univ. of Swat, Khyber Pakhtunkhwa, Pakistan

Abstract: The purpose of the present paper is to discuss Pseudo solution of fractional boundary value problem in nonreflexive Banach space. Furthermore, using weak uniqueness of non compactness measure we find the existence of solution FBVP in abstract spaces.

> CP-Mo-D-61-3
14:10–14:30
Large Deviations for Stochastic Integrodifferential Equations
Balachandran, Krishnan
Bharathiar Univ.
Suvinthra, Murugan
Bharathiar Univ., Coimbatore

Abstract: In this work we establish a Freidlin-Wentzell type large deviation principle for stochastic integrodifferential equations. Large deviation theory is an interesting branch of probability theory which deals with the study of rare events. The study of rare events is essential as the impact of its occurrence may be large. The general large deviation principle (LDP) was formulated by Varadhan (1966) and LDP for stochastic differential equations was studied by Freidlin and Wentzell (1970). In this work, we implement the theory developed by Budhiraja and Dupuis (Probability and Mathematical Statistics 20 (2000) 39-61) to establish the LDP for stochastic integrodifferential equations. The compactness argument is proved on the solution space of corresponding skeleton equation and the weak convergence is done for Borel measurable functions whose existence is asserted from the infinite dimensional version of Yamada-Watanabe theorem.

CP-Mo-D-61-4
14:30–14:50
Existence Results of Abstract Impulsive Integro-differential Systems with Measure of Non-compactness
Kandasamy, Malar
Erode Arts & Sci. College
Annamalai, Anguraj
PSG College of Arts & Sci.,

Abstract: In this paper, we study the existence of solutions of the nonlocal integro-differential equations with interval impulse and measure of non compactness by using M&#1255;nch fixed point theorem. Finally, an example is given to illustrate our main result.

> CP-Mo-D-61-5
14:50–15:10
Stepanov Almost Automorphic Solution of Fractional Order Differential Equations
Syed, Abbas
IIT Mandi

Abstract: In this paper, we discuss the existence and uniqueness of Stepanov almost automorphic solution of fractional order differential equations. We use the tool of resolvent family and fixed point technique to establish our results. At the end an example is provided to illustrate the analytical findings.

> CP-Mo-D-61-6
15:10–15:30
Positive Solutions for Systems of Higher-order Nonlinear Multi-point Boundary Value Problems
Luca Tudorache, Rodica
"Gheorghe Asachi" Technical Univ. of Iasi

Abstract: We investigate a system of higher-order nonlinear differential equations with two parameters subject to multi-point boundary conditions. Under some assumptions on the parameters, we prove the existence and nonexistence of positive solutions by using the Guo-Krasnosel’ski fixed point theorem. In a special case, we also study the multiplicity of positive solutions by applying the fixed point index theory. For this problem, if the nonlinearities do not possess any sublinear or superlinear growth conditions and may be singular, we prove the existence of positive solutions. A system of higher-order differential equations with sign-changing nonlinearities and integral boundary conditions is also investigated. This is a joint work with Prof. Johnny Henderson ( Baylor University, Waco, Texas, USA) and stud. Alexandru Tudorache (Gh. Asachi Technical University of Iasi, Romania).

CP-Mo-D-62
13:30–15:30
Partial Differential Equations
Chair: HERNANE-BOUKARI, DAHIA
Univ. OF Sci. & Tech. HOUARI BOUMEDIENE (USTHB)

Abstract:

> CP-Mo-D-62-1
13:30–13:50
A Study of Free Surface Flow Problem over A Topography.
HERNANE-BOUKARI, DAHIA
Univ. Of Sci. & Tech. HOUARI BOUMEDIENE (USTHB)

Abstract: In this work, we study theoretically and numerically a free surface flow problem, over an obstacle lying on the bottom of infinite channel. We take into account of the gravity but we neglect the effect of the superficial tension. An numerical method based on the minimization of the functional of the total energy of the system, is used to determine the equilibrium free surface flow, which is the principal unknown.

> CP-Mo-D-62-2
13:50–14:10
NUMERICAL SOLUTION OF FRACTIONAL HEAT EQUATION WITH VARIABLE COEFFICIENTS
Prakash, Periasamy
Periyar Univ.

Abstract: In this paper we consider the one dimensional space and time fractional heat equation with variable coefficients with Dirichlet boundary condition. By using a second order discretization for spatial derivative, we transform the fractional heat equation into a system of fractional ordinary differential equations which can be expressed in integral form. Further the integral equation is transformed into a difference equation by modified trapezoidal method. Numerical results are provided to verify the accuracy and efficiency of the proposed method.

> CP-Mo-D-62-3
14:10–14:30
ELECTROMAGNETIC WAVE PROPAGATION IN HETEROGENEOUS LINES FOR ARBITRARY LARGE TIME INTERVALS

Schedules: Monday Sessions
27
Abstract: The specific case of the differential Maxwell system is studied as mathematical model of electromagnetic wave propagation in heterogeneous lines under expofunctional excitations. It is shown, that such system is equivalent to the general wave PDE (partial differential equation) with respect to all electromagnetic field intensities. Solvability criterion of this system in the class of non generalized functions is proved, and the main types of corresponding boundary problems are suggested and solved explicitly.

Abstract: There exist numerical solution oscillation and negative flux for typical discrete scheme when solving multi-group multi-media sophisticated time-dependent neutron transport equations which brings difficulty for mathematics and physics analysis. In this paper, the numerical solution oscillation for sophisticated problem is investigated. The influence of time discrete scheme and space discrete scheme on this oscillating phenomenon is analyzed for neutron transport equations. In addition, the preserving positive neutron transport scheme is studied. The new scheme can take 0 order moment and 1 order moment of the neutron transport equation. Numerical experiments show that second-order time evolution scheme and linear discontinuous finite element method yield more accurate results and provide very smooth physical quantity curves. Based on the non-oscillation scheme, the positivity scheme give the non negative neutron angular flux. These preserving physical properties neutron transport schemes maintain the smooth of neutron multiplication constant and positivity of neutron flux.

Abstract: Diffusion problems are encountered in a wide range of scientific fields such as heat transfer, plasma physics, and oil reservoir simulation. A finite volume scheme is given for solving diffusion equations on general polygonal meshes. It has only cell-centered unknowns. Local stencils are used for constructing normal flux across the interface. Moreover, the stencils can be chosen adaptively according to the diffusion coefficient and/or the mesh geometry. The scheme is suitable for arbitrary polygonal meshes including the nonconforming ones. Numerical results show that the convergence rate is close to second order for problems with or without discontinuities.

Abstract: We consider discrete convolution operator in the Lebesgue spaces of square integrable functions both for a whole m-dimensional Euclidean space, and for certain canonical domains such as a half-space and a cone. It was found there are certain correlations between solvability of discrete equations and its continual analogue. More precisely, the symbol of a discrete convolution operator with Calderon– Zygmund kernel its symbol takes the same values, and its topological degree is the same both for a discrete case and the continual one [1-3]. For this purpose the authors have constructed the theory of periodic Riemann boundary problem, and this fact permits to consider more complicated case of a discrete equation in a multi-dimensional cone, in Euclidean space. Moreover, the introduced methods are very useful for studying solvability of a wide class of difference equations. This talk is based on a joint work with A.V. Vasilyev. The reported study was partially supported by RFBR, research project No. 14-41-03595 a. [1] Vasilyev V.B. Elliptic equations and boundary value problems in non-smooth domains. Operator Theory: Advances and Applications. 2011, V.213. Birkhauser, Basel. P.105-121. [2] Vasilyey A.V., Vasilyev V.B. Discrete singular operators and equations in a half-space. Azerb. J. Math. 2013, V.3, No.1. P.84-93. [3] Vasilyiev A.V., Vasilyev V.B. Discrete singular integrals in a half-space. arXiv:1410.1049.
pressed MR Image Recovery
Zhong, Jianjun
Shanghai Univ.

Abstract: We consider to solve a class of minimization model arising from the compressive Magnetic Resonance image recovery. This model is one of the most powerful models in compressive Magnetic Resonance image recovery, which involves a composite regularization.

In this lecture, we propose a fast algorithm for this minimization model and give some theoretically results. Numerical results show the effectiveness of our proposed algorithm.

CP-Mo-D-64 13:30–13:50
Probability and Statistics
Chair: Jun, He
Univ. of Electronic Sci. & Tech. of China

Dempster-Shafer (D-S) Evidence Theory and Some Key Problems
Jun, He
Univ. of Electronic Sci. & Tech. of China

Abstract: As one of the most important mathematical methods, Dempster-Shafer (D-S) evidence theory has been widely used in many fields. This paper summarizes the development and recent study of the explanations of D-S model, evidences combination algorithms, the improvement of the conflict during evidences combination, and compares all explanation models, algorithms and improvements and their applicable conditions. We try to provide a reference for future research and application through this summarization.

CP-Mo-D-64-1 13:30–13:50
Dempster-Shafer (D-S) Evidence Theory and Some Key Problems
Jun, He
Univ. of Electronic Sci. & Tech. of China

Abstract: The mathematical modelling of patient profiles in the era of individualized medicine sketched and the previously introduced efficiency of targeted clinical trials, are here extended. This extension is done by considering on one hand patient profiles as a multidimensional heterogeneous vector with deterministic and random components; and on the other hand by proceeding to a further stratification of responder patients. That stratification is accomplished by assuming that in the case of conventional (untargeted) clinical trials, both the control and treatment groups, are mixtures of k+1 strata defined by their k+1 genotypes and noted, respectively R0, R1, R2, R3,......Rk with R0 being the non responder patients stratum and (Ri, i = 1.....k) be the k strata of responder patients. Ri patients (i = 1.....k) are thus assumed to be more likely to respond to a molecularly targeted therapy than R0 patients.

CP-Mo-D-64-3 14:10–14:30
Sufficiency and Adequacy of the T-ratio in Determining the Presence of Multicollinearity In A Regression Model
Agunbiade, Adebayo
Obafemi Awolowo Univ.

Abstract: This research focuses on the diagnostic of multicollinearity and so investigates the sufficiency and adequacy of the t-ratios only to confirm its presence. To achieve this, a three-equation simultaneous model with three multicollinear exogenous variables is presented. Monte Carlo simulation indicates that the asymptotic results provide a better estimate with the Variance Inflation Factor, however a combination of the factors will suffice and not just the t-ratio only in determining the presence of multicollinearity.

CP-Mo-D-64-4 14:30–14:50
Multidimensional Scaling Using Factor Scores
PICAR, JOY
DAVAO DEL NORTE STATE COLLEGE

Abstract: In this paper, we show how the modified factor scores obtained from factor analysis can be used as inputs to the classical multidimensional scaling problem. Some optimality theorems related to the Takanu stress function are stated and proved. The use of factor scores in multidimensional scaling is justified on the basis of easy interpretability. Simulation results showed that PCA on Factor Scores gave a better value of the stress measure compared to the classical method of the multidimensional scaling.

CP-Mo-D-64-5 14:50–15:10
Optimal Experimental Design for Estimating the Effective Window Based on Triple Response
Tian, Yubin
Beijing Inst. of Tech.

Abstract: In some explosive tests, the testing specimens are subjected to a variety of stress levels to generate nonresponse, response, or over response. These data are used to estimate the effective window of stress levels for response. Based on binary response (response or nonresponse), several sensitivity testing procedures have been proposed. Among them, Jeff Wu and Yubin Tian’s three-phase optimal design which is dubbed 3pod performs well in terms of efficiency and robustness. In this paper, we extend the 3pod to triple response and propose an optimal design to estimate the effective window for response. Illustration shows that the optimal design is locally concentrated on four levels. The efficiency and the robustness of the design are studied through extensive simulations.
of results is observed. Corresponding mode shapes are also drawn.

**CP-Mo-D-65-5**

14:50–15:10

**Couple Stresses, Discrete Models and the Fracture of Rock**

Atkinson, Colin

imperial college

Coman, Ciprian

schlumberger gould research

**Abstract:** The cracked Brazilian disc test is considered for both sandstone and marble rocks and comparisons made with an analysis based on a discrete model. A detailed comparison is made of the fracture path in these experiments and also with experiments of uncracked samples. The discrete theory is also compared with micropolar and couple-stress continuum theories via exact analysis of crack tip behaviour in these continuum theories.

**CP-Mo-D-65-6**

15:10–15:30

**STRESS OF A TRUNNION JOINT**

Liu, Zhonghua

Xi'an Jiaotong Univ.

Feng, Sheng

Xi'an Jiaotong Univ.

Geng, Haipeng

Xi'an Jiaotong Univ.

Cai, Yandong

Xi'an Jiaotong Univ.

Yu, Lie

Xi'an Jiaotong Univ.

**Abstract:** A trunnion joint is modeled as a circular plate with a rotational spring at the outer peripheral portion to resist rotation. Asymmetrical bending deflection is produced when an external moment acts on the inner side of the circular plate. The equations of the circular plate with a special outer peripheral boundary condition are derived. Choosing the stiffness of the rotational spring and the ratio of the outer radius and inner radius of the circular plate as two parameters, hoop stress and tangential stress are calculated. The effect of the stiffness of the rotational spring on the radial stress and hoop stress becomes obvious for a larger ratio of the outer radius and inner radius. However, the tangential stress is independent of the stiffness of the rotational spring.

**MS-Mo-D-66**

13:30–15:30

VIP4-3

Current Trends in Wavelet Methods - Part I of II

For Part 1, see MS-Mo-E-66

Organizer: Chandra, Pammy

Guru Nanak Dev Univ., Amritsar

Organizer: Siddiqi, Prof., Abul

Sharda Univ., NCR

**Abstract:** A formal development of wavelet methods was initiated by a geophysicist Morlet and subsequently Meyer, Mallat, Daubechies, Donoho, Coifman et al played important role in providing a solid mathematical foundation of this theme. Several variants of wavelets such as wavelet packets, wave packets, complex wavelets, dyadic wavelets, curvelets, shearlets, framelets, vector valued wavelets have been studied along with their interesting applications. Relevance of wavelet methods to computerized tomography specially to the Radon transform and its variants have been studied in the recent years. It is well known by now that radon transform plays a significant role in medical imaging. In this mini symposium, updated results in the above mentioned fields will be presented including the results of the speakers in this area.

**MS-Mo-D-66-1**

13:30–14:00

**Representation of Scaling Functions by Walsh Series**

Farokv, Yuri

Russian Presidential Acad. of National Economy & Public Administration

**Abstract:** We give a review of recent results on compactly supported scaling functions which can be written as the Walsh series. Among the main subject to be discussed are sufficient conditions for the uniform convergence of the corresponding gap series with applications to wavelet approximation and signal processing. [1] Yu. A. Farokv, Wavelet expansions on the Cantor group, Math. Notes (96) (2014), 996-1007.

**MS-Mo-D-66-2**

14:00–14:30

**Wavelet Analysis of EEG**

Zahra, Noore

Sharda Univ.

Nas, Shaheen

SET, SHARDA Univ.

Parveen, Nazia

SRMS, BAREILLY

**Abstract:** The aim of this study is to predict epileptic seizures based on the analysis of EEG spectrum. This study can be done by recording the EEG data of seizures and non-seizures and then analyze the data set using wavelet transform tool. EEG signals exhibit several patterns of rhythmic or periodic activity in different frequency bands. This may include computation of entropy, energy and statistical parameters of the signal such as mean, variance, standard deviation

**MS-Mo-D-66-3**

14:30–15:00

**Sampling Expansion**

Skopina, Maria

St. Petersburg State Univ.

Abstract: The well-known sampling theorem (also called Kotel'nikov or Shannon formula) is very useful for engineers. Up to now, an overwhelming diversity of digital signal processing applications and devices are based on it and more than successfully use it. We study approximation by multivariate Kotel’nikov-Shannon type expansions with exact and falsified values. For the one-dimensional case, we also constructed ‘‘ sampling wavelet decompositions’’, i.e. frame-like wavelet expansion with coefficients interpolating a signal at the dyadic points.

**EM-Mo-E-01**

16:00–18:00

EM-01-1

**On Construction of H-symmetric Wavelets**

Krivosehein, Aleksandr

Saint Petersburg State Univ.

Abstract: A symmetry is one of the most desirable properties for wavelet systems in applications. For an arbitrary symmetry group H, we give explicit formulas for refinable masks that are H-symmetric and have sum rule of order n. The description of all such masks is given. Several methods for the construction of H-symmetric wavelets (and multi-wavelets) providing approximation order n in different setups are developed.

**Organizer: Giesbrecht, Mark**

Univ. of Waterloo

Organizer: Kaitlofen, Erich

North Carolina State Univ.

Organizer: Saley EI Din, Mohab

Univ. Pierre & Marie Curie

Organizer: Zhi, Liheong

Acad. of Mathematics & Sys. Sci.

**Abstract:** Hybrid symbolic-numerical computation methods, which first appeared some twenty years ago, have gained considerable prominence. Algorithms have been developed that improve numeric robustness (e.g., in quadrature or solving ODE systems) using symbolic techniques prior to, or during, a numerical solution. Likewise, traditionally symbolic algorithms have seen speed improvements from adaptation of numeric methods (e.g., lattice reduction methods). There is also an emerging approach of characterizing, locating, and solving "interesting nearby problems", wherein one seeks an important event (for example a nontrivial factorization or other useful singularities), that in some measure is close to a given problem (one that might have only imprecisely specified data). Many novel techniques have been developed in these complementary areas, but there is a general belief that a deeper understanding and wider approach will foster future progress. The problems we are interested are driven by applications in computational physics (quadrature of singular integrals), dynamics (symplectic integrators), robotics (global solutions of direct and inverse problems near singular manifolds), control theory (stability of models), and the engineering of large-scale continuous and hybrid discrete-continuous dynamical systems. Emphasis will be given to validated and certified outputs via algebraic and exact techniques, error estimation, interval techniques and optimization strategies.

Our workshop will follow up on the seminal SIAM-MSRI Workshop on Hybrid Methodologies for Symbolic-Numeric Computation held in November 2010 and the Fields Institute Workshop on Hybrid Methodologies for Symbolic-Numeric Computation, November 16-19, 2011 at the University of Waterloo, Canada. We will provide a forum for researchers on all sides of hybrid symbolic-numeric computation.

**EM-Mo-E-01-1**

16:00–16:30

**At the Interface Between Symbolic and Numeric Computation**

Watt, Stephen

Univ. of Waterloo

Abstract: We explore various areas where symbolic and numeric computation touch, and how the computation changes as it becomes more symbolic or more numeric. The placement of this boundary can open new ways to think about problems, for example by allowing many cases to be considered simultaneously (as with symbolic domain decomposition), or by combining analytic and algebraic methods (as with approximate polynomial algorithms). This paper will present current work on problems in this area.

**EM-Mo-E-01-2**

16:30–17:00

**How Sub-sampling Can Lead to More Robustness and Higher Resolution in Parametric Spectral Analysis**

Abstract: The well-known sampling theorem (called also Kotel’nikov or Shannon formula) is very useful for engineers. Up to now, an overwhelming diversity of digital signal processing applications and devices are based on it and more than successfully use it. We study approximation by multivariate Kotel’nikov-Shannon type expansions with exact and falsified values. For the one-dimensional case, we also constructed ‘‘ sampling wavelet decompositions’’, i.e. frame-like wavelet expansion with coefficients interpolating a signal at the dyadic points.

**Organizer: Safey El Din, Mohab**

Univ. of Waterloo

Organizer: Kaltofen, Erich

North Carolina State Univ.

Organizer: Saley EI Din, Mohab

Univ. Pierre & Marie Curie

Organizer: Zhi, Liheong

Acad. of Mathematics & Sys. Sci.

**Abstract:** Hybrid symbolic-numerical computation methods, which first appeared some twenty years ago, have gained considerable prominence. Algorithms have been developed that improve numeric robustness (e.g., in quadrature or solving ODE systems) using symbolic techniques prior to, or during, a numerical solution. Likewise, traditionally symbolic algorithms have seen speed improvements from adaptation of numeric methods (e.g., lattice reduction methods). There is also an emerging approach of characterizing, locating, and solving "interesting nearby problems", wherein one seeks an important event (for example a nontrivial factorization or other useful singularities), that in some measure is close to a given problem (one that might have only imprecisely specified data). Many novel techniques have been developed in these complementary areas, but there is a general belief that a deeper understanding and wider approach will foster future progress. The problems we are interested are driven by applications in computational physics (quadrature of singular integrals), dynamics (symplectic integrators), robotics (global solutions of direct and inverse problems near singular manifolds), control theory (stability of models), and the engineering of large-scale continuous and hybrid discrete-continuous dynamical systems. Emphasis will be given to validated and certified outputs via algebraic and exact techniques, error estimation, interval techniques and optimization strategies.

Our workshop will follow up on the seminal SIAM-MSRI Workshop on Hybrid Methodologies for Symbolic-Numeric Computation held in November 2010 and the Fields Institute Workshop on Hybrid Methodologies for Symbolic-Numeric Computation, November 16-19, 2011 at the University of Waterloo, Canada. We will provide a forum for researchers on all sides of hybrid symbolic-numeric computation.

**EM-Mo-E-01-1**

16:00–16:30

**At the Interface Between Symbolic and Numeric Computation**

Watt, Stephen

Univ. of Waterloo

Abstract: We explore various areas where symbolic and numeric computation touch, and how the computation changes as it becomes more symbolic or more numeric. The placement of this boundary can open new ways to think about problems, for example by allowing many cases to be considered simultaneously (as with symbolic domain decomposition), or by combining analytic and algebraic methods (as with approximate polynomial algorithms). This paper will present current work on problems in this area.

**EM-Mo-E-01-2**

16:30–17:00

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Differential Galois Groups over Laurent Series Fields

We develop a parametric method to retrieve fine-scale information from coarse-scale measurements. We exploit, rather than avoid, aliasing to regularize the problem and increase the frequency resolution. Our technique is used to tackle some challenges encountered in magnetic resonance spectroscopy.

On Integer Relation Finding Problem

Given a real vector \( \mathbf{x} \), an integer relation for \( \mathbf{x} \) is a nonzero integer vector \( \mathbf{m} \) such that \( \mathbf{m} \cdot \mathbf{x} = 0 \). This is used to tackle some difficulties encountered in magnetic resonance spectroscopy. Our technique converges locally quadratically to such a matrix under mild transversality assumptions. Joint work with Eric Schost.

A Quadratically Convergent Algorithm for Structured Low-Rank Approximation

Given an input matrix \( \mathbf{M} \), Structured Low-Rank Approximation (SLRA) is the problem of computing a matrix of given rank \( r \) in a linear-affine subspace of matrices such that the Frobenius distance to \( \mathbf{M} \) is small. We present a Newton-like iteration for SLRA, whose main feature is that it converges locally quadratically to such a matrix under mild transversality assumptions. Joint work with Damien Stehlé and Gilles Villiard.

Differential Algebra and Related Topics - Part II of VIII

On the Hyper transcendent of Solutions of Mahler Equations

Darboux Transformations for Lax Operators Associated with Kac-Moody Algebras

Darboux Transformations of the Vector Sine-Gordon Equation and Its Soliton Solutions

Conservation Laws and Symmetries of Hunter-Saxton Equation Revisited
Hirota and Sasa-Satsuma equations.

For Part 6, see IM-We-E-04
For Part 4, see IM-Tu-E-04

Mathematics and Algorithms in Computer-Aided Manufacturing, Manufacturing Systems and Numerical Control - Part II of VI
For Part 1, see IM-Mo-D-04
For Part 3, see IM-Tu-D-04
For Part 4, see IM-Tu-E-04
For Part 5, see IM-We-D-04
For Part 6, see IM-We-E-04

Organizer: Li, Hongbo Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Organizer: Shpitalni, Moshe Technion, Israel

Abstract: The fast development of advanced manufacturing technology has witnessed the growing importance of mathematical methods and algorithms, ranging from algebraic geometry, discrete geometry and differential geometry to differential equations, computational mathematics and computer mathematics. Conversely, problems arising from the field of advanced manufacturing have also stimulated the development of such branches in pure and applied mathematics as computational geometry and mathematics mechanization.

Mathematics and Algorithms for Computer-Aided Manufacturing, Engineering and Numerical Control is intended to be an interdisciplinary forum focusing on the interaction between the side of mathematical methods and algorithms, and the other side of computer-aided manufacturing (CAM), computer-aided engineering (CAE) and computer numerical control (CNC). It concentrates on (but is not restricted to) the following topics: tool path planning, multiscale simulation, feature-based process chain with CAM/CNC coupling, interpolation for CNC controllers.

The proposed industrial mini-symposium of 20 talks will provide an excellent platform for the participants to get acquainted with new research results, to exchange new ideas, and to create new collaboration.

To ensure full success of the proposed mini-symposium, we have invited 8 speakers from abroad. All are knowledgeable world experts in their fields, with impressive records of research, publications and awards, as well as solid background of mathematics. The invited speakers are from various countries and represent different aspects in Manufacturing, Manufacturing Systems and Computer Numerical Control.

►IM-Mo-E-04-1
16:00–18:00
Machine Tool Vibrations and Machined Surface Quality
Stepan, Gabor Budapest Univ. of Tech. & Economics

Abstract: The lecture summarizes the free, forced, self-excited, regenerative and parametrically forced machine tool vibrations together with their different combinations. The relation to machined surface quality is demonstrated in industrial case study. The stability of milling and especially the high-speed milling processes are explained and the development of the related surface quality parameters are presented. As an inverse application, vibration based and experimental methods are also introduced to identify the nonlinear characteristics of cutting forces.

►IM-Mo-E-04-2
16:45–17:30
Application of Field-based Optimization Methods in NC Tool-path Computation
Lee, Chen-Han Huazhong Univ. of Sci. & Tech.

Abstract: NC tool-path research has evolved from computing acceptable tool-paths to finding optimal ones. NC machining is a multi-objective problem and the various optimization objectives often compete with each other. We propose a field-based framework in order to work with various objectives together. We present our recent works in: well-behaving path trajectories, s-smooth and gouge-free tool-axis distribution, automated machining region sub-division, B-spline tool-path fitting, machine-kinematic tensor, global tool-path shape optimization, and spatial path error compensation.

►IM-Mo-E-04-3
17:30–18:00
Double Spiral Tool Path Generation and Linking Method for Complex Pocket Machining
Zhou, Bo SIA
JiBin, Zhao SIA

Abstract: We propose a new double spiral tool-path generation and linking method for complex pockets with islands which can be used for high speed machining (HSM). Taking into account the path interval, step length and other simplifying parameters, precise milling can be achieved without retraction operations to ensure optimal processing performance and shorter processing time. For the application of the above algorithm, the simulation results indicate that this method is superior to existing machining methods.

►MS-Mo-E-05
16:00–18:30
Compressed Sensing, Extensions and Applications - Part II of III
For Part 1, see MS-Mo-D-05
For Part 3, see MS-Tu-D-05

Organizer: Kulyukin, Gitta Technische Universität Berlin
Organizer: Holger, Rauhut RWTH Aachen Univ.

Abstract: Compressed sensing has seen an enormous research activity in recent years. The key principle is that (approximately) sparse signals can be recovered efficiently from what was previously believed to be vastly incomplete information. For this reason, compressed sensing and its algorithms (often convex optimization approaches) have a large range of applications such as magnetic resonance imaging, radar, wireless communications, and more. Remarkably, all provably optimal measurement schemes are based on randomness and therefore, compressed sensing connects various mathematical fields such as random matrix theory, optimization, approximation theory, and harmonic analysis. Recent developments have extended the theory and its algorithms to the recovery of low rank matrices from incomplete information, to the phaseless estimation problem, and to low tensor recovery. The minisymposium aims at bringing together experts in the field and to provide an overview of its most recent results.

►MS-Mo-E-05-1
16:00–16:30
Analysis of Low Rank Matrix Recovery via Mendelson’s Small Ball Method
Terstiege, Ulrich RWTH Aachen Univ.
Holger, Rauhut RWTH Aachen Univ.
Kabanava, Maryia RWTH Aachen Univ.

Abstract: We study low rank matrix recovery from undersampled measurements via nuclear norm minimization. We aim to recover a matrix X from few linear measurements (Frobenius inner products with measurement matrices). For different scenarios of independent random measurement matrices we derive bounds for the minimal number of measurements sufficient to uniformly recover any rank r matrix with high probability. Our results are stable under passing to only approximately low rank matrices and under noisy measurements.

►MS-Mo-E-05-2
16:30–17:00
Tensor Completion in Hierarchical Tensor Formats
Schneider, Reinhold Inst. for Mathematics

Abstract: Hierarchical Tucker tensor format (HT - Hackbusch tensors ) and Tensor Trains (TT- Tsyryshnikov tensors, I.Oseledets) have been introduced recently for low rank tensor product approximation. Hierarchical tensor decompositions are based on sub space approximation by extending the Tucker decomposition into a multi-level framework. Therefore they inherit favorable properties of Tucker tensors, e.g. they offer a stable and robust approximation, but still enabling low order scaling with respect to the dimensions. For many high dimensional problems, hard to be handled so far, this approach may offer a novel strategy to circumvent the curse of dimensionality. For uncertainty quantification we cast the original boundary value problem, with uncertain coefficients problem into a high dimensional parametric boundary value problem, discretized by Galerkin method. The high dimensional problem is cast into an optimization problems, constraint by the restriction to tensors of prescribed ranks r. This problem could be solved by optimization on manifolds, or more simply by alternating least squares. Since the norm of the underlying energy-space is a cross norm preconditioning is required only for the spatial part and e.g. performed by standard multi grid approaches, e.g. BPX. Moreover residual based error estimators can be applied to estimate the (total) error of the parameter dependent BVP. These estimators can be used to balance FEM discretization, chaos polynomial expansion and low rank approximation. Of importance is, that this leads to a modification of the orthogonality of the used component tensors.

►MS-Mo-E-05-3
17:00–17:30
Hierarchical Tensors Approximation for Uncertainty Quantification
Schneider, Reinhold Inst. for Mathematics

Abstract: Hierarchical Tucker tensor format (HT - Hackbusch tensors ) and Tensor Trains (TT- Tsyryshnikov tensors, I.Oseledets) have been introduced recently for low rank tensor product approximation. Hierarchical tensor decompositions are based on sub space approximation by extending the Tucker decomposition into a multi-level framework. Therefore they inherit favorable properties of Tucker tensors, e.g. they offer a stable and robust approximation, but still enabling low order scaling with respect to the dimensions. For many high dimensional problems, hard to be handled so far, this approach may offer...
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**MS-Mo-E-05-4 17:30–18:00**

*Non-Linear l_r-Residual Minimization in A Greedy Algorithm for Phase Retrieval*

Sigl, Juliane
Technical Univ. Munich

**Abstract:** Motivated by a very efficient greedy algorithm we introduced recently for solving phase retrieval problems with convergence guarantees, we present a modification to iteratively reweighted least squares to solve non-linear residual minimizations in $l_r$-norms.

**MS-Mo-E-05-5 18:00–18:30**

*On Deterministic Structured Sampling of Structured Signals in Compressed Sensing*

Adcock, Ben
Simon Fraser Univ.

**Abstract:** Recent theoretical developments in CS reveal that in many applications the optimal random sampling strategy depends on the structure of the signal itself. Thus, we are faced with the intriguing problem of designing optimal sampling strategies for classes of signals. However, in tomography problems the sampling patterns are mostly deterministic (although highly structured), yet using standard l1 recovery works very well, but only on certain structured signals. We will discuss a new theory explaining this.

**MS-Mo-E-06 Delay Systems and Applications - Part II of II**

For Part 1, see MS-Mo-D-06

**Organizer:** Braverman, Elena
Univ. of Calgary

**Abstract:** The purpose of the minisymposium is to provide a wide forum for presentations and discussions on the recent trends in the theory of differential and difference equations with deviations. The topic includes delayed and advanced systems, as well as various applications of such models, for example, in mathematical biology.

**MS-Mo-E-06-1 16:00–16:30**

*Delay-Delayed Feedback in the Haematopoietic System*

Belair, Jacques
Universite de Montreal

**Abstract:** The production and control of mammalian blood cells is regulated through an intertwined system of feedback mechanisms involving differentiation of cell lines and hormonal interactions between circulating cells and cells at different stages of maturation. Time delays naturally occur as maturation time of the latter, and lifetime of the former. We present some recent results, on the influence of distributions of delay in maturation time, and also on stability in coupled negative feedback loops.

**MS-Mo-E-06-2 16:30–17:00**

*On Neutral First Order Delay Differential Equations with M Compensurate Delays*

Cahlon, Baruch
oakland Univ.

**Abstract:** In this paper we derive a robust algorithmic stability test to determine asymptotic stability of a first linear delay differential equations with constant coefficients and constant delays. A new necessary condition for asymptotic stability is obtained. In proving our results we make use of Pontryagin’s theory for quasi-polynomials and Chebyshev polynomials of the first and second kind.

**MS-Mo-E-06-3 17:00–17:30**

*Characterizing the Multiplicity of Spectral Values for Time-Delay Systems*

Islam, BOUSSADA
IPSA & LSS, Supélec-CNRS-U PSUD

Iroth, Dina
Univ. Paris Sud

Niculescu, Silviu-ianul
CNRS

**Abstract:** A standard approach in analyzing the stability of time-delay systems consists in characterizing the associated spectrum. By characterization it is meant; the identification of the spectral values as well as their associated multiplicities. Efficient approaches for identifying such spectral values exist. However, the multiplicity issue was not deeply investigated. This contribution provides an answer to the multiplicity problem.

**MS-Mo-E-06-4 17:30–18:00**

*Frequency-Sweeping Stability Test for Linear Systems with Multiple Delays*

Li, Xu-Guang
Northeastern University, China

Niculescu, Silviu-ianul
CNRS

Cela, Arben
UPG, ESIIEE Paris

**Abstract:** We study the stability of time-delay systems with multiple delays, by extending a recently proposed frequency-sweeping framework. First, we consider the case where one delay parameter is free and the other ones are fixed. Such a case can be systematically investigated by proving the invariance property. Next, we will propose a method to compute the number of unstable roots for any given combination of multiple delays.

**MS-Mo-E-07 Mathematics of Climate: From the Tropics to Antarctica - Part II of III**

For Part 1, see MS-Mo-D-07

For Part 3, see MS-Tu-D-07

**Organizer:** Stechmann, Samuel
Univ. of Wisconsin-Madison

**Organizer:** Golden, Kenneth
Univ. of Utah

**Abstract:** The Earth offers a multitude of modeling challenges, from the dynamics of the atmosphere and oceans, to the melting of the polar ice caps. To understand and model these climate processes, a wide range of mathematics is needed, such as differential equations, multiscale modeling, and stochastic processes. In this minisymposium, the presentations span a broad range of climate processes and mathematical areas, and will be accessible to a more general audience. They include a blend of modeling, experiments, and data analysis, and demonstrate how mathematics is being employed to address fundamental problems of climate science.

**MS-Mo-E-07-1 16:00–16:30**

*Modeling the Madden-Julian Oscillation: Nonlinear Waves, Stochastic Dynamics, and Data Analysis*

Stechmann, Samuel
Univ. of Wisconsin-Madison

**Abstract:** The Madden-Julian Oscillation (MJO) is a planetary-scale wave envelope of tropical clouds and precipitation. In this presentation, a system of nonlinear PDEs is presented as a model for the MJO (the MJO Skeleton Model). Three aspects are described: nonlinear traveling wave solutions, a stochastic version of the model, and a method for identifying the MJO in observational data.

**MS-Mo-E-07-2 16:30–17:00**

*Effect of Stratiform Heating on the Planetary Scale Organization of Tropical Convection*

Khouider, Boualem
Univ. of Victoria

**Abstract:** It is now widely recognized that stratiform heating contributes significantly to the tropical rainfall and to the dynamics of tropical convective systems. In particular, it has been established that stratiform anvil formations in the wake of deep convection play a central role in the dynamics of tropical mesoscale convective systems through the wide spread of downdrafts from the evaporation of stratiform rain in the lower troposphere strengthening the recirculation of subsiding air towards and away from the convection centre, which in turn triggers cold pools and gravity currents in the boundary layer leading to further lifting thus helping the mesoscale organization of convection. Here, aquaplanet simulations with a warm pool like surface forcing and using a coarse resolution GCM coupled with a stochastic multicloud parameterization, which has been previously proved to simulate well tropical convective systems on a wide range of scales, including the Madden-Julian oscillation and the monsoon intra-seasonal oscillation, as well as the spectrum of convectively coupled waves, are used to demonstrate the sensitivity and importance of stratiform heating for the organization of convection on the MJO scale. More precisely, it is shown that when some key model parameter are set to produce higher stratiform heating fractions, the model produces mainly low-frequency and planetary scale MJO-like wave disturbances while lower to moderate stratiform heating fractions yield mainly synoptic scale convectively coupled Kelvin-like waves. Furthermore, it is shown that when the effect of stratiform downdrafts are switched off in the model, the MJO-scale organization is destroyed despite the use of larger stratiform heating parameters. It is thus conjectured here that it is the strength and extend of stratiform downdrafts that sets the preferred scale for convection organization with mechanisms that are in essence similar to mesoscale convective systems.

**MS-Mo-E-07-3 17:00–17:30**

*Atmospheric Flow Regimes on Planetary Scales*
Ocean Dynamical Adjustment and Atmospheric CO2 Feedback
Zanna, Laure
Univ. of Oxford

Abstract: Our work assesses the role of wind and buoyancy forcing in setting the surface ocean pCO2 and the uptake of natural and anthropogenic carbon. We will examine the Southern Ocean mixed-layer budget and the role of the ocean circulation in determining the long-term levels of atmospheric CO2 using idealised and complex GCM experiments. We will propose a set of scalings to quantify the feedbacks of ocean dynamics on atmospheric CO2 under climate change.

MS-Mo-E-07-4 17:30–18:00
Ocean Dynamical Adjustment and Atmospheric CO2 Feedback
Zanna, Laure
Univ. of Oxford

Abstract: The atmospheric compressible flow equations admit a wide range of different flow regimes distinguished by their characteristic length and time scales. In climate research we are interested in large-scale features involving the internal Rossby radius, the Oboukhov scale (or external Rossby radius), and the planetary scale and in their mid-latitude–tropical interactions. In this lecture I will summarize various pertinent asymptotic limit regimes that have been identified over the past decade and discuss their implications.

MS-Mo-E-08 16:00–18:00 202B
Numerical methods for compressible multi-phase flows - Part II of VI
For Part 1, see MS-Mo-D-08
For Part 3, see MS-We-E-47
For Part 4, see MS-Th-BC-47
For Part 5, see MS-Th-D-47
For Part 6, see MS-Th-E-47
Organizer: Deng, Xiaolong Beijing Computational Sci. Research Center
Organizer: Wei, Suhua Inst. of Applied Physics & Computational Mathematics
Organizer: Tian, Baolin Institute of Applied Physics & Computational Mathematics
Organizer: Tiegang, Liu Beihang Univ.
Organizer: Sussman, Mark Florida State Univ.
Organizer: Wang, Shuanghu IAPCM

Abstract: Compressible multi-phase flows appear in many natural phenomena, and are very important in many applications, including space science, aerospace engineering, energy, homeland security, etc. Numerical calculation is a key for understanding many related problems. More and more numerical methods are being developed and improved. In this mini-symposium, novel numerical methods will be presented to show the progress in the area of compressible multi-phase flows, including interface capturing/tracking methods, phase change calculations, mixing methods, fluid-structure interaction methods, multi-physics calculations, adaptive mesh refinement, and high performance computing.

MS-Mo-E-08-1 16:00–16:30
A Remapping-free High-order ALE Method Based on Undistorted Temporal-spatial Control Volumes
Jin, Qi Inst. of Applied Physics & Computational Mathematics
Li, Jiequan Beijing Normal Univ.

Abstract: This work develops a remapping-free high-order ALE method based on undistorted temporal-spatial control volumes. According to the Hodge decomposition theorem, mesh moving velocities are generated by the irrotational component of fluid’s velocity. Then based on the finite volume framework, 2-D Euler equations in integral form are discretized in such undistorted hexahedral temporal-spatial control volumes. Besides numerical fluxes are computed by GRP solver to get a high-precision approximation. Typical numerical examples verify the new method.

MS-Mo-E-08-2 16:30–17:00
Numerical Simulations of Free Surface Flows Based on CLSVOF Method, Multi-moment Methods and Density-scaled Balanced CSF Model
Yokoi, Kensuke Cardiff Univ.

Abstract: We propose a practical numerical framework for free surface flows. The numerical framework consists of the CLSVOF method, the THINC/WLIC (tangent of hyperbola for interface capturing/weighted line interface calculation) scheme, multi-moment methods (CIP-CGL and VSIAKS) and the density-scaled balanced CSF (continuum surface force) model. The numerical results have shown that the numerical framework is highly reliable and can well capture free surface flows with complex interface geometries like droplet splashing.

MS-Mo-E-08-3 17:00–17:30
An Improved Compressible, Multiphase Semi-implicit Method with Moment of Fluid Interface Representation
Sussman, Mark Florida State Univ.

Abstract: We present improvements made to our algorithm first reported in Journal of Computational Physics (2014). The improvements enable more accurate simulation of compressible multiphase flows, but with the same cost. Examples are presented for high pressure atomization of liquid in gas and for multiphase problems consisting of materials with large viscosity. As with our 2014 method, our improved method is asymptotically preserving, conservative, simulates materials with disparate material properties, and does not require Riemann solvers.

MS-Mo-E-08-4 17:30–18:00
High Resolution Numerical Simulation of Explosion Problems
Wang, Cheng Beijing Inst. of Tech.

Abstract: In this paper, a high resolution large scale parallel computation software is developed based on positivity preserving for finite difference WENO method, high order boundary treatment method, multi-medium interface treatment. The software can simulate some explosion problems such as flame acceleration and DDT, explosion in air and water and concrete, shaped charge jet, jet penetration and etc. By constructing artificial solutions and comparison with experimental results, the accuracy and computation results are validated and verified.
variety of natural and social phenomena. Ultradiscretization is a mathematical tool for constructing CAs from continuous systems. It has been successfully used to obtain CA models that share important features with continuous phenomena. The purpose of this organized session is to offer researchers the opportunity to discuss recent advances in ultradiscrete systems and in particular their application to fundamental biology.

**Max-min-plus Analysis for One-dimensional Particle Cellular Automata**

Abstract: We shall explain how to construct discrete models that are guaranteed to exhibit local and global dynamics similar to that of continuous models for specific systems. Local faithfulness of the discrete models will be ensured using techniques that originated in the study of integrable mappings. The ultradiscretization technique, which also originated in the study of solitonic cellular automata, will prove to be crucial for ascertaining the faithfulness of the global behaviour of these discrete models.

**Gaps on the Flow of the Simplified Path-preference Cellular Automaton Model**

Yochi, Nakata The Univ. of Tokyo

Abstract: The path-preference model is a cellular-automaton model to describe the dynamics of RNA polymerase II in transcription. We found that evolution equations for some rules are expressed in the form of a max-min-plus expression by introducing addition operation on \( \oplus \).

**Mathematical Modeling for Angiogenesis**

Tokihito, Tetsuji the univ. of Tokyo

Abstract: Angiogenesis is the morphogenetic phenomenon in which new blood vessels emerge from an existing vascular network and configure a new network. Based on recent experiments with time-lapse fluorescent imaging, we propose mathematical models for the dynamics of vascular endothelial cells (ECs) in angiogenic morphogenesis. The model successfully reproduces cell mixing behavior, elongation and bifurcation of blood vessels and suggests that the two-body interaction between ECs is essential to the dynamics of ECs.

**Modeling Natural Phenomena Through Discretisation and Ultradiscretisation**

Willow, Ralph the univ. of Tokyo

Abstract: We shall explain how to construct discrete models that are guaranteed to exhibit local and global dynamics similar to that of continuous models for specific systems. Local faithfulness of the discrete models will be ensured using techniques that originated in the study of integrable mappings. The ultradiscretization technique, which also originated in the study of solitonic cellular automata, will prove to be crucial for ascertaining the faithfulness of the global behaviour of these discrete models.

**Gaps on the Flow of the Simplified Path-preference Cellular Automaton Model**

Yoichi, Nakata The Univ. of Tokyo

Abstract: The path-preference model is a cellular-automaton model to describe the dynamics of RNA polymerase II in transcription. We found that the number of particles is dominant to the dynamics of simplest version of this model and observed that there are not only expected phase shift but also several non-continuous gaps as the number of particles increases. By considering limit cycles, we discuss the condition where such gaps appear.

**Recent advances in matrix computations for extreme-scale computers - Part II of II**

For Part 1, see MS-Mo-D-11

Organizer: Li, Xiaoye Lawrence Berkeley National Laboratory
Organizer: Duff, Iain STFC Rutherford Appleton Laboratory

**Preconditioners and Solvers for CFD Applications on GPU-based Supercomputers**

De Sturler, Eric Virginia Tech

Abstract: We discuss relevant issues to obtain high performance for solvers and especially preconditioners on GPUs. Fine grained parallelism is essential. We demonstrate results for several CFD applications. This is joint work with Katarzyna Swirydowicz, Chris Roy, Amit Amritkar, and Danesh Tafti.

**Efficient Deadlock-free Asynchronous Approaches for A Distributed-memory Sparse Direct Solver**

Sid-Lakhdir, Wissam M. Texas A&M Univ.

L’Excellent, Jean-Yves Inria & Univ. of Lyon

Amestoy, Patrick INPT-IRIT Univ. of Toulouse

Abstract: We describe how to enhance parallelism in an asynchronous distributed-memory environment with limited memory dedicated to communication. In order to maximize asynchronism, we characterize deadlock situations and establish global properties to prevent or avoid them. We also characterize some communication patterns and define a class of broadcast trees ensuring good efficiency for series of successive asynchronous broadcast s. The impact of this work is illustrated on asynchronous sparse multithreaded solvers but has a larger scope.

**Fine-grained Parallel Incomplete LU Factorization**

Chow, Edmond Georgia Inst. of Tech.

Abstract: We present a highly parallel algorithm for computing incomplete LU factorizations. All nonzero factors in the factorization are computed in parallel, using one or more sweeps that iteratively improve the accuracy of the factorization. Numerical tests show that very few sweeps are needed to construct a factorization that is an effective preconditioner. The approach can also update an existing factorization, giving it a potential niche in the solution of sequences of linear systems.

**Minimum Degree and Cycles of Specific Lengths**

Liu, Chun-Hung Princeton Univ.

Abstract: We prove that every graph of minimum degree at least \( k+1 \) contains \( k \) cycles of either consecutive lengths, or consecutive even lengths, or consecutive odd lengths.

**Degree and Cycles of Specific Lengths**

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Liu, Chun-Hung Princeton Univ.

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**Minimum Degree and Cycles of Specific Lengths**

Liu, Chun-Hung Princeton Univ.

Abstract: We prove that every graph of minimum degree at least \( k+1 \) contains \( k \) cycles of either consecutive lengths, or consecutive even lengths, or consecutive odd lengths.
We propose numerical schemes to solve linear kinetic equations in and Anomalous Diffusion Asymptotics. In these limits, the classical explicit schemes suffer from schemes in the joint quasi-neutral and fluid limits for the collisional Vlasov-

**Abstract:**
We discuss the development of asymptotic stable and consistent

**THE QUASI-NEUTRAL AND FLUID LIMITS.**

status and future developments of the field. It also provides a platform for experts in analysis and algorithm in kinetic equations to discuss the current tensive studies in recent years. This minisymposium aims to bring together

**Abstract:**
This leads to multiple spatio-temporal scales which introduce difficulties in applications, it is common that dense and dilute parts coexist in the system. In these occurring in gas dynamics and transport phenomenon, as examples. In these mini-symposium sessions, we will bring some of the most active re-searchers in this field, together with postdocs and students. The purpose is to present the most current results, provoking new ideas, as well as motivate the young researchers to work in the field.

**A Blow Up Analysis of Brakke Mean Curvature Flow**
Fang, Daoyuan
Zhejiang New University
Abstract: In this talk, we will present some results on Oldroyd-B model. We first give the global solution to incompressible Oldroyd-B model with non-small coupling constant in $L^p$ scaling invariant spaces. Secondly, global solution to compressible Oldroyd-B model with non-small coupling constant in $L^p$ scaling invariant spaces is established. Finally, we consider the relation between compressible and incompressible model.

**AN ENERGETIC VARIATIONAL APPROACH FOR ION TRANSPORT**
Xu, Shixin
Soochow University
Liu, Chun
Penn State University
Sheng, Ping
Hong Kong University of Sci. & Tech.

Abstract: The transport and distribution of charged particles are crucial in the study of many physical and biological problems. In this talk, we employ an Energy Variational Approach to derive the coupled Poisson-Nernst-Planck-Stokes system. All of the physics is included in the choices of corresponding energy law and kinetic transport of particles. The variational derivations give the coupled force balance equations in a unique and deterministic fashion. We also discuss the situations with different types boundary-

**A Blow Up Analysis of Brakke Mean Curvature Flow**
Toyogawa, Yoshihiro
Tokyo Institute of Technology

Abstract: Starting with the definition of mean curvature flow in the setting of
Schedules: Monday Sessions

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Geometric Measure Theory due to Brakke, I describe our regularity results of recent years. They include partial regularity theorems for unit density Brakke flow which corresponds to the parabolic extension of Allard regularity theory, and a regularity theorem of triple junction which is a partial extension of Simon’s regularity theorem of singular sets of minimal submanifolds.

- **MS-Mo-E-14-4**
  - **The Mathematical Problems of Isotropic-Nematic Interface**
  - **Zhang, Pingwen**
  - **Peking Univ.**
  - **Abstract:** Liquid crystals represent a vast and diverse class of anisotropic soft matter materials which are intermediate between isotropic liquids and crystalline solids. The various liquid crystal phases can be characterized by the type of ordering: one of the most common liquid crystal phases is the isotropic phase, another is the nematic phase. In this talk, a wide spectrum of mathematical problems of isotropic-nematic interface will be considered. One set of problems to be considered is the relationship between these different levels of modeling, for example how one can make a rigorous passage from molecular/statistical descriptions to continuum theories. Special consideration will be given to the existence, uniqueness and regularity of the solutions of the Landau-de Gennes theory.

- **MS-Mo-E-15-1600–18:00**
  - **Structure of Helicity and Global Solutions of Incompressible Navier-Stokes Equation Jointly with Zhen Lei and Fanhua Lin**
  - **Zhou, Yi**
  - **Fudan Univ.**
  - **Abstract:** In this paper we derive a new energy identity for the general three-dimensional incompressible Navier-Stokes equations by the virtue of a special structure of helicity. The new energy identity is critical with respect to its natural scaling. Moreover, it is conditionally coercive. As an application we construct a family of finite energy smooth large solutions to the Navier-Stokes equations whose critical norms can be arbitrarily large.

- **MS-Mo-E-15-1**
  - **16:00–16:30**
  - **Kobayashi-Warren-Carter Type Models of Grain Boundary Motions with Anisotropies**
  - **Shirakawa, Ken**
  - **Faculty of Education, Chiba Univ.**
  - **Abstract:** In this talk, coupled systems of parabolic type PDEs including anisotropic singular diffusions are considered. These systems are modified versions of the Kobayashi-Warren-Carter model of planar grain boundary motion, and are derived by taking into account the effect such that the Wulff shape rotates in response to the change of crystalline orientation. After the presentation of modeling ideas, the mathematical approaches to our systems will be discussed on the basis of the time-discretization methods.

- **MS-Mo-E-15-2**
  - **16:30–17:00**
  - **Motion of Surfaces by Crystalline Mean Curvature: Viscosity Solutions Approach**
  - **Pozar, Norbert**
  - **Kanazawa Univ.**
  - **Abstract:** In this talk we will introduce an extension of the notion of viscosity solutions in the context of very singular parabolic problems that arise in particular as the level-set formulation of the surface evolution driven by a crystalline mean curvature. We will discuss comparison principle, stability under approximation by regularized problems, and existence of solutions. This talk is based on joint work with Mi-Ho Giga and Yoshikazu Giga from University of Tokyo.

- **MS-Mo-E-15-3**
  - **17:00–17:30**
  - **An Implicit Interface Boundary Integral Method for Mullins-Sekerka Problem**
  - **Tsai, Richard**
  - **The Univ. of Texas at Austin**
  - **Abstract:** We introduce a boundary integral method defined in a tubular neighborhood of an interface without the need for explicit parametrization. This method is applied to evolve an implicit interface according to Mullins-Sekerka dynamics.

- **MS-Mo-E-15-4**
  - **17:30–18:00**
  - **Stability of Crystalline Curvature Flow of a Graph-like Curve**
  - **Nakayasu, Atsushi**
  - **The Univ. of Tokyo**
  - **Abstract:** We study motion of a graph-like curve by crystalline curvature with inhomogeneous driving force. Reflecting the singularity of the anisotropy the equation is non-local. In this talk we will show some results on stability of this equation from a viscosity solutions point of view. A central idea is to find the effective region to determine the quantity of the non-local curvature.

- **MS-Mo-E-16**
  - **16:00–18:00**
  - **Data-driven mathematical models for production and traffic flow - Part II of II**
  - For Part 1, see **MS-Mo-D-16**
  - **Organizer:** HERTY, MICHAEL
  - **Rivera, Goettlich, Simone**
  - **RWTH AACHEN Univ.**
  - **Abstract:** We bring together researchers working on microscopic models based on partial differential equations for modeling nonlinear phenomena in traffic or production. Contrary to existing approaches we emphasize mathematical models obtained from empirical or measured data. The models may be obtained by mean field limits, statistical approaches or by phenomenological approaches. We are interested in mathematical differential models of either kinetic or hyperbolic type commonly observed in the field of traffic and production. The exchange between these two applications should lead to new insights and mathematical techniques.

- **MS-Mo-E-16-1**
  - **16:00–16:30**
  - **Model Fidelity of Data-Fitted Second-Order Traffic Models**
  - **Seibold, Benjamin**
  - **Temple Univ.**
  - **Abstract:** We investigate whether second-order macroscopic traffic models can reproduce the behavior of real traffic flow better than the first-order Lighthill-Whitham-Richards (LWR) model. First, suitable types of second-order models are selected that systematically generalize the LWR model, and thus inherit data-fitting strategies from it. Second, the predictive accuracy of the various models is compared using a version of the three-detector problem test, considering vehicle trajectories and loop sensor data.

- **MS-Mo-E-16-2**
  - **16:30–17:00**
  - **Optimization for Supply Chain Network with Resilient Policy**
  - **Wang, Xinping**
  - **Southeast Univ.**
  - **Zhao, Lindu**
  - **Inst. of Sys. Engineering, School of Economics & Management, Southeast Univ.**
  - **Sun, Shengnan**
  - **Inst. of Sys. Engineering, School of Economics & Management, Southeast Univ.**
  - **Abstract:** We establish a continuum model with partial differential equations of conservation laws to simulate material flow in supply chain networks. Optimal inflow profile and distribution policy are derived to satisfy a given customer demand in normal operation. Taken the optimal setup in normal operation as initial values, we then study resilient policies against possible disruptions of supply chain members. Numerical examples explore influence of different parameters on the optimal decisions of resilient policies.

- **MS-Mo-E-16-3**
  - **17:00–17:30**
  - **Data Based Intersection Modeling with Higher Order Traffic Flow Models of the GSOM Family**
  - **Lebacque, Jean-Patrick**
  - **IFSTTAR**
  - **Khoshyaran, Megan**
  - **ETC Economics Traffic Clinic**
  - **Abstract:** GSOM traffic models are macroscopic models which combine traffic conservation, fundamental diagram and individual driver behavior. They are expressed as systems of conservation equations, for which the inhomogeneous Riemann problem can be solved analytically, allowing efficient numerical solutions and intersection modeling. The object of the paper is to develop intersection models for GSOM models based on the traffic data of the Cipebus project. This data is extensive, includes control information and is density based.

- **CP-Mo-E-16-4**
  - **17:30–17:50**
  - **How Gestures and Diagrams Facilitate Emergence of Mathematical Creations in Supervisor-Graduate Student Research Meetings**
  - **Menz, Petra**
  - **Simon Fraser Univ.**
  - **Abstract:** In this paper I present the preliminary findings of data collected from the mathematics research meetings of two supervisor-graduate student pairs. My study is based on the ideas of the philosopher Gilles CHAMBERLAIN (Figuring Space – Philosophy, Mathematics, and Physics, 2000) that diagrams are the connection and gestures are the articulation between the virtual and
the actual. Through this work, insights into abstract thinking and diagramming as the creative ground for expert mathematicians are provided.

MS-Mo-E-18 16:00–18:30 2098
Nonlinear Dispersive Wave Equations - Part II of II
For Part 1, see MS-Mo-D-18
Organizer: Yanzi, Zhang Missouri Univ. of Sci. & Tech.
Organizer: Cai, Yongyong Beijing Computational Sci. Research Center
Organizer: Lakoba, Taras Univ. of Vermont

Abstract: Nonlinear dispersive wave equations have applications in various fields, such as quantum mechanics, nonlinear optics, fluid dynamics, electromagnetic theory and so on. This mini-symposium focuses on both theoretical and numerical studies on various nonlinear dispersive wave equations. The topics include, but not limited to, existence of traveling wave solutions, orbital stability of solitary waves, numerical algorithms to solve nonlinear wave equations, and numerical computations.

Numerical Methods for (fractional) Schrodinger Equations
Duo, Siwei Missouri Univ. of Sci. & Tech.
Yanzi, Zhang Missouri Univ. of Sci. & Tech.

Abstract: Recently, one debate in the literature is whether the fractional Schrödinger equation in an infinite potential well has the same eigenfunctions as those of its standard (non-fractional) counterpart. Due to the nonlocality of the fractional Laplacian, it is challenging to find the eigenvalues and eigenfunctions of the fractional Schrödinger equation analytically. In this talk, we numerically study the eigenfunctions of the fractional Schrödinger equation.

Multiscale Methods for (fractional) Schrodinger Equations
Duo, Siwei Missouri Univ. of Sci. & Tech.
Yanzi, Zhang Missouri Univ. of Sci. & Tech.

Abstract: Split-step methods have been widely used in solving time-dependent PDEs. In this talk, we discuss the numerical stability of the split-step method for solving the (fractional) nonlinear Schrödinger (NLS) equation. The stable conditions are analyzed for the plane wave solutions, and numerical experiments are provided to verify our analytical results. In addition, the performance of the split-step method is studied and compared in solving the standard and fractional NLS.

Ground States and Dynamics of Spin-orbit-coupled Bose-Einstein Condensates
Cai, Yongyong Beijing Computational Sci. Research Center
Bao, Weizhu National Univ. of Singapore

Abstract: We study analytically and asymptotically as well as numerically ground states and dynamics of two-component spin-orbit-coupled Bose-Einstein condensates (BECs) modeled by the coupled Gross-Pitaevskii equations (CGPEs). In fact, due to the appearance of the spin-orbit (SO) coupling in the two-component BEC with a Raman coupling, the ground state structures and dynamical properties become very rich and complicated.

Kinetic Nonlocal Interaction Models and Zero Inertia Hydrodynamic Limit
Tan, Changhui Univ. of Maryland

Abstract: In this talk, we introduce nonlocal interaction models, which arise from modeling the emergence of complex biological systems. Interactions include attraction, repulsion and alignment. We study the wellposedness of the kinetic system and its zero inertia hydrodynamic limit. The uniqueness of the limiting system is proved by imposing momentum conservation condition. This is a joint work with Razvan Fetcu and Weiiran Sun.

Numerical Methods for Shallow Water Waves Using the Green-Naghdi Equation
Xu, Liwei Chongqing Univ.

Abstract: In this talk, we first introduce a numerical model for the Green-Naghdi equation. Two numerical schemes, including spectral methods and discontinuous Galerkin (DG) methods, are developed to solve the model, and numerical solutions are presented to show the efficiency and accuracy of both numerical models and methods.

MS-Mo-E-19 16:00–18:00 307B
Multiscale methods with applications in fluid mechanics and materials modeling. - Part II of II
For Part 1, see MS-Mo-D-19
For Part 3, see MS-Tu-D-19
Organizer: Brown, Donald Univ. of Bonn
Organizer: Henning, Patrick Univ. of Muenster

Abstract: With this Minisymposium we aim to gather leading researchers in the field of numerical multiscale methods, i.e. methods that are constructed to efficiently tackle differential equations with a large spectrum of length and time scales. The speakers present a wide range of different applications and approaches resulting in an extensive exchange of ideas. Among others, parabolic and hyperbolic multiscale problems are discussed, as well as Maxwell’s equations or the two-phase flow equations in porous media. The minisymposium focuses on the practical aspects of the methods, as well as on questions regarding a corresponding numerical analysis.

Multiscale Methods for Perforated Domains with Applications to Li-Ion Batteries Modeling.
Brown, Donald Peterseim, Daniel Univ. of Bonn Universität Bonn

Abstract: Many porous media applications exhibit complex microstructure and are multiscale in nature. The possible applications include heat conduction in metallic foams and lithium ion batteries. We develop a multiscale method to solve problems in complex porous microstructures. Using a coarse-grid quasi-interpolation operator to define a fine detail space and local orthogonal decomposition, we construct multiscale corrections to coarse-grid basis functions with microstructure. By truncating the corrector functions we produce a computationally efficient scheme.

Model Reduction for Multi-phase Flow in Heterogeneous Media with POD-DEIM
Yang, Yanfang Texas A&M Univ.

Abstract: We propose a global-local model reduction method for fast multi-scale reservoir simulations in highly heterogeneous porous media. We introduce an auxiliary variable in our model reduction that allows achieving a high degree of model reduction. The Discrete Empirical Interpolation Method is used to approximate the nonlinear functions in Newton iterations. Our numerical results, utilizing a two-phase immiscible flow show a substantial speed-up.

Homogenization of the Stochastic Navier–Stokes Equation in Perforated Domains.
Bessaih, Hakima Univ. of Wyoming

Abstract: Some stochastic models are considered including the two dimensional Navier-Stokes equation in a perforated domain with a dynamical slip boundary condition. The dynamics are driven by a noise on the interior and on the boundary of the domain. Different scalings are considered that give rise to different limit problems. For a particular scaling used on the Navier-Stokes equations, we obtain a Darcylaw with memory. We mainly use the two scale convergence method to pass to the limit. Moreover, the passage to the limit is performed on the variational formulation.

Multiscale Techniques for Parabolic Equations
Persson, Anna Chalmers Univ. of Tech.

Abstract: We use the local orthogonal decomposition technique to derive a generalized finite element method for linear and semilinear parabolic equations with spatial multiscale diffusion coefficients. We consider nonsmooth initial data and a backward Euler scheme for the temporal discretization. Convergence of optimal order, depending only on the contrast, but not on the variations in the diffusion coefficient, is proven in the \( L^\infty(L^1) \)-norm.

MS-Mo-E-20 16:00–18:10 210B
Low-rank Tensor Approximation in Multi-parametric and Stochastic PDEs - Part II of II
For Part 1, see MS-Mo-D-20
Organizer: Litvinenko, Alexander KAUST, UQ & ECRC Centers
Organizer: Matthies, Hermann TU Braunschweig, Inst. of Scientific Computing
Organizer: Nouy, Anthony Ecole Centrale Nantes

Abstract: Approximations of stochastic and multi-parametric differential equations may lead to extremely high dimensional problems that suffer from the so
We study the Darcy problem with log-normal permeability. A per-
Problem
Tensor Train Approximation of Moment Equations for the Log-Normal Darcy
Abstract: In this talk, we discuss low-rank tensor techniques for the solution of
parameter-dependent PDEs. In particular, our aim is to adaptively con-
struct approximations in the hierarchical tensor format from a relatively small
set of data samples. Once this approximation from an offline computation
is available, the evaluation of quantities of interest becomes a cheap online

task. Moreover, the explicit tensor representation can be used to compute
stochastic properties of the solution in a straightforward way.

Hierarchical Tensor Approximation of Parameter-dependent PDEs
Ballani, Jonas
EPF Lausanne

Abstract: In this talk, we discuss low-rank tensor techniques for the solution of
parameter-dependent PDEs. In particular, our aim is to adaptively con-
struct approximations in the hierarchical tensor format from a relatively small
set of data samples. Once this approximation from an offline computation
is available, the evaluation of quantities of interest becomes a cheap online

task. Moreover, the explicit tensor representation can be used to compute
stochastic properties of the solution in a straightforward way.

Tensor Train Approximation of Moment Equations for the Log-Normal Darcy
Problem
Nobile, Fabio
MATHICSE - EPFL
Bonizzoni, Francesca
Faculty of Mathematics, Univ. of Vienna
Kressner, Daniel
EPFL

Abstract: We study the Darcy problem with log-normal permeability. A per-
turbation approach around the mean permeability is adopted. The resulting
recursive deterministic problem satisfied by the expected value of the stochas-
tic solution is discretized on a tensor product of finite element spaces and the
solution is sought in a low-rank Tensor Train format. We develop an algorithm
for solving the recursive first moment problem in TT format and show its
effectiveness with numerical examples.

On the Convergence of Alternating Optimisation in Tensor Format Represen-
tations
Espig, Mike
RWTH Aachen Univ.

Abstract: During the last years, tensor format representation techniques were
successfully applied to the solution of high-dimensional problems like
stochastic and parametric partial differential equations. The most popular ap-
proach to low-rank approximation is alternating optimisation like the alternat-
ing least squares (ALS) method. The convergence of alternating optimisation
for tensor format approximation is analysed in this talk. Our theoretical results
are illustrated on explicit examples.

Numerical Solution of the Infinite Dimensional Stochastic LQR Problem
Mena, Hermann
Univ. of Innsbruck

Abstract: We consider a stochastic linear quadratic regulator (SLQR) control
problem on Hilbert spaces. For a well-posed SLQR problem, the optimal con-
roll is given in terms of a stochastic Riccati equation and a backward stochas-
tic differential equation. Existence and uniqueness of the solutions are avail-
able only for certain special cases. We investigate the numerical treatment of
the SLQR problem, in particular, the convergence of the Riccati operators.
In addition, we discuss efficient numerical methods for solving large-scale s-
 tochastic Riccati equations arising from the discretization. The performance
of our approach is illustrated by numerical results.

An Algorithm for Finding the Spectral Radius of Nonnegative Tensor
Qingzhi, Yang
Nankai Univ.

Abstract: In this talk, based on an algorithm proposed by Ng, Qi and Zhou
for finding the spectral radius of nonnegative irreducible tensor, we present a
method to solve the spectral radius for general nonnegative tensor by using in-
exact inner loop strategy. And we give the convergence result and computing
complexity of the algorithm.

Waves and tomography in geosciences and medical imaging
Organizer: Leung, Shingyu
Hong Kong Univ. of Sci. & Tech.
Organizer: Chung, Eric
The Chinese Univ. of Hong Kong
Organizer: Qian, Jianliang
Michigan State Univ.

Abstract: Wave propagation and related tomography problems are essential
components for many applications including geosciences and medical imaging.
There are in literature various works that address some of the issues
arising from these applications, such as discretization techniques, multiscale
modeling, fast solvers and inversion algorithms. However, many challenging
open problems remain. The aim of this minisymposium is therefore to bring
together researchers in the fields to exchange recent advances and ideas, as
well as to foster interdisciplinary collaborations.

Theory and Numerics of Wave-luminescence Tomography
Ren, Kui
Univ. of Texas at Austin

Abstract: In wave-luminescence imaging (WLI), we use waves such as ul-
trasound and microwaves to generate luminescent light inside a scattering
medium. We then measure on the surface of the medium outgoing photon
density. From this measurement, we intend to image the distribution of the
luminescence source inside the medium. We present here some recent the-
oretical and numerical results on WLI in various simplified settings. We show
how to construct “good” probing waves for stable reconstructions.

Multi-layer Structures for the Direct Solution of High Dimensional Problems
Xia, Jianlin
Purdue Univ.

Abstract: We propose multi-layer hierarchically semiseparable (HSS) struc-
tures for the efficient factorizations of dense matrices arising from high dimen-
sional discretized problems. The problems include discretized integral equa-
tions and dense Schur complements in the factorizations of discretized PDEs.
Unlike existing work on hierarchically semiseparable (HSS) structures which is
essentially 1D, the HSS framework integrates multiple layers of rank and

tree structures. We lay theoretical foundations for HSS structures and justify
the feasibility of HSS approximations for these dense matrices. Rigorous rank
bounds for the low-rank structures are given. Representative subsets of mesh
points are used to illustrate the multi-layer structures as well as the structured
factorization. Systematic fast and stable MHS algorithms are proposed, par-
ticularly convenient direct factorizations. The new structures and algorithms
can yield direct solvers with nearly linear complexity and linear storage for
solving some practical 2D and 3D problems.

High-order Factorization of Traveltime and Amplitude with Applications in Ge-
ometrical Optics
Luo, Songlin
Iowa State Univ.

Abstract: We present an factorization approach to resolve the source singu-
larities of traveltime and amplitude when solving the eikonal and transport
equations that result from geometrical optics approximations of high frequen-
cy wave propagation governed by Helmholtz equation. The factorization ap-
proach facilitates efficient computation of high accuracy phase and amplitude,
which in return are used to rebuild faithful waves. The approach is further uti-
ized in the fast Huygens sweeping method that is designed to capture the
cautics.

Advances in Seismic Diffraction Imaging
Fomel, Sergey
The Univ. of Texas at Austin

Abstract: Unlike specular reflections, which are created by continuous reflec-
tors, diffraction waves are caused by small discontinuities in reflectivity. Us-
ing recently developed techniques, it is possible to separate diffractions from
specular reflections and to utilize them for high-resolution subsurface imag-
ing and inversion. We describe recent developments in the field of seismic
diffraction imaging, including the use of dip-angle gathers, oriented velocity
continuation, and double-path-integral imaging.

Reverse Time Migration Based on Generalized Multiscale Finite Element For-
ward Modeling
Fu, Shubin
Texas A&M Univ.

Abstract: Wave equation migration methods provide accurate and detailed
subsurface images by incorporating the influence of complex wave arrivals
and features that are not included in solutions based on ray theory. We apply
the generalized multiscale finite element method for reverse time migration.
Results shows multiscale RTM produces accurate images with a significant
We present recovery-based a posteriori error estimators for finite element approximations of elliptic PDEs typically contain parameters, which are known only up to some limited regularity assumptions. Robust adaptive numerical methods are a posteriori error estimators that are able to accurately locate sources of global and local error in the current approximation. Talks in this mini-symposium will cover some recent advances in the development and analysis of both a posteriori estimators and (convergent) adaptive schemes, as well as indicate directions of future research.

- **Robust A Posteriori Error Analytical Techniques for Second and Fourth Order Elliptic Singularly Perturbed Problems**
  - Shaohong, Du
  - Chongqing Jiaotong Univ./Beijing Computational Sci. Research Center
  - Zhimin, Zhang
  - Beijing Computational Sci. Research Center, Wayne State Univ.
  - Abstract: For singularly perturbed problems, a novel dual norm is introduced, under which robust residual-type and recovery-type a posteriori error estimators are analyzed. For fourth order elliptic singularly perturbed problems, a new size of the error for its mixed finite element methods is presented, and a novel analytical technique is developed to obtain robust residual-based a posteriori estimator in this size. Numerical experiments are reported to support theoretical results.

- **Functional A Posteriori Error Estimates and Incompletely Known Data**
  - Mali, Olli
  - Univ. of Jyvaskyla
  - Repin, Sergey
  - Univ. of Jyvaskyla
  - Neittaanmaki, Pekka
  - Univ. of Jyvaskyla
  - Abstract: In this talk, the error estimates of functional type are used to study the effect of incompletely known data in problems generated by elliptic PDEs. PDEs typically contain parameters, which are known only up to some limited accuracy. The error estimates of functional type have suitable properties for a worst case scenario type analysis; they do not rely on any numerical method, they are guaranteed, and they depend explicitly on the problem data.

- **Local H(div) Recovery-based A Posteriori Error Estimators for Elliptic Equations**
  - Zhang, Xu
  - Purdue Univ.
  - Cai, Zhiqiang
  - Purdue Univ.
  - Abstract: We present recovery-based a posteriori error estimators for finite element approximation of elliptic equations. The flux is recovered in $H(div)$-conforming finite element subspaces by approximating equilibrium and constitutive equations simultaneously in a weighted $H(div)$ norm. The recovery techniques are performed locally on appropriate patches of triangular elements. A posteriori error estimators are constructed based on difference of numerical flux and recovered flux. We will discuss the reliability and efficiency bounds of these local error estimators.

- **Testing Computationally the Instance Optimality of Adaptive Finite Element Methods**
  - Veeser, Andreas
  - Univ. of Milan
  - Fierro, Francesca
  - Univ. of Milan
  - Schmidt, Alfred
  - Univ. of Bremen, Centre for Industrial Mathematics
  - Abstract: Basing upon a localization of the error of the Ritz projection (Veeser, submitted) and adaptive tree approximation (Binev/DeVore '04), we approximately compute best errors with respect to the number of degrees of freedom and compare them with the corresponding errors of the adaptive finite element method. Our computational results complement the theoretical ones (e.g., Diening/Kreuzer/Stevenson '14) in which the error is augmented by the oscillation of the estimator.

- **Computable Error Estimates for Monte Carlo Finite Element Approximation of Elliptic PDE with Lognormal Diffusion Coefficients**
  - Hall, Eric
  - KTH Royal Inst. of Tech.
  - Hoel, Haakon
  - Univ. of Oslo
  - Sandberg, Mattias
  - KTH Royal Inst. of Tech.
  - Szepessy, Anders
  - KTH Royal Inst. of Tech.
  - TEMPONE, RAUL
  - KING ABDULLAH Univ. of Sci. & Tech.
  - Abstract: The Monte Carlo (and Multi-level Monte Carlo) finite element method can be used to approximate observables of solutions to diffusion equations with lognormal distributed diffusion coefficients, e.g. modeling ground water flow. Typical models use lognormal diffusion coefficients with Hölder regularity of order up to 1/2 a.s. This low regularity implies that the...
high frequency finite element approximation error (i.e. the error from frequencies larger than the mesh frequency) is not negligible and can be larger than the computable low frequency error. We address how the total error can be estimated by the computable error.

**Finite Element Analyses on Optimal Control Problems Constrained by Stochastic PDEs**

Sun, Tongjun (Shandong Univ.)

**Abstract:** We consider optimal control problem governed by PDEs with stochastic perturbation in its coefficients. The objective is to minimize the expectation of a cost functional with the constrained control. We represent the stochastic PDEs in term of the generalized polynomial chaos expansion and obtain the deterministic optimal problem. By applying the well-known Lions’ Lemma, we obtain the necessary and sufficient optimality conditions. We establish a scheme to approximate the optimality system with respect to both the spatial space and the probability space by Stochastic Galerkin method. Then prior error estimates are derived for the state, the co-state and the control variables. Numerical examples are presented to illustrate our theoretical results.

**Recent Advances in Kinetic Equations: Numerical Methods and Their Applications - Part II of II**

For Part I, see MS-Mo-D-24

**Organizer:** Haack, Jeff (Los Alamos National Laboratory)
**Organizer:** Hu, Jingwei (Purdue Univ.)
**Organizer:** Tang, Min (Shanghai Jiao Tong Univ.)

**Abstract:** Kinetic equations and related models play an important role in many science and engineering branches. Examples include: gas/plasma dynamics, radiative transfer, semiconductor modeling, complex systems in biological or social sciences, etc. Designing numerical methods in these applications present similar challenges, ranging from multiscale modeling, nonlinear analysis, to large computational expense requiring high performance computing. This minisymposium aims to report the recent progress in the development of numerical methods for various kinetic equations, and by bringing researchers from diverse fields, to stimulate new problems and methods.

**Rescaling Velocity Methods for Kinetic Equations Coming from Physics and Biology**

Rey, Thomas (Lille 1 Univ.)

**Abstract:** Rescaling velocity methods have been widely used in the last years to solve numerically a large class of partial or even integro-differential equations exhibiting concentration or spreading, without the use of remeshing technique. In this talk, I will review the current literature on the topic, and present some results obtained in collaboration with Francis Filbet and Changhui Tan.

**Multi-species BGK with Velocity Dependent Cross Section for Dense Plasmas**

Haack, Jeff (Los Alamos National Laboratory)

**Abstract:** In this talk, I will present joint work with C. Hauck (ORNL) and M. Murillo (LANL) on velocity-dependent multi-species BGK models for dense plasmas. This model improves on the ad-hoc nature of ‘traditional’ BGK and can directly incorporate different cross section models.

**Convergence of Filtered Spherical Harmonic Equations for Radiation Transport**

Kuepper, Kerstin (RWTH Aachen Univ.)
Frank, Martin (RWTH Aachen Univ.)

**Abstract:** We analyze the global convergence properties of the filtered spherical harmonic (FPH) equations for radiation transport. The well-known spherical harmonic (PN) equations are a spectral method (in angle) for the radiation transport equation and are known to suffer from Gibbs phenomena around discontinuities. The filtered equations include additional terms to address this issue that are derived via a spectral filtering procedure.

**Fast Semi-Lagrangian Schemes for Kinetic Equations**

Dimarco, Giacomo (Univ. of Ferrara)

**Abstract:** A new class of semi-Lagrangian schemes is discussed. The purpose is to drastically reduce the cost related to the discretization of the linear transport part by fixing the shape of the distribution function once for all avoiding reconstructions to find the feet of the characteristic. Hence, the cost of the solution of the original kinetic equation is almost entirely due to the projection of the solution onto the grid to compute the collision operator.
rates for divergence-conforming B-spline spaces, and applications including incompressible and mass transport coupled flows to illustrate the accuracy of our framework.

**MS-Mo-E-25-4**

T-splines and Generalized T-splines

Bracco, Cesare

Univ. of Florence

Cho, Durbin

Dongguk Univ.

Abstract: T-splines are a generalization of the classical tensor-product B-splines based on meshes (called T-meshes) which allow T-junctions, that is, vertices which are endpoints of less than 4 edges, unlike in the tensor-product case. The use of such meshes is very relevant since it allows to adopt local refinement techniques. The talk will present several results about T-splines, in particular concerning their linear independence and their generalization to a noteworthy non-polynomial case (Generalized T-splines),

**MS-Mo-E-25-5**

Regularization of Inverse Problems on Manifolds by Isogeometric Discretization

Dong, Guozhi

Univ. of Vienna

Abstract: In this talk, we will present some results on the regularization within inverse problems defined on a manifold domain. We do a comprehensive convergence analysis, including error estimates on both the regularization models and the numerical approximates. The analysis shows that when a so-called isogeometric regularization may be applied. This is a joint work with Bert Juttler, Otmar Scherzer and Thomas Takacs.

**MS-Mo-E-26**

Perturbation theory for linear/nonlinear eigenvalue problems in action - Part II of II

For Part 1, see MS-Mo-D-26

Organizer: Nakatsukasa, Yuji

Univ. of Tokyo

Organizer: Miedlar, Agnieszka

EPF Lausanne

Abstract: In numerical analysis, perturbation theory has earned their fame as primarily theoretical contributions, but nonetheless their role in practical computations is crucial. Perturbation results are used extensively for analyzing stability of numerical algorithms or the accuracy of numerical approximation, and sometimes to inspire new algorithm design. Applications include solving PDEs, simulating dynamical systems and model reduction. With the goal to share its beauty and practical importance to a broader audience, this minisymposium reviews classical and recent outstanding results and open problems in eigenvalue perturbation theory, treating both matrices (linear, polynomial and general nonlinear eigenvalue problems) and linear operators.

**MS-Mo-E-26-1**

Tropical Diagonal Scaling for Asymptotic Eigenvalue Problems

Marchesini, Andrea

Ecole polytechnique

Abstract: We study the behaviour of the eigenvalues of a parametric matrix polynomial Q in a neighbourhood of zero. If we suppose that the entries of Q have Puiseux series expansion, we can build an auxiliary matrix polynomial Q whose entries are the leading exponents of those of P. We show that preconditioning P via a diagonal scaling based on the tropical eigenvalues of Q can improve conditioning and backward error of the eigenvalues.

**MS-Mo-E-26-2**

Moving A Specified Eigenvalue and Eigenvector

Nakatsukasa, Yuji

Univ. of Tokyo

Fukaya, Takeshi

Hokkaido Univ.

Miedlar, Agnieszka

TU Berlin

Abstract: Given a simple eigenvalue and its corresponding right/left eigenvectors, we derive a perturbation that moves the eigenvalue or/and the associated eigenvector, such that the other eigenvalues and eigenvectors stay unaffected by the perturbation. We discuss extensions to generalized and quadratic eigenvalue problems. Such perturbation can be useful for example for deflation techniques, increasing the spectral gap or determining the set of linearly independent eigenvectors and computing the matrix exponential.

**MS-Mo-E-26-3**

Matrix Nearness Problems for Lyapunov-type Stability Domains

Kostic, Vladimir

Univ. of Novi Sad

Miedlar, Agnieszka

EPF Lausanne

Abstract: We consider Lyapunov-type domains in their general setting and formulate two appropriate matrix nearness problems - the distance to destabilization and distance to localization - which generalize the distance to instability and the distance to stability, in both, discrete and continuous sense. Then, we present numerical algorithms for their solution. Performed computations cover different cases for medium size and large sparse matrices that come from different scientific and industrial applications.

**MS-Mo-E-27**

Numerical Simulations in Poromechanics - Part II of III

For Part 1, see MS-Mo-D-27

For Part 3, see MS-Tu-D-27

Organizer: Gaspar, Francisco

Univ. of Zaragoza

Organizer: Hu, Xiaozhe

Tufts Univ.

Organizer: Rodrigo, Carmen

Univ. of Zaragoza

Organizer: Zikatanov, Ludmil

The Pennsylvania State Univ.

Abstract: Poromechanics studies the interactions between fluid motion and deformation in porous media. It has important applications including consolidation, subsidence due to fluid withdrawal, and hydraulic fracturing. Many elastoplastic models and solver schemes have been developed for poromechanics but the design of effective simulation techniques for handling the coupling between fluid motion and solid deformation is still a challenging task. The main theme of the minisymposium is on the advanced numerical algorithms for simulating poromechanics. The focus is on robust discretizations, adaptivity and efficient nonlinear and linear solvers for various poroelastic models and their applications.

**MS-Mo-E-27-1**

A Mixed Finite Element Method for the Biot's Interface Problem

Yi, Son-Young

Univ. of Texas at El Paso

Abstract: We consider the Biot model in heterogeneous porous media. The discontinuities of the material coefficients give rise to an interface problem of the Biot model, with a physically consistent set of interface conditions. We discretize the equations using a mixed FEM that uses pore pressure, fluid flux, displacement, and total stress as primary unknowns. We discuss the issue of locking and also present a block preconditioner for the resulting saddle point system.

**MS-Mo-E-27-2**

Block Preconditioners for Poromechanics Problems

Bhateja, Radim

Inst. of Geonics CAS

Abstract: Numerical solution of poroelasticity problems discretized in space by Courant elements for solids, Raviart-Thomas elements for fluid velocities and piecewise constants for pressures is considered. Time discretization uses backward Euler or higher order methods. Schur complement based block preconditioners are investigated for the solution of the arising saddle point systems with a special emphasis on those using grad-div augmented blocks. The influence of inexact solution of subproblems, robustness and application to nonlinear poromechanics is discussed.

**MS-Mo-E-27-3**

Auxiliary Space Multigrid Method for Poroelasticity Problem

Kraus, Johannes

Univ. of Duisburg-Essen

Abstract: We consider a poroelasticity problem which couples the elastic behavior of fully saturated porous media with flow of an incompressible fluid. For the arising linear system we study a family of block type preconditioners based on an additive approximation of the Schur complement resulting from elimination of the pressure unknown. The proposed method to solve the reduced system is an auxiliary space multigrid method that combines techniques from domain decomposition, multigrid, and auxiliary space preconditioning.

**MS-Mo-E-27-4**

Solution of Stable Discretizations of the Biot's Consolidation Problem by Monolithic Multigrid Solvers

Gaspar, Francisco

Univ. of Zaragoza

Hu, Xiaozhe

Tufts Univ.

Rodrigo, Carmen

Univ. of Zaragoza

Zikatanov, Ludmil

The Pennsylvania State Univ.

Abstract: Numerical difficulties arise in the solution of the poroelasticity problem, appearing non-physical oscillations in the pressure field approximation. When non stabilized discretizations are used. Besides, a very important aspect is the efficient solution of the resulting system after the discretization of
Abstract: Development of C++ Libraries for the Weak Galerkin Finite Element Methods

MS-Mo-E-28 16:00–18:00 109
Weak Galerkin Method and Its Applications - Part II of III
For Part 1, see MS-Mo-D-28
For Part 3, see MS-Tu-D-28
Organizer: Chen, Long
Univ. of California at Irvine
Organizer: Ye, Xiu
Univ. of Arkansas at Little Rock
Organizer: Zhang, Ran
Jilin Univ.

Abstract: The Weak Galerkin method is an extension of the standard Galerkin finite element method where classical derivatives were substituted by weakly defined derivatives on functions with discontinuity. As such, the WG methods have the flexibility in handling complex geometry and low regularity solutions, the simplicity in analyzing real-world physical problems, and the symmetry in reformulating the original PDEs. The aim of this mini-symposium is to bring together specialists in order to exchange ideas regarding the development of WG-FEMs and its industry and research applications. Since women are an underrepresented group in mathematics and engineering, we pay a particular attention to attract female participants.

► MS-Mo-E-28-1 16:00–16:30
A Two-level Algorithm for Weak Galerkin Methods for Diffusion Problems
Xie, Xiaoping
Sichuan Univ.

Abstract: We develop a two-level algorithm for the weak Galerkin (WG) finite element methods based on local RT and BDM mixed elements for two- and three-dimensional diffusion problems. We first show the condition numbers of the stiffness matrices arising from the WG methods are of $O(h^{-2})$, then derive the convergence of the algorithm without any regularity assumption. Finally we provide some numerical results. This work is joint with Binjie Li.

► MS-Mo-E-28-2 16:30–17:00
The Lower Bounds of Eigenvalue Problems by Weak Galerkin Method
Zhang, Ran
Jilin Univ.

Abstract: This article is devoted to computing the eigenvalue and its lower bounds of the Laplace eigenvalue problem by a weak Galerkin (WG) finite element methods. The WG method is on the use of weak functions and their weak derivatives defined as distributions. The WG method is highly flexible by allowing the use of discontinuous functions on arbitrary polygons or polyhedra with certain shape regularity.

► MS-Mo-E-28-3 17:00–17:30
Development of C++ Libraries for the Weak Galerkin Finite Element Methods
Liu, Jianguo
Colorado State Univ.

Abstract: In this talk, we present preliminary results on development of C++ libraries for the weak Galerkin (WG) finite element methods. We will show how inheritance and polymorphism are implemented in C++ code for the WG finite elements. Integration of the WG C++ libraries with other scientific computing libraries, e.g., PETSc and VisIt, will be demonstrated. We shall also present simulations of 3-dim Darcy flow computation using the WG C++ library.

► MS-Mo-E-28-4 17:30–18:00
BDDC Domain Decomposition Algorithms for Weak Galerkin Methods
Tu, Xuejin
Univ. of Kansas

Abstract: A Balancing domain decomposition by constraints (BDDC) algorithm is studied for solutions of large sparse linear algebraic systems arising from weak Galerkin discretization of second order elliptic boundary value problems. The condition number for the preconditioned system is estimated and numerical results are provided to confirm the results.

► MS-Mo-E-29 16:00–18:00
Multilevel Monte Carlo methods and applications - Part II of III
For Part 1, see MS-Mo-D-29
For Part 3, see MS-Tu-D-29
Organizer: TEMPOLE, RAUL
KING ABDULLAH Univ. Of. Sci. & Tech.
Organizer: Giles, Michael
Univ. of Oxford
Organizer: Nobile, Fabio
MATHICSE - EPFL

Abstract: Monte Carlo methods are general, flexible sampling methods for the computation of expected values of observables arising in stochastic systems. Monte Carlo methods are very attractive since they are simple to implement and their rate of convergence is very robust. Still, in the context of random evolution of large systems arising from the discretization of differential equations subject to randomness, their cost can be too large for practical purposes. The recently matured Multilevel Monte Carlo method extended, to multiple levels, the idea of using a coarse numerical approximation as a method for control variance to a finer one, reducing the variance and the required number of samples on the finer grid. Multilevel Monte Carlo changed the computational landscape of stochastic problems described in terms of differential equations, which are commonplace, for instance, when carrying out Uncertainty Quantification in applications. In this mini-symposium we intend to present the latest algorithmic and theoretical contributions to Multilevel Monte Carlo methods, focusing also on novel applications arising in, among others, stochastic social, chemical and biological modeling, wireless communication networks, computational finance, stochastic particle systems and engineering modeling with random PDEs.

► MS-Mo-E-29-1 16:00–16:30
Multilevel Quasi-Monte Carlo Methods for Lognormal Diffusion Problems
Kuo, Frances
Univ. of New South Wales

Abstract: In this joint work with Rob Scheichl (Bath), Christoph Schwab (Zurich), Ian Sloan (UNSW), and Elizabeth Ullmann (Hamburg), we analyze a multilevel quasi-Monte Carlo scheme applied to linear functionals of solution of a model steady-state flow in porous media. The permeability is modeled as a lognormal random field, leading to Gaussian integrals. Much emphasis is placed on the design of QMC rules that achieve dimension-independent error bounds with good convergence rates and under weak assumptions.

► MS-Mo-E-29-2 16:30–17:00
Multi-level Simulation of SPDEs Arising from Large Particle Systems
Reisinger, Christoph
Oxford Univ.

Abstract: We present two multilevel algorithms for the simulation of large systems of exchangeable SDEs. The first one constructs a multilevel structure by nested systems of SDEs of smaller dimensionality, while the second one uses the limiting stochastic partial differential equation governing the infinite-dimensional system and applies the multilevel idea on the level of the spatial and time mesh. We prove optimal complexity bounds for a model problem and show applications to more complex models.

► MS-Mo-E-29-3 17:00–17:30
Estimation of Central Statistical Moments with MLMC and Applications
Chernov, Alexey
Univ. of Oldenburg
Bierig, Claudia
Univ. of Reading

Abstract: In this talk we review the general methodology of the Multilevel Monte Carlo method for estimation of the variance and higher order central statistical moments for forward uncertainty propagation, address convergence of the estimators and indicate possible extensions. We illustrate the performance of the proposed approach on a model problem of contact between an elastic membrane and a rigid rough random surface.

► MS-Mo-E-29-4 17:30–18:00
Improving MLMC for SDEs with Applications to the Langevin Equation and Atmospheric Dispersion
Mueller, Eike
Univ. of Bath
Scheichl, Robert
Univ. of Bath
Sharpard, Tony
Univ. of Bath

Abstract: We apply several well-known tricks to improve the efficiency of the Multilevel MC method for SDEs: modified equations analysis as an alternative to strong-approximation theory for the integrator; operator splitting techniques; extrapolation; and discrete random variables in place of Gaussian increments. We extend the MLMC complexity theorem to allow for bias between the levels and show that combined our modifications can lead to an increase in efficiency of almost two orders of magnitude in practice.

► MS-Mo-E-30 16:00–18:00
Recent Advances in the Solution of Least Squares Problems
Organizer: Hayami, Ken
National Inst. of Informatics

Abstract: Least squares problems appear in many important applications in science and engineering. Recently, there have been many developments in the solution of least squares problems of various kinds. Examples are fast and robust solvers for large scale least squares problems combining Krylov subspace methods with efficient preconditioners such as stationary inner iterations or balanced incomplete factorization. There are also advances in other kinds of least squares problems, such as nonnegative constrained least squares problems, nonlinear least squares problems, total least squares problems and integer least squares problems etc. This mini-symposium will address advances in recent advances in such areas.
squares (TLS) problems and develop randomized algorithms for the TLS and the truncated total least squares (TTLS) solutions of large-scale discrete ill-posed problems.

- **MS-Mo-E-30-2 16:30–17:00**
  - **Some Efficient Hybrid Algorithms for Large Scale Non-negative Constrained Least Squares Problems**
  - Zheng, Bing
  - Lanzhou Univ.
  - Zheng, Yu-Tao
  - Lanzhou Univ.
  - **Abstract:** Inspired by the successive projection method, some efficient hybrid algorithms with active-set methods are presented, which make active-set methods suitable for solving large scale non-negative constrained linear least squares problems. The convergence analysis for the hybrid algorithms is discussed under some proper assumptions. The numerical experiments show that these hybrid algorithms can outperform the existing methods. This hybrid process is also applied for efficiently solving the problems with multiple right-hand terms.

- **MS-Mo-E-30-3 17:00–17:30**
  - **Integer Least Squares Estimation: Theory and Algorithms**
  - Chang, Xiao-Wen
  - McGill Univ.
  - **Abstract:** Integer least squares (ILS) problems arise from many applications. We first review some theory about ILS estimation. In particular we present two theoretical results, which rigorously justify the use of the well-known LLL reduction as preprocessing for solving ordinary ILS problems. Then we review some numerical approaches for solving ILS problems. We will focus on the widely used discrete enumeration approach. Some lower bounds will be presented to prune the search tree.

- **MS-Mo-E-30-4 17:30–18:00**
  - **Modulus Iterative Methods for Box Constrained Least Squares Problems**
  - Zheng, Ning
  - The Graduate Univ. for Advanced Studies
  - Hayami, Ken
  - National Inst. of Informatics
  - Yin, Jun-Feng
  - Tongji Univ.
  - **Abstract:** For the solution of large sparse box constrained least squares problems (BLS), a new iterative method is proposed by using CG method for inner iterations and the modulus iterative method in the outer iterations for the solution of linear complementarity problem resulting from Karush-Kuhn-Tucker conditions of BLS problem. Theoretical convergence analysis is presented. Numerical experiments show the efficiency of the proposed methods compared to projection methods with less iteration steps and CPU time.

- **MS-Mo-E-31 16:00–18:00**
  - **Numerical Computation with Functions and Chebfun - Part II of III**
  - For Part 1, see MS-Mo-D-31
  - For Part 3, see MS-Tu-D-31
  - **Organizer:** Trefethen, Lloyd N.
  - Univ. of Oxford
  - **Organizer:** Guettel, Stefan
  - The Univ. of Manchester
  - **Abstract:** A recent theme in algorithms and software is efficient numerical computation with functions in a manner that "feels symbolic" since the accuracy is high and underlying discretizations (Chebyshev, Fourier,...) are hidden from the user. Projects of this kind include Chebfun, pychebfun, ApproxFun, and PaCAL. A pervasive theme in this work is the use of continuous analogues of familiar discrete mathematical objects and algorithms. This minisymposium will present new developments in the areas of (1) differential and integral equations, (2) working with functions, and (3) rootfinding and linear algebra.

- **MS-Mo-E-31-1 16:00–16:30**
  - **A Fast and Well-conditioned Spectral Method for Solving Singular Integral Equations**
  - Slepyrev, Richard Mikhail
  - Univ. of Oxford
  - **Abstract:** From fracture mechanics and fluid dynamics to acoustic and electromagnetic scattering, boundary integral equations reduce the dimensionality of the underlying partial differential equations by one. The tradeoff for this reduction in complexity is the introduction of singular integral kernels. In this work, we use several remarkable properties of Chebyshev polynomials including their spectral convergence, their Hilbert and Cauchy transforms, and low rank bivariate approximations to construct a fast and well-conditioned spectral method.

- **MS-Mo-E-31-2 16:30–17:00**
  - **Rectangular Differentiation Matrices**
  - Xu, Kuan
  - Univ. of Oxford
  - **Abstract:** The emergence of rectangular spectral collocation methods offers a novel but more flexible and robust way to implement boundary condition-
Abstract: We propose a decomposition approach for uncertainty analysis of systems governed by partial differential equations (PDEs). The system is split into local components using domain decomposition. Our domain-decomposed uncertainty quantification (DDUQ) approach performs uncertainty analysis independently on each local component in an “offline” phase, and then assembles global uncertainty analysis results using pre-computed local information in an “online” phase.

A Domain Decomposition Approach for Uncertainty Analysis
Liao, Qileng ShanghaiTech Univ.

Abstract: We propose a decomposition approach for uncertainty analysis of systems governed by partial differential equations (PDEs). The system is split into local components using domain decomposition. Our domain-decomposed uncertainty quantification (DDUQ) approach performs uncertainty analysis independently on each local component in an “offline” phase, and then assembles global uncertainty analysis results using pre-computed local information in an “online” phase.

Abstract: Energy corrected schemes compensate the pollution effect for finite element problems where local point singularities otherwise lead to a globally reduced order of convergence. The energy correction recovers the optimal far-field convergence. This is achieved computationally by only a local change of a few coefficients of the standard stiffness matrix, whose structure remains otherwise unchanged. In this reduced order approach, no mesh grading is needed nor explicitly enlarging the finite element space.

Energy Corrected Schemes in Flow Problems for Optimal Control
Ruede, Ulrich FA Univ. Erlangen
Wohlhmut, Barbara Technische Universitaet Muenchen
Pustejovska, Petra Technische Universitaet Muenchen
John, Lorenz Technische Universitaet Muenchen

Abstract: Energy corrected schemes compensate the pollution effect for finite element problems where local point singularities otherwise lead to a globally reduced order of convergence. The energy correction recovers the optimal far-field convergence. This is achieved computationally by only a local change of a few coefficients of the standard stiffness matrix, whose structure remains otherwise unchanged. In this reduced order approach, no mesh grading is needed nor explicitly enlarging the finite element space.

Stabilization and Fine-tuning of Projection-based Reduced Order Models for Compressible Flow via Minimal Subspace Rotation on the Stiefel Manifold
Tezaur, Irina Sandia national Laboratories
Balajewicz, Maciej Stanford Univ.

Abstract: For a ROM to be stable and accurate, the dynamics of the truncated subspace must be accounted for. This talk proposes an approach for stabilizing and fine-tuning projection-based fluid ROMs in which truncated modes are accounted for a priori via minimal rotation of the projection subspace. No empirical turbulence modeling terms are required. Mathematically, the approach formulates a quadratic matrix program on the Stiefel manifold. The method is evaluated on incompressible and compressible flow problems.

Random Graphs and Complex Networks - Part II of II
For Part 1, see MS-Mo-D-32

Organizer: Han, Dong Shanghai Jiao Tong Univ.
Organizer: Wu, Xian Yuan School of Math. Sci., Capital normal Univ.
Organizer: Zhang, Xiao-Dong Shanghai Jiao Tong Univ.


Asymptotic Behavior for Long-range Self-Avoiding Walks in High Dimensions
Chen, Lung-Chi National Chengchi Univ.

Abstract: We consider long-range self-avoiding walk on $\mathbb{Z}^d$ whose 1-step distribution is given by $D$. Suppose that $D(x)$ decays as $|x|^{-d-\delta}$ with $\delta > 2$. The upper-critical dimension $d_c$ is $2/(\alpha+2)$ for self-avoiding walk. Assume certain heat-kernel bounds on the $n$-step distribution of the underlying random walk. In this talk, I present that the critical two-point function obeys various critical exponents take on their respective mean-field values if the dimension $d > d_c$.

Limiting Spectral Distribution of Random Birth-death Q Matrices
Han, Dong Shanghai Jiao Tong Univ.
Zhang, Deng Shanghai Jiao Tong Univ.

Abstract: This article studies the limiting spectral distributions of random birth-death Q matrices. Under the strictly stationary ergodic conditions, we prove that the empirical spectral distribution converges weakly to a non-random probability distribution. Furthermore, in the situations without strictly stationary ergodic conditions, we study a class of random birth-death Q matrices, corresponding to generalizations of the Beta-Hermite ensemble, and establish the existences as well as convolution formulations of their limiting spectral distributions.

Phase Transition on the Degree Sequence of A Random Graph Process with Vertex Copying and Deletion
Dong, Zhao Acad. of Mathematics & Sys. Sci., CAS

Abstract: This paper focuses on the degree sequence of a random graph process with copying and vertex deletion. A phase transition is revealed as the following: when copying strictly dominates deletion, the model possesses a power law degree sequence; and when deletion strictly dominates copying, it possesses an exponential one; otherwise, the model possesses an intermediate degree distribution. Author: Kai-Yuan Cai, Zhao Dong, Ke Liu, Xian-Yuan Wu.

Interplay between Collective Behavior and Spreading Dynamics on Complex Networks
Fu, Xinchu Shanghai Univ.

Abstract: Based on the dynamical characteristics and traditional physical models, we construct several new bidirectional network models of spreading phenomena. By theoretical and numerical analysis of these models, we find that the collective behavior can inhibit spreading behavior, but, conversely, this spreading behavior can accelerate collective behavior. The results show that an effective spreading control method is to enhance the individual awareness to collective behavior.

Computational Methods and Applications for the Boltzmann Equations - Part II of II
For Part 1, see MS-Mo-D-34

Organizer: Wang, Yanli Inst. of Applied Physics & Computational Mathematics

Abstract: The Boltzmann equation is very important in a number of high-tech fields such as the space exploration, plasma and the semiconductor simulations. However, the numerical cost of solving the Boltzmann equation directly in large systems is still unaffordable. The highly efficient numerical solvers are needed to solve this problem. Or, people may build the simplified models instead of directly solving the Boltzmann equation, where the moment method is the main method. The numerical difficulties in different application areas also vary greatly and are always hard to solve. Numerical methods to solve the Boltzmann equation are also widely used in these related application areas. Recently, the research on direct Boltzmann solvers and moment methods together with their applications are very active. The purpose of this mini-symposium is to gather most representative researchers and report their progress. It invites speakers from different parts of the world and provides a good opportunity to exchange ideas.

Direct Modeling for Computational Fluid Dynamics
Xu, Kun Hong Kong Univ. of Sci. & Tech.

Abstract: Computational fluid dynamics (CFD) studies the flow motion in a discretized space. Its basic scale resolved is the mesh size and time step. The CFD algorithm can be constructed through a direct modeling of flow motion in such a space. This talk will present the principle of direct modeling for the CFD algorithm development, and the construction unified gas-kinetic scheme (UGKS). The UGKS accurately captures the gas evolution from rarefied to continuum flows.

Solution of Canonical Flow Problems Using A Robust Hyperbolic Moment Closure
McDonald, James Univ. of Ottawa

Abstract: Flows existing at moderate levels of rarefaction are difficult to simulate. Traditional continuum models are physically inaccurate and methods tailored for higher rarefaction, such as particle methods and direct discretizations of the Boltzmann equation, can be prohibitively expensive. Moment closures offer the possibility of efficient and accurate models in the transition regime between continuum and free-molecular flow. This talk explores the predictive capabilities of robust hyperbolic moment closures for canonical transition-regime flow problems.
Abstract: Levermore’s maximum entropy offered a landmark moment closure in gasket theory. However, no closed-form expression for the fluxes are available if moments beyond second order. In this talk, a approximation 14 moment closure for the Boltzmann equation are proposed, based on Bi-Gaussian distribution function. The resulting equations not only possess almost all the advantages of maximum entropy, e.g. globally hyperbolic, convex entropy function, smooth shock structure, but also have a closed-form expression for the fluxes.

Abstract: A New Lattice Boltzmann Solver on Unstructured Grid and Study of Its Performance

Zhuo, Xiaohie
The Inst. of Software, Chinese Acad. of Sci.

Weishan, Denge
Inst. of Software, CAS

Xu, Jin
Inst. of Software

Abstract: In this paper, we present a new solver for Lattice Boltzmann Equation (LBE) using Discontinuous Galerkin (DG) method on unstructured grid with nodal basis. The numerical method and parallel model are explained in detail, and benchmark results will be shown. Furthermore, in order to study its performance, another solver for Navier-Stokes (NS) equation using Continu- ous Galerkin (CG) method has been used for comparison. Similarly, both the numerical method and its parallel model are explained. Same benchmarks and simulations have been used in order to compare them. The advantages and shortcomings of this new solver will be discussed.

Abstract: Calculations of Strong-Coupled Radiative Transfer Problems in 2D

Shuanggui, Li
Institute of Applied Physics & computational mathematics

Abstract: On quadrilateral subcells in an arbitrarily connected grid of polygo- nal cells, subcell-balance methods methods have been developed for the Sn (discrete ordinate) equations approximation of the linear Boltzmann equation. In this work, we generaliz the simple corner-balance method to solve the nonlinear radiative transfer equation and the associated electron and ion con- ductive equations. These are integrated into a program architecture which requires zonally averaged quantities, and a subcell-cell temperature mapping method is proposed. Numerical results show the scheme presented is compa- rative to the diamond scheme in rectangle grid and feasible for transport dominated problems on non-orthogonal meshes such as might be generated by Lagrangian hydrodynamic distortions.

Numerical methods improvements and large-scale computing techniques for electromagnetic simulations in different disciplines - Part II of II

For Part I, see MS-Do-D-35

Organizer: Xu, Jin
Inst. of Software

Organizer: Liu, Jinglei
Delaware State Univ.

Abstract: In order to simulate complicated EM phenomena, such as inho- mogeneous medium, curve interface and boundary, complicated BCs, many new techniques need to be developed and old ones be extended, such as DG, Matched Interface and Boundary (MIB) method, high-order algorithms, Method of Moment (MOM), Fast Algorithms, etc. These methods are effi- cient and powerful in current EM simulations, but there are also many new challenges need to be solve. Therefore, new developments and extensions are needed. Furthermore, in order to use large-scale supercomputers, orig- inal algorithms need to be modified and efficient parallel models need to be developed. Combination of above techniques can dramatically improve the capability of electromagnetic simulations. This mini-symposium focuses on these new methods improvements, including high-order methods, algorithm- s and large-scale computing techniques, which can improve EM simulations dramatically.

Efficient High-Order Algorithms for Solving Drift-Diffusion Systems

HE, YING
UC Davis

MIN, MISUN
Argonne National Laboratory

Abstract: I will discuss about some recent developments of spectral element method (SEM) for solving the drift-diffusion equations, which have been used a lot in semiconductor device simulation, biological ion channels problems, etc. The drift-diffusion system is a non-linear system, involving the coupling of two transport equations for the carrier concentrations with the Poisson equation for the electric potential. I will present our SEM algorithms and demonstrate the computational results for the study of potassium channel.

Abstract: The Finite-Difference Time-Domain (FDTD) method is a very popular numerical method for solving the Maxwell’s equations of electrodynamic- s. In this talk, we present some of the recently developed FDTD based meth- ods for problems involving complex media, including the anisotropic media for simulating electromagnetic metamaterial cloaking devices, the magneto- electric material for spacetime cloak, and nonlinear metamaterials for second harmonic generation (SHG).

A RECOVERY BASED LINEAR FINITE ELEMENT METHOD FOR BI- HARMONIC PROBLEMS

CHEN, HONGTAO
Xiamen Univ.

Organizer: Weishan, Deng Inst. of Software, CAS

Abstract: We analyze a gradient recovery based linear finite element method to solve bi-harmonic equations and the corresponding eigenvalue problems. Our method uses only $C^0$ element, which avoids complicated construction of $C^1$ elements and nonconforming elements. Optimal error bounds under various Sobolev norms are established. Moreover, after a post-processing the recovered gradient is superconvergent to the exact one. Finally, some numerical experiments are presented to validate our theoretical findings.

Abstract: It seems to be not so. One reason may be that that the effect is not as simple as one might expect: it depends on the wires having finite radius. Nor it is as strong as one might imagine: the shielding improves only linearly as the mesh spacing decreases. Mathematically, the subject is an appealing case study in strong as one might imagine: the shielding improves only linearly as the mesh spacing decreases. Mathematically, the subject is an appealing case study in the behaviour of harmonic functions, with links to Brownian motion and dif- fusion processes. Physically, Faraday cage shielding can be regarded as a process of electrostatic induction by a surface of limited capacitance. The talk will present results developed jointly with Jon Chapman and Dave Hewett.

Mathematics of the Faraday Cage

Trefethen, Lloyd N.
Univ. of Oxford

Abstract: Everybody has heard of the Faraday cage effect, in which a wire mesh does a good job of blocking electric fields. Surely the mathematics of such a famous and useful phenomenon has been long ago worked out and written up in the textbook? It seems to be not so. One reason may be that that the effect is not as simple as one might expect: it depends on the wires having finite radius. Nor it is as strong as one might imagine: the shielding improves only linearly as the mesh spacing decreases. Mathematically, the subject is an appealing case study in the behaviour of harmonic functions, with links to Brownian motion and dif- fusion processes. Physically, Faraday cage shielding can be regarded as a process of electrostatic induction by a surface of limited capacitance. The talk will present results developed jointly with Jon Chapman and Dave Hewett.

Structure-preserving methods for nonlinear Hamiltonian systems II-III

Organizer: Feng, Bao-Feng
The Univ. of Texas-Pan American

Organizer: Hu, Xing-Biao
Inst. of Computational Mathematics, Chinese written

Organizer: Wang, Shang-Zui
AMSS, CAS

Organizer: Hong, Jialin
Inst. of Computational Mathematics, Chinese Acad. of Sci. (CAS)

Abstract: During the last 50 years, there has been a wide interest in the s- tudy of nonlinear Hamiltonian systems, especially Hamiltonian PDEs. Among which an important class are integrable, in the sense that they can be solved exactly, admit enough number of conservation laws. On the other hand, there have been major advances in the numerical methods of integrable Hamilto- nian systems. Symplectic, multi-symplectic and energy-preserving methods have been popular in simulating these equations. Nevertheless, an impor- tant question still deserve to be explored is how to appropriately discretize
nonlinear Hamiltonian systems and to gain a superior performance for long time simulations while keeping their common features as many as possible. The purpose of this organized minisymposium is to bring together researcher-s from both integrable system and numerical analysis to discuss recent ad- vances on numerical aspects of nonlinear Hamiltonian systems.

**MS-Mo-E-36-1** 16:00–16:30

**Totally Conservative Integrator for Integrable Hamiltonian Systems and Its Generalization to Holonomic Constrained Systems**

Minesaki, Yukitaka
Tokushima Bunri Univ.

Abstract: Some holonomic constrained systems have the Hamiltonian, which is the sum of the Hamiltonian of an integrable system, Stäckel systems, and terms including a Lagrange multiplier and holonomic constraint. Applying canonical transformations and discrete variational derivative and then elimin- inating the multipliers, we give a new integrator. It can analytically repro- duce equilibrium orbits for the N-body problem. As a special case, it can be used with the totally conservative integrator retaining all preserved quantities of the Stäckel system.

**MS-Mo-E-36-2** 16:30–17:00

**Integrable Self-adaptive Moving Mesh Methods for A Class of Nonlinear Wave Equations with Hodograph Transformation**

Feng, Bao-Feng
The Univ. of Texas-Pan American Univ.

Abstract: In the present talk, I will firstly report our recent work on integrable discretizations for a class of soliton equations with hodograph transformation- s such as the Camassa-Holm, the short-pulse (SP), the reduced Ostrovsky equations. Then, I will show how these integrable discretizations can be suc- cessfully used as a self-adaptive moving mesh method for the numerical sim- ulation of these PDEs. This is a joint work with Dr.Ohta at Kobe University and Dr. Maruno at Waseda University.

**MS-Mo-E-36-3** 17:00–17:30

**Lattice Boussinesq Equation and Convergence Acceleration Algorithms**

He, Yi
Wuhan Inst. of Physics & Mathematics, Chinese Acad. of Sci.

Abstract: In this talk, we will give the molecule solution of an equation related to the lattice Boussinesq equation with the help of determinant identities. It is shown that this equation can for certain sequences be used as a numer- ical convergence acceleration algorithm. Reciprocally, we will derive a non- autonomous form of the integrable equation related to the lattice Boussinesq equation by a new algebraic method.

**MS-Mo-E-36-4** 17:30–18:00

**SYMPLECTIC INTEGRATORS FOR NONSYMPLECTIC PROBLEMS**

Sanz-Serna, J. M.
Universidad Carlos III de Madrid

Abstract: I shall show how symplectic Runge-Kutta and partitioned Runge-Kutta methods appear in a hidden but natural way in a number of areas. These include the computation of sensitivities, automatic differentiation, optimal control, Lagrangian mechanics, etc.
and the standard Brownian excursion is utilised to construct goodness-of-fit tests. Asymptotic properties of the tests are examined and their performance is assessed on a task of comparing tumour images which allow for tree-like representations.

**MS-Mo-E-38-3** 17:00–17:30

*Inference and Experimental Design for Models of Biochemical Dynamics*

Komorowski, Michał

Polish Acad. of Sci.

Abstract: Dynamical models in quantitative biology are characterised by more complex structures and substantially larger sets of parameters than models used in physics and engineering. Viable methods of inference and experimental design should be therefore adapted to specificity of these models. In my talk I will present a framework capable of parameter inference and experimental design for both noisy and complex, systems of biochemical dynamics.

**MS-Mo-E-38-4** 17:30–18:00

*Stochastic Dynamics on Large Contact Networks*

Rempala, Grzegorz

The Ohio State Univ.

Abstract: We develop a general framework for analyzing dynamics of certain classes of contact processes on random (configuration model) graphs with given degree distributions. The work is motivated by the need for a realistic but also mathematically tractable and statistically predictive dynamic model of the recent Ebola epidemic. We expand the traditional model of an SIR stochastic epidemic on a graph by including heterogenous contact and infectivity structure to account for the disease-specific features.

**MS-Mo-E-39** 16:00–18:00

For Part 1, see **MS-Mo-D-39**

For Part 3, see **MS-Tu-D-39**

Recent advances on inverse scattering problems - Part II of III

Abstract: We will discuss our research program concerning a systematic search for extreme events in viscous incompressible flows. It is motivated by questions related to singularity formation in the 3D Navier-Stokes system and other hydrodynamic models. We will demonstrate how new insights concerning extreme behavior in such models can be obtained by formulating these questions in terms of variational PDE optimization problems which can be solved computationally using discrete gradient flows. [Joint work with Diego Ayala]

**MS-Mo-E-39-1** 16:00–16:30

*Inverse Scattering for Rough Surfaces with Tapered Wave Incidence*

Lei, Zhang

Heilongjiang Univ.; Zhejiang Univ.

Abstract: The study of Inverse scattering for rough surfaces has been the subject of intensive investigation for its application in a number of important research fields, such as remote sensing, target recognition, surface optics, as well as semiconductor physics. Here we consider the Inverse scattering for rough surfaces with tapered wave Incidence, some theoretical and numerical results are given.

**MS-Mo-E-39-2** 16:30–17:00

*C0IPG Error Analysis for Transmission Eigenvalue Problem*

Ji, Xia

Chinese Acad. of Sci.

Abstract: We consider a non self-adjoint fourth eigenvalue problem and use the Discontinuous Galerkin (DG) methods to compute it. For the fourth order problem, DG methods are competitive since they have less degrees of freedom and simpler than the other classical finite element methods. We propose an interior penalty discontinuous Galerkin method using C0 Lagrange elements (C0IPG) and study its theoretical error estimate. Moreover, the optimal convergence is obtained.

**MS-Mo-E-39-3** 17:00–17:30

*Inverse Scattering from Extended Sources*

Rundell, William

Texas A&M Univ.

Abstract: We look at classical inverse acoustic scattering based on the nonhomogeneous Helmholtz equation where one seeks to recover the location and shape of an extended source \( J \) from measurements of far (or near) field data. We will look at two very different algorithms, one using only a single frequency incident field, the other where we have multfrequenciy information.

**MS-Mo-E-39-4** 17:30–18:00

*A Recursive Algorithm for Multi-frequency Acoustic Inverse Source Problems*

Lu, Shuai

School of Mathematical Sci., Fudan Univ.

Bao, Gang

Zhejiang Univ.

Rundell, William

Texas A&M Univ.

Abstract: An iterative/recursive algorithm is studied for recovering unknown sources of acoustic field with multi-frequency measurement data. Under additional regularity assumptions on source functions, the first convergence result towards multi-frequency inverse source problems is obtained by assuming the background medium is homogeneous and the measurement data is noise-free. Error estimates are also provided when the observation data is contaminated by noise. Numerical examples verify the reliability and efficiency of our proposed algorithm.

**MS-Mo-E-40** 16:00–18:30

For Part 1, see **MS-Mo-D-40**

**MS-Mo-E-40-1** 16:00–16:30

*Extreme Vortex States and the Hydrodynamic Blow-Up Problem*

Protas, Bartosz

MoSatec Univ.

Abstract: The generalized DeGregorio equation is a 1D model of the 3D Euler equations and Navier-Stokes equations. This equation is obtained by adding an advection term and the viscous dissipation term to the Constantin-Lax-Majda equation. In this talk, I am concerned with the relation between singular blow-up solutions to the non-viscous equation as well as a "turbulent" statistical properties of solutions to the equation with small viscosity.

**MS-Mo-E-40-2** 16:30–17:00

*On the Generalized Non-viscous/viscous De Gregorio Equation - Singular Solutions and Statistical Properties*

Takashi, Sakajo

Kyoto Univ.

Abstract: We will discuss our research program concerning a systematic search for extreme events in viscous incompressible flows. It is motivated by questions related to singularity formation in the 3D Navier-Stokes system and other hydrodynamic models. We will demonstrate how new insights concerning extreme behavior in such models can be obtained by formulating these questions in terms of variational PDE optimization problems which can be solved computationally using discrete gradient flows. [Joint work with Diego Ayala]

**MS-Mo-E-40-3** 17:00–17:30

*Assessing Late-time Singular Behaviour in Symmetry-plane Models of 3D Euler Flow*

Bustamante, Miguel

Univ. College Dublin

Abstract: We introduce a one-parameter family of models of the 3D-Euler fluid equations on a 2D symmetry plane, which provide a collection of blowup scenarios admitting analytical solutions. We exploit these features to validate a novel finite-time blowup assessment method in numerical simulations: the mapping to regular systems. We show a 3-order-of-magnitude accuracy increase on the measured singularity time when employing the mapping, with negligible computational expense. Relevant blowup quantities include vortex-stretching rate and analyticitly-strip width.

**MS-Mo-E-40-4** 17:30–18:00

*Burgers Vortex System and Hermite Polynomials*

Kimura, Yoshifumi

Graduate School of Mathematics, Nagoya Univ.

Abstract: The Burgers vortex is well-known as a steady exact solution of the Navier-Stokes equation which is often used as a model for vortex motion in turbulence. In this talk, we extend this solution first to a time dependent problem, and then to the motion of a group of gaussian vortices. It will be shown that the solution for the latter problem is written with the superposition of Hermite polynomials.

**MS-Mo-E-40-5** 18:00–18:30

*Computer-assisted Proofs in Incompressible Fluids*

Gomez-Serrano, Javier

Princeton Univ.

Abstract: In this talk I will discuss how, guided by numerical simulations, one can accomplish to produce completely rigorous, computer-assisted theorems in problems related to fluid mechanics using interval arithmetics. Specifically, I will talk about the Muskat and the vortex patch (and its generalization known as the alpha-patch) problems. The talk is based in joint work with Angel Castro, Diego Cordoba, Rafael Granero-Belinchon and Alberto Martin Zamora.
A parallel implementation of the preconditioner AINV for the solution of general sparse linear systems of equations is presented. This preconditioner computes an explicit sparse approximate inverse whose application just requires matrix operations. This feature is appropriate for the parallel simulation of particle transport in well logging problems. We discuss semi-analytical methods to deterministic approaches in the modeling of particle transport in well logging problems. In particular, the adjoint transport equation is explored to estimate source-detector measurements.

**Abstract:** Nuclear measurement techniques have played a relevant role in dealing with problems as hydrocarbon exploration. The key to understanding the responses of the related logging tools are gamma rays and neutron transport. In this work we discuss semi-analytical methods to deterministic approaches in the modeling of particle transport in well logging problems. In particular, the adjoint transport equation is explored to estimate source-detector measurements.
Network Organization as A Dynamical System
Aoki, Takaaki    Kagawa Univ.

Abstract: Real-world networks continuously change to meet the evolving needs of society. To manage such dynamic networks, we studied an adaptive network model, combining the dynamics of a resource carried by random walkers and resource-regulated weighted connections. Under suitable conditions, the resource and the weights converged to power-law distributions, while they microscopically continued to change. We analyzed the equilibrium states from the perspective of the dynamical system and found that the system has multi-stability including chaotic states.

- MS-Mo-E-42-4  17:30–18:00  Phase Behavior of Bond Percolation on Hierarchical Small-world Networks
  Nogawa, Tomoaki    Toho Univ.
  Abstract: Cooperative systems on some small-world networks exhibit phase behavior that is essentially different from that of finite-dimensional systems. Remarkably, a number of systems show critical phases, i.e., the systems show the behavior that is observed at critical points of second-order transitions in a finite range of the control parameters. We discuss the nature of the phase and the phase transitions of percolation on a family of hierarchical small-world networks based on the renormalization-group analysis.

- MS-Mo-E-42-5  18:00–18:30  Mining Temporal Patterns in Time-varying Social Networks
  Takaguchi, Taro    National Inst. of Informatics
  Abstract: Social networks are essentially temporal; the web of social interactions varies its form over time at all time scales from seconds to years. Such temporal patterns have considerable impact on dynamical processes such as disease spreading and information propagation. Digital logs of social interactions in online and offline settings unveil universal temporal patterns, such as heterogeneity in interevent times. In this talk, recent advances in social temporal network analysis will be reviewed and summarized.

Game-theoretic Models of Marketing Decisions in Supply Chains

- MS-Mo-E-43  16:00–18:00  Game-theoretic Models of Marketing Decisions in Supply Chains
  Organizer: Aust, Gerhard    TU Dresden
  Organizer: Xie, Jinxing    Tsinghua Univ.
  Abstract: The coordination of decisions in supply chains is a popular topic in operations research, whose complexity arises from the individual objectives of the different companies involved on the one hand, but also from interdependencies between their strategies on the other hand. These characteristics turn game theory into an appropriate solution approach, as it allows analyzing the strategic decision-making of individuals under different frameworks like, for instance, power imbalance within the supply chain. This symposium shall be dedicated especially to the game-theoretic analysis of marketing decisions, which are used to influence consumer demand including, but not limited to pricing and advertising.

Bilateral Participation Co-op Advertisement System

- MS-Mo-E-43-1  16:00–16:30  Game-theoretic Models of Marketing Decisions in Supply Chains
  Aust, Gerhard    TU Dresden
  Abstract: This talk shall give an overview on the application of game-theoretic models to analyze the behavior of supply chain members. As decisions in supply chains are highly interdependent and often impact the profit of the remaining echelons, game theory has proven to be an adequate instrument to determine the companies’ best strategies. Special focus will be given to decision related to marketing like pricing, advertising, etc., as these activities are used to influence consumer demand.

Benefits of Bilateral Participation in Cooperative Advertising

- MS-Mo-E-43-2  16:30–17:00  Benefits of Bilateral Participation in Cooperative Advertising
  Xie, Jinxing    Tsinghua Univ.
  Abstract: We propose a bilateral participation co-op advertisement system for a one-manufacturer/ multi-retailer distribution channel, where the manufacturer’s national advertising expense is shared by the retailers. We show that the bilateral participation system is capable of coordinating the distribution channel under a very general channel structure and sales response function and can lead to a Pareto improvement over any unilateral participation system.

A Newsvendor Model with Strategic Voting Consumers

- MS-Mo-E-43-3  17:00–17:30  A Newsvendor Model with Strategic Voting Consumers
  Qinglong, Gou    Univ. of Sci. & Tech. of China
  Zhang, Juzhi    Univ. of Sci. & Tech. of China
  Abstract: We propose the concept of strategic voting consumers as an extension of strategic consumers and apply it in a newsvendor model to investigate its impact on supply chain decisions. Results show that: (i) strategic voting consumer will reduce the newsvendor seller’s retail price and its order quantity significantly; and (ii) the wholesale price and markdown money contracts cannot coordinate the supply chain under some certain conditions.

Cooperation Advertising Strategy in A Dual Channel Supply Chain with A Risk-averse Retailer

- MS-Mo-E-43-4  17:30–18:00  Cooperation Advertising Strategy in A Dual Channel Supply Chain with A Risk-averse Retailer
  Li, Bo    Tianjin Univ.
  Hou, Peng-wen    Tianjin Univ.
  Abstract: This paper considers a dual-channel supply chain with a manufacturer and a retailer. The retailer with risk aversion adopts advertising strategy and the manufacturer may either choose co-op advertising strategy or not. A Stackelberg game model is established and the equilibrium solutions are given. We find that co-op advertising strategy can increase the performance of the supply chain. But, both don’t always benefit from the strategy and their decisions are related to the advertising cost coefficient.

Sparse Recovery of High-dimensional Data

- MS-Mo-E-44  16:00–18:10  Sparse Recovery of High-dimensional Data
  Organizer: Wang, Chuan-Long    Taiyuan normal Univ.
  Organizer: Chen, Di-Rong    Wuhan Textile Univ., Beijing Univ. of Aeronautics & Astronautics
  Organizer: Aust, Gerhard    TU Dresden
  Organizer: Xie, Jinxing    Tsinghua Univ.
  Organizer: Hou, Peng-wen    Tianjin Univ.
  Organizer: Wang, Chuan-Long    Taiyuan normal Univ.
  Organizer: Chen, Di-Rong    Wuhan Textile Univ., Beijing Univ. of Aeronautics & Astronautics
  Organizer: Xie, Jinxing    Tsinghua Univ.
  Abstract: This minisymposium will provide a forum for the exchange of expertise, experience and insights among world leaders and young researchers who are active in the area of sparse recovery of high-dimensional data and related fields. It is envisaged that this minisymposium will stimulate further research, and act as a vehicle to promote this important field.

The Exact Recovery of Sparse Signals via Orthogonal Matching Pursuit

- MS-Mo-E-44-1  16:00–16:30  The Exact Recovery of Sparse Signals via Orthogonal Matching Pursuit
  Liao, Anping    Hunan Univ.
  Xie, Jiaxin    Hunan Univ.
  Yang, Xiaobo    Hunan Univ.
  Cheng, Liang    Hunan Univ.
  Abstract: In this paper, some sufficient conditions for the exact recovery of sparse signals via orthogonal matching pursuit (OMP) are investigated. Some conditions under which all k-sparse signals or the support of the k-sparse signals can be exactly recovered via the OMP algorithm are presented. Because the computation of the condition is typically difficult, a new computable condition is presented, under the condition all k-sparse signals can be recovered exactly through the OMP algorithm.

Directional Complex Wavelet Tight Framelets with Applications to Image Processing

- MS-Mo-E-44-2  16:30–17:00  Directional Complex Wavelet Tight Framelets with Applications to Image Processing
  Han, Bin    Univ. of Alberta
  Abstract: Separable wavelets are known to have some shortcomings limiting full potential of wavelet-based applications. We discuss recent exciting developments on directional tensor product complex tight framelets (TP-CTFs). For image/video denoising/inpainting, we show that TP-CTFs have superior performance compared with current state-of-the-art methods. Such TP-CTFs inherit almost all the advantages of traditional wavelets but with directionality for capturing edges, enjoy desired features of DCT for capturing oscillating textures, and are computationally efficient.

Sparse Recovery with Frame Representation

- MS-Mo-E-44-3  17:00–17:30  Sparse Recovery with Frame Representation
  Song, Li    zhejiang Univ.
  Abstract: In this talk, I shall introduce some new results on sparse recovery under frame representation from the point of views of approximation theory. In particular, we will focus on reviewing our joint works with Dr. Lin, Dr. Zhang and Dr. Xia.

Numerical Algorithm and Its Revision for Solving A Class of Nonsingular Integro-Differential Equations of the First Kind

- MS-Mo-E-44-4  17:30–17:50  Numerical Algorithm and Its Revision for Solving A Class of Nonsingular Integro-Differential Equations of the First Kind
  Chiang, Shihchung    Chung Hua Univ.
  Abstract: This study presents a numerical algorithm for solving a class of integro-differential equations of the first kind. This class of equations consists of an integro-differential term containing an Abel-type nonsingular kernel. The first kind equations with a weakly singular kernel originated from an aeroelasticity problem. In the present study, the authors obtained satisfactory results after applying a previous version of the algorithm for singular equations, and obtained superior results by revising the numerical algorithm and the corresponding nonsingular equations. The authors propose numerical algorithms
that do not involve transforming the original equation into the corresponding
Volterra equation, but still facilitate determining the numerical solution of the
original equation. In addition, the feasibility of the proposed numerical algo-
rithm is also demonstrated by applying it to examples in which both the CPU
times and maximum errors compared with exact solutions are shown.

Organizer: Chen, Changbo Chinese Acad. of Sci.
Organizer: Moreno Maza, Marc The Univ. of Western Ontario

For Part 3, see MS-Tu-D-45
For Part 1, see MS-Mo-D-45

Triangular decomposition of polynomial systems: solvers and applications -
16:00–18:00 213A
MS-Mo-E-45

Numerical Simulation of the Weissenberg Effect: Some Numerical Experiments
Cumínato, Jose Alberto S&I#227;o Paulo Univ.
Oishi, Cassio UNESP - Sao Paulo State Univ.
Figueiredo, Rafael Univ. of S&I#227;o Paulo (USP)

Abstract: The Weissenberg effect is encountered in many industrial applica-
tions involving mixing processes. In this experiment a rotating rod is inserted
into a container filled with a viscoelastic fluid. The behavior of the fluid is strik-
ing: it moves in the opposite direction of the centrifugal force and climbs up
the rod. This effect has been experimentally reproduced by many researcher-
ners. However, there are few numerical works dealing with a rigorous study of
this effect. One of the main challenges of this simulation is to provide numer-
ical methods which achieve high elasticity rate and that represent the correct
shape of the free surface. In this work a finite difference scheme is presented
which is based on the projection method. The conformation tensor is em-
ployed to solve the viscoelastic model. The interface between the fluids is
modelled by ELVIRA. We shall present simulations of the Weissenberg effect
for the Oldroyd-B model.

MS-Mo-E-45 16:00–18:00 213A
Triangular decomposition of polynomial systems: solvers and applications -
Part of Part 1
For Part 1, see MS-Mo-D-45
For Part 3, see MS-Tu-D-45
For Part 4, see MS-Tu-E-45

Organizer: Moreno Maza, Marc The Univ. of Western Ontario
Organizer: Chen, Changbo Chinese Acad. of Sci.

Abstract: The Characteristic Set Method of Wen Tsun Wu has freed Ritt’s
decomposition from polynomial factorization, opening the door to a variety of
discoveries in polynomial system solving. In the past three decades the work
of Wu and his school has been extended to more powerful decomposition algorithms and ap-
plicated to different types of polynomial systems or decompositions: differential
systems, difference systems, real parametric systems, primary decomposi-
tion, cylindrical algebraic decomposition. Today, triangular decomposition al-
gorithms provide back-engines for computer algebra system front-end solver-
s, such as Maple’s solve command and have been applied in various areas
both in the academia and in the industry.

In this proposed workshop, we hope to gather researchers who have applied
and extended the works of Joseph Fels Ritt and Wen Tsun Wu. Our goals are:
first, to disseminate the techniques and software tools which have been de-
veloped by this vibrant community and, second, to stimulate further devel-
opments and applications of polynomial system decomposition by means of
characteristic sets.

At the International Congress on Mathematical Software (ICMS 2014), a
satellite conference of the International Congress on Mathematics, in Seoul
(South Korea), a session on the same topics as the proposed one had
gathered 9 talks, see http://www.csd.uwo.ca/~moreno/ICMS_Triangular_
Decomposition_Session.html

About another 30 researchers had expressed interest in participating to this
session but were not able to do so at that time the year or in that location.
Moreover, three other sessions of ICMS 2014 had talks on this subject of
polynomial system decomposition by means of characteristic sets.

In a sum, the proposed workshop for ICIAM 2015 is expected to be well at-
tended and to generate rich interactions. At the same time, the available soft-
ware such as the RegularChains library (see http://www.regularchains.org)
will support software demonstration of the applications of the Characteristic
Set Method.

Organizer: Shi, Cong Univ. of Vienna
Organizer: Ammari, Habib Ecole Normale Superieure

Abstract: Photoacoustic Imaging is a promising imaging method that visual-
izes biological material parameters. In a typical PAT session, the object is
exposed to a short pulse of an electromagnetic wave. The object absorbs a
fraction of the induced energy, heats up, and reacts with thermoelastic expan-
sion. This in turn produces acoustic waves, which can be recorded outside the
specimen. The mathematical formulation of PAT is an inverse problem related to
the wave equation - to reconstruct the source term of the wave equation from
measurements of the acoustic wave. PAT combines the high resolution of ultrasound waves and high contrast of EM waves.

The classical mathematical models of PAT ignore the attenuation effects and
dispersion within the object, which leads to inaccurate images. There are two
main challenges in the topic: one is to model the attenuation effect mathemati-
cally, the other is to compensate for the effect in image reconstruction.

To correctly model the attenuation effect in a given media, we need to investi-
gate the relation between attenuation, dispersion, and causality. It is known
that attenuation and dispersion are connected by the Kramers-Kronig rela-
tion. Several attenuation models are documented in the literature, and most of
them are derived from power laws. On the other hand, the research on
compensation for the attenuation effect has only begun recently, and much
remains to be done on both of the problems. This minisymposium focuses on
recent advances in this field.

MS-Mo-E-46 16:00–18:00 306B
Attenuation and Dispersion in Photoacoustic Imaging - Part II of II
For Part 1, see MS-Mo-D-46

Organizer: Shi, Cong Univ. of Vienna
Organizer: Ammari, Habib Ecole Normale Superieure

Analysis of the Attenuated Wave Equation in Photoacoustic Imaging
Shi, Cong Univ. of Vienna

Abstract: In this talk, we will investigate the degree of ill-posedness for the
PAT inverse problem with attenuation. We define two cases of attenuation,
called “strong” and “weak”. Most classical attenuation models belong to the
“strong attenuation” category, and we can prove that the inversion of such
models is severely ill-posed. In contrast, in the “weak attenuation” case, we
have proved that the inverse problem is mildly ill-posed. This helps with the
selection of attenuation models.

MS-Mo-E-46-2 16:00–17:00
Computing the Decomposition Group of A Triangular Ideal by Using Elimina-
Yongbin, Li School of Mathematical Sci.,Univ. of Electronic Sci.
& Tech. of China

Abstract: Given an ideal generated by a triangular set of multivariate poly-
nomials, we present an alternative method for computing the decomposition
of the triangular ideal using elimination methods.

MS-Mo-E-45-3 17:00–17:30
Solving Parametric Polynomial Optimization by Triangular Decomposition
Chen, Changbo Chinese Acad. of Sci.
Moreno Maza, Marc The Univ. of Western Ontario

Abstract: In this talk, we present two methods for solving parametric poly-
nomial optimization: (1) a general method by means of cylindrical algebraic
decomposition based on triangular decomposition; (2) a generic approach
based on real comprehensive triangular decomposition. The motivation of
this work is to solve optimization problems arising in model predictive con-
trol, where many on-line optimization problems can be reduced to a single
parametric optimization problem to be solved in the off-line phase.

MS-Mo-E-45-4 17:30–18:00
DISCOVERING MULTIPLE LYAPUNOV FUNCTIONS FOR SWITCHED HY-
BRID SYSTEMS
She, Zhihun Beihang Univ.

Abstract: In this paper we analyze local asymptotic stability of switched hy-
brid systems, whose subsystems have polynomial vector fields, by discover-
ing multiple Lyapunov functions in quadratic forms. We start with an alge-
braizable sufficient condition for the existence of quadratic multiple Lyapunov
functions. Then, we apply real root classification together with a projection
operator to obtain a multiple Lyapunov function. Finally, we test our approach
on some examples using a prototypical implementation.

MS-Mo-E-46 16:00–18:00 306B

Qualitative Analysis of Biological and Control Systems Using Algebraic Meth-
ods
Niu, Wei Beihang Univ.

Abstract: This talk is concerning on qualitative analysis of biological and con-
trol systems, modeled as systems of differential or difference equations, using
algebraic methods. We will explain how to study the problems of detecting
steady states, analyzing stability and different kinds of bifurcations, and
constructing limit cycles for both continuous and discrete biological models. A
systematic account of our investigations on these problems is provided.

MS-Mo-E-45-1 16:00–16:30
Combining Photoacoustic and Optical Coherence Tomography
Elbaur, Peter Univ. of Vienna

Abstract: Since a quantitative reconstruction for photoacoustic imaging typi-
cally relies on some knowledge of the electromagnetic field around the object,
we want to propagate the idea to supplement the photoacoustic measurement with an optical coherence tomography measurement. As both methods give information about the light propagation in the medium, photoacoustics involving mainly the absorption, optical coherence tomography mainly the scattering properties, they perfectly complement each and thus make a quantitative reconstruction possible.

 ► CP-Mo-E-46-3 17:00–17:20

 Synchrosqueezed Transform and Variational Method for Crystal Image Analysis
 Yang, Haizhao  Stanford Univ.
 Lu, Jianfeng  Duke Univ.
 Wirth, Benedikt  Univ. of Munster
 YING, LEXING  Stanford Univ.

 Abstract: We propose an efficient two-step method for crystal image analysis. In the first step, a 2D synchrosqueezed transform (SST) is applied to extract mesoscopic and microscopic information from atomic crystal images. This method analyzes atomic crystal images as superpositions of non-linear wave-like components. In particular, crystal defects are interpreted as the irregularity of local energy of the SST, crystal rotations are described as the angle deviation of local wave vectors from their references; the gradient of a crystal elastic deformation can be obtained by a linear system generated by local wave vectors. In the second step, a variational model based on the physical understanding of the crystal elastic deformation is proposed to optimize the initial information in the first step. Several numerical examples of synthetic and real crystal images are provided to illustrate the efficiency, robustness, and reliability of our methods.

 MS-Mo-E-47 16:00–18:00
 Analytical and algorithmic advances in the immersed boundary method - Part II of II
 For Part 1, see MS-Mo-D-47

 Organizer: Stockie, John  Simon Fraser Univ.
 Organizer: Lai, Ming-Chih  National Chiao Tung Univ.

 Abstract: The immersed boundary method is a well-known approach for modeling fluid-structure interaction (FSI) problems involving highly deformable elastic structures. Applications include a wide range of biofluid mechanical systems and the method is increasingly being applied to engineering problems as well. Recently, major advances have been achieved in algorithms (fast and robust solvers), theoretical results (convergence and stability analyses) and model extensions intended to capture a wider spectrum of FSI phenomena (multiphase flows, membrane transport, stochastic effects). This minisymposium will highlight these recent advances and survey some of the complex fluid flows that can be simulated using the method.

 ► MS-Mo-E-47-1 16:00–16:30

 A Strongly Consistent and Stable Approximation Strategy to Couple Compressible and Purely Elastic Materials with Incompressible Viscous Fluids in Immersed Boundary Methods and Immersed Finite Element Methods
 Heltai, Luca  SISSA

 Abstract: We present a variational formulation of the immersed finite element method, which allows incompressible Newtonian fluids to interact with a general hyperelastic solid: we allow (i) the mass density to be different in the solid and the fluid, (ii) the solid to be either viscoelastic of differential type or purely elastic, and (iii) the solid to be either compressible or incompressible. The proposed method is stable and strongly consistent. Various benchmarks are presented.

 ► MS-Mo-E-47-2 16:30–17:00

 Simulations of Pulsating Soft Coral
 Khatiri, Shilpa  Univ. of California, Merced

 Abstract: Soft coral of the family Xeniidae have a pulsating motion, a behavior not observed in many other sessile organisms. We are studying how this behavior may give these coral a competitive advantage. We will present direct numerical simulations of the pulsations of the coral and the resulting fluid flow by solving the Navier-Stokes equations coupled with the immersed boundary method. Also, results of transporting nutrients and waste coupled with these models will be discussed.

 ► MS-Mo-E-47-3 17:00–17:30

 A New Penalty Immersed Boundary Method for A Rigid Body in Fluid
 Kim, Yongsam  Chung-Ang Univ.

 Abstract: We introduce a new penalty immersed boundary (pIB) method for the interaction between a rigid body and a surrounding fluid. The new pIB method is based on the idea of splitting an immersed boundary, which here is a rigid body, notionally into two Lagrangian components. The application problems include the interaction of two descending cylinders or balls and the dynamics of a freely falling maple seed with autorotation.

 MS-Mo-E-48 16:00–18:00
 Computational learning and model optimization - Part II of II
 For Part 1, see MS-Mo-D-48

 Organizer: Schönlieb, Carola-Bibiane  Univ. of Cambridge
 Organizer: Chung, Matthias  Virginia Tech
 Organizer: De Los Reyes, Juan Carlos  ModelMat

 Abstract: Many scientific fields such as engineering, life sciences, and geophysics encounter large scale problems where observations are contaminated with noise. To infer reliable information from experiments novel modeling techniques and inversion methods are needed. Computational learning and optimized modeling approaches are essential. To target challenges in these fields we will discuss statistical learning methods, optimization and design techniques under uncertainty, and inverse problems of big data.

 ► MS-Mo-E-48-1 16:00–16:30

 Machine Learning and Experimental Design for Inverse Problems in Medical Imaging
 Tarvainen, Tanja  Case Western Reserve Univ.
 Calvetti, Daniela  Case Western Reserve Univ.

 Abstract: Electrical impedance tomography aims at estimating conductivity distribution inside a body from current/voltage measurements from the boundary. The estimation can be done sequentially, either because of the measurement protocol, time evolution of the target, or because of the learning about the model discrepancies that are related to coarse modeling. In this talk, some of these aspects are addressed in the framework of ensemble filtering techniques.

 ► MS-Mo-E-48-2 16:30–17:00

 Ensemble Filtering in Electrical Impedance Tomography
 Somersalo, Erkki  Case Western Reserve Univ.
 Calvetti, Daniela  Case Western Reserve Univ.

 Abstract: Electrical impedance tomography aims at estimating conductivity distribution inside a body from current/voltage measurements from the boundary. The estimation can be done sequentially, either because of the measurement protocol, time evolution of the target, or because of the learning about the model discrepancies that are related to coarse modeling. In this talk, some of these aspects are addressed in the framework of ensemble filtering techniques.

 ► MS-Mo-E-48-3 17:00–17:30

 Learning in Variational Image Regularisation
 Schönlieb, Carola-Bibiane  Univ. of Cambridge

 Abstract: We propose a bilevel optimization approach in function space for the determination of the optimal total variation (TV) regularisation technique. Starting with a generic TV-like approach - which may feature spatially dependent and higher-order TV regularisers - the optimal parameters in the model are determined. They are numerically computed by using a dynamically sampled quasi-Newton method, together with semismooth Newton algorithms for the the solution of the TV-problems. Exhaustive numerical discussion will be presented.

 ► MS-Mo-E-48-4 17:30–18:00

 Learning and Experimental Design for Inverse Problems in Medical Imaging
 Brune, Christoph  Univ. of Twente
 Osting, Braxton  Univ. of Utah

 Abstract: In several medical inverse problems compressive sensing and informative data collection is of great importance, particularly with regard to patient treatment, hardware limits and costs. We focus on the design and learning of subsampled, ill-posed imaging operators. Within the framework of experimental design and bi-level optimization we analyze specific criteria including Fisher information and mutual coherence. A specific application in MRI and photoacoustic tomography shows improved reconstruction quality induced by reduced uncertainty via model.
ence involve rare but significant exit events and/or transition events between stable states. The transitions happen on a time scale much longer than the intrinsic time scale of the dynamical system. Examples of such events are conformational changes of biomolecules, chemical reactions, etc. The purpose of this minisymposium is to bring together experts working in theory, numerical algorithms and application issues, such as analysis of models for metastable systems, free energy calculation, importance sampling, accelerated dynamics, and sampling of transition pathways.

**MS-Mo-E-49-1 16:00–16:30**  
*Enhanced Sampling Simulations of Chemical Reactions in Solution*  
Gao, Yiqin  
Peking Univ.

**Abstract:** Many chemical reactions occur in solutions and it is desirable to understand how solvation affects their mechanisms using molecular simulation. Such studies are normally hindered by the complex energy landscapes of molecular systems. Most of the molecular mechanism studies are performed with a pre-selected reaction coordinate. We will discuss how integrated tempering sampling (ITS) and trajectory sampling techniques can be combined with QM/MM simulations to study chemical reactions in solution.

**MS-Mo-E-49-2 16:30–17:00**  
*Efficient Numerical Methods for Brownian, Langevin and Other Stochastic Differential Equations for Sampling A Probability Distribution, with Applications in Multiscale Modelling and Machine Learning*  
Leimkuhler, Benedict  
Univ. of Edinburgh

**Abstract:** With the correct choice of numerical method, stochastic differential equations (SDEs) provide a rigorous, efficient and flexible approach to calculating averages with respect to a prescribed distribution. I will discuss efficient discretization methods and numerical analysis for systems of gradient type. I will also describe adaptive SDE methods that can automatically recover invariant distributions when the gradient is perturbed by error, for applications in multiscale modelling and machine learning.

**MS-Mo-E-49-3 17:00–17:30**  
*Investigation Conformational Changes of Biological Macromolecules Using Kinetic Network Models*  
Huang, Xiuhui  
The Hong Kong Univ. of Sci. & Tech.

**Abstract:** Markov State Models (MSMs), a kinetic network model, built from molecular dynamics (MD) simulations provide one means of overcoming this gap without sacrificing atomic resolution by extracting long time dynamics from short MD simulations through the coarse graining on the phase space and time. I will introduce a new efficient dynamic clustering algorithm for the automatic construction of MSMs for multi-body systems.

**MS-Mo-E-49-4 17:30–18:00**  
*Shrinking Dimer Dynamics and Its Variants for Reliable Transition State Search*  
Zhang, Lei  
Peking Univ.

**Abstract:** Exploring complex energy landscape is a challenging issue in many applications. Besides locating equilibrium states, it is often also important to identify the transition states given by saddle points. In this talk, we discuss the mathematics and algorithms, in particular, the shrinking dimer dynamics and its variants, developed to compute transition states. Some applications will be considered.

**MS-Mo-E-50 16:00–18:30**  
*Modeling human cooperation*  
Organizer: Zhang, Boyu  
Beijing Normal Univ.

**Abstract:** The evolution of cooperation is one the most important question in evolutionary biology and social science. Recent years, a number of theoretical approaches based on kin selection, direct and indirect reciprocity (e.g., reward and punishment), graph selection and group selection have been developed to explain the emergence and maintenance of cooperation in human society. These approaches involve mathematical tools from game theory, graph theory, dynamical systems, stochastic processes and others. The aim of this minisymposium is to provide a platform for comparing and orchestrating different research approaches in modeling human cooperation, and strengthen the connection between the theory and experiments.

**MS-E-50-1 16:00–16:30**  
*Co-evolution of Conforming and Cooperation in Social Dilemmas*  
Zhang, Boyu  
Beijing Normal Univ.

**Abstract:** We study the n-round PD game and the n-round m-person PGG by restricting individual strategies to the set of conforming behaviors. In the both games, TFT can prevent the invasion of non-cooperative strategies if the number of rounds is larger than a critical value. Adaptive dynamics analysis shows that conforming in general promotes the evolution of cooperation, and there is an evolutionary path from AllD to TFT-like strategies.

**MS-Mo-E-50-2 16:30–17:00**  
*Solving the Collective-risk Social Dilemma with Risky Assets in Well-mixed and Structured Populations*  
Chen, Xiaojie  
Univ. of Electronic Sci. & Tech. of China

**Abstract:** The collective-risk social dilemma game has recently received much attention from different scientific communities, as a well-known paradigm for studying the evolution of cooperation in the climate change game. In this talk, I will first introduce the collective-risk social dilemma game with risky assets, and then show how the introduction of risky assets influences the evolution of cooperation both in well-mixed and structured populations.

**MS-Mo-E-50-3 17:00–17:30**  
*The Evolution of Cooperation: Theory and Experiment*  
Cressman, Ross  
Wilfrid Laurier Univ.

**Abstract:** The evolution of cooperation remains a fundamental puzzle in evolutionary biology and social science. Theoretically, cooperation should not evolve for the Prisoner’s Dilemma (PD) or Public Goods Game (PGG) without favorable extending circumstances whereas experiments consistently demonstrate cooperation. An overview of experiments and related theory is given before considering recent progress; the role of peer punishment in PD, of institutional reward/punishment in PGG, of player control over the number of rounds in repeated games.

**MS-Mo-E-50-4 17:30–18:00**  
*Why We Punish: Preemptive Punishment and Retrospective Moral Assessment*  
Sasaki, Tatsuya  
Univ. of Vienna

**Abstract:** Free riders can invade a society of cooperators, causing social dilemmas. Empirical and theoretical research on joint venture games indicates that social dilemmas can be overcome by punishment or reputation building. Since these public systems are costly, however, the so-called second-order free rider problem arises, leading to eroding cooperation. We try by using game-theoretical investigations show how the problem can be solved with considering preemptive punishment and retrospective moral assessment.

**MS-Mo-E-50-5 18:00–18:30**  
*The Role of Institutional Incentives and the Exemplar in Promoting Cooperation*  
Li, Cong  
Department of mathematics & statistic, Univ. of Montreal

**Abstract:** We studied a repeated PGG experiment with an institutional reward and punishment. The result shows that institutions which both reward and punish (IP) promote cooperation significantly better than either institutions which only punish (IP) or which only reward (IR). Our analysis shows that other intrinsic motivations that combine conforming behavior with reactions to being rewarded/punished provide a better explanation of observed outcomes.

**Lyapunov Function Method in Mathematical Biology - Part I of II**

**MS-Mo-E-51 16:00–18:00**  
209A  
Lyapunov Function Method in Mathematical Biology - Part I of II  
For Part 2, see MS-Tu-D-51

**Organizer:** Shuai, Zhisheng  
Univ. of Central Florida

**Organizer:** Wang, Chuncheng  
Harbin Inst. of Tech.

**Organizer:** Wang, Jiniang  
Heilongjiang Univ.

**Abstract:** The method of Lyapunov functions is a standard tool to analyze models arising in mathematical biology. These models often incorporate complex interactions among multiple species, age structure, behavior and spatial heterogeneity, and different time scales, and are in the form of ordinary differential equations, partial differential equations, functional differential equations, integro-differential equations, etc. A difficulty in applying the method is the ad hoc nature of the construction of a suitable Lyapunov function. This minisymposium will gather researchers employing a variety of mathematical techniques that guide the construction of Lyapunov functions for ecological and epidemiological models.

**MS-Mo-E-51-1 16:00–16:30**  
*Impact of Intracellular Delay, Immune Activation Delay and Nonlinear Incidence on Viral Dynamics*  
Takeuchi, Yasuhiro  
Aoyama Gakuin Univ.

**Abstract:** This presentation considers a class of viral infection models with two type discrete delays, one of which represents an intracellular latent period for the contacted target cells with viruses to begin producing virions, the other of which represents a time delay needed in cytotoxic T cells (CTLs) immune response before immune becomes effective after the invasion by a nov-
el pathogen. By constructing Lyapunov functionals we investigate the global stability of the equilibria.

**MS-Mo-E-51-2 16:30–17:00**

**Global Analysis on Virus Dynamics**

Shu, Hongying  
Tongji Univ.

**Abstract:** Determining sharp conditions for the global stability of equilibria remains one of the most challenging problems in the analysis of models for the management and control of biological systems. Yet such results are necessary for derivation of parameter thresholds for eradication of pests or clearing infections. This applies particularly to models involving nonlinear and delays. In this talk, we provide some general results applicable to immune system dynamics.

**MS-Mo-E-51-3 17:00–17:30**

**Modeling Age-structured HIV Infection Dynamics with Both Virus-to-cell Infection and Cell-to-cell Transmission**

Wang, Jiniang  
Heilongjiang Univ.

**Abstract:** Recent studies reveal that cell-to-cell transmission via formation of virological synapses might contribute significantly to virus spread. Age-structured models can be employed to study the variations in modeling the death rate and virus production rate of infected cells. Some basic mathematical arguments are achieved by using functional-analytic approaches. The global stability of equilibria, depending on basic reproduction number is obtained by constructing suitable Lyapunov functions.

**MS-Mo-E-51-4 17:30–18:00**

**Cyclic Structures on Epidemic Models and Its Stability in View of Renewal Equations and Delay Equations**

Enatsu, Yoichi  
Tokyo Univ. of Sci.

**Abstract:** We focus on asymptotic stability of equilibria of epidemic models with cyclic structures such as SIRS, SIS models. In the situation that the models incorporate an age of infection, unsolved stability problems for an endemic equilibrium arising from the cyclic structure are presented by summarizing our recent results. By characterizing an age-distributed parameter of a transmission coefficient, a reformulation procedure into differential equations with distributed- or discrete- delays, is also discussed.

**MS-Mo-E-52 16:00–18:30**

**212A Mathematics in population genetics and evolution - Part II of II**

For Part 1, see MS-Mo-D-52

**Organizer:** Yang, Zhining  
Univ. College London

**Organizer:** Ma, Zhiming  
AMSS, CAS

**Abstract:** Population genetics provides mechanistic interpretations of Charles Darwin’s theory of evolution by natural selection. It is a discipline in the life sciences that has a strong interplay with statistics, computer science and applied mathematics, founded by R.A. Fisher, S. Wright, and J. B. S. Haldane. It is essential both for understanding biological evolution and for interpreting the ever-increasing genomic datasets, and has thus gained momentum in the last few decades because of the rapid accumulation of genetic data, driven by the various genome projects. This symposium will focus on probabilistic modeling and statistical analysis of modern genetic and genomic data, and the statistical and computational challenges that we face. The symposium will provide a forum for statisticians and computer scientists interested in this exciting field of biology to exchange ideas and experiences with evolutionary biologists, and to discuss various problems at the cutting edge of the field.

**MS-Mo-E-52-1 16:00–16:30**

**The population Trajectories of Many Species: A Synthesis**

Zhai, Weiwei  
Genome Inst. of Singapore

**Abstract:** Population demographic history is a fundamental parameter in species evolutionary past. One very attractive method is the Pairwise Sequential Markovian Coalescent model where a single genome can be used to infer the past demographic change. In this work, we collected the population history across a wide range of species, we found that, there are many common determinants of past demographic change including recent divergence, global temperature fluctuation and a suite of many other factors.

**MS-Mo-E-52-2 16:30–17:00**

**A Maximum Likelihood Implementation of An Isolation-with-Migration Model for Three Species**

Zhu, Tianqi  
Beijing Inst. of genomics, CAS

**Abstract:** The isolation-with-migration models account for the phylogenetic structure of the populations while accommodating gene flow among them. We extend our previous maximum likelihood implementation of the symmetrical isolation-with-migration model for three species to accommodate arbitrary loci with two or three sequences per locus. The method is useful for analyzing genome-scale sequence data. We conduct a simulation study to examine the statistical properties of the likelihood ratio test for gene flow and analyzed a Drosophila dataset.

**MS-Mo-E-52-3 17:00–17:30**

**A New Measure of Population Differentiation**

Ma, Liang  
Acad. of Mathematics & Sys. Sci. & Inst. of Zoology, CAS

Zhong, De-Xing  
Inst. of Zoology & Beijing Inst. of Genomics, CAS

**Abstract:** Population differentiation (subdivision) is a fundamental process of evolution, and many population genetic studies and applications demand the inference of population differentiation. Debates over the validity of the traditional population differentiation measure FST remain unsettled since 2008. Here, a new statistic, IST, the Inflation Index, are proposed, complementary to current measures. It is defined as the amount of inflation of gene identity within subpopulations to its idealized value and standardized by its theoretic maximum range.

**MS-Mo-E-52-4 17:30–18:00**

**Computational Approaches to Reconstructing Evolutionary Histories of Single Cells**

Truszkowski, Jakub  
EMBL-European Bioinformatics Inst.

Goldman, Nick  
EMBL-European Bioinformatics Inst.

**Abstract:** Advanced single-cell sequencing technology can determine individual cells’ genomes, enabling us to survey the heterogeneity of cells within a population and reconstruct the history of cell divisions using phylogenetic methods. We present a method for reconstructing cell lineages, accounting for stochastic sequencing errors. The problem reduces to finding a series of cuts in a graph; our resulting algorithm outperforms standard methods for this task. We discuss possible implications for developmental biology, and sketch future directions.

**MS-Mo-E-52-5 18:00–18:30**

**Inference of Fine-scale Population Size Using the Allele Frequency Spectrum from Large Sample Genomic Sequences**

Chen, Huay  
Beijing Inst. of Genomics, CAS

Chen, Kun  
Dana Farber Cancer Inst., Harvard Medical School

**Abstract:** Inference historical population size is essential for population genetic study. Large sample genomic sequences provide unprecedented opportunities for learning population histories, however, the sample size is much beyond the limit of existing methods. We develop accurate approximation for the allele frequency spectrum for large samples. The approximation is in simple analytical form, and computationally very efficient comparing the simulation-based methods. More importantly, the result is accurate and flexible for various complex demographic scenarios.

**MS-Mo-E-53 16:00–18:00**

**311B New Developments in Stochastic Games: Mean Field Models and Beyond**

**Organizer:** Łukkowski, Mike  
UC Santa Barbara

**Organizer:** Leung, Tim  
Columbia Univ.

**Abstract:** Mean-field games theory was introduced in 2006 by Lasry and Lions and by Huang, Caines and Malhamé as a way to describe consensus among a large population of individuals. Various applications appear in economy, finance and engineering. In the past 5 years rapid developments have taken place to address existence and uniqueness of the corresponding stochastic equilibria, connections to controlled McKean-Vlasov diffusion processes and numerical approximation methods. The minisymposium will feature 4 talks devoted to recent applications of these theories related to systemic risk, commodity market oligopolies and Stackelberg games.

**MS-Mo-E-53-1 16:00–16:30**

**Systemic Risk and Mean Field Games: Grouping Systems and A Central Bank**

SUN, LI-HSIEN  
National Central Univ.

**Abstract:** We consider heterogeneous grouping cases where parameters are identical within their own groups but different between groups. Given this heterogeneity, a central bank has to keep deposits or provide extra cash flow instead of acting as a clearing house and systemic risk happens in the more complicated manner than the homogeneous case. In addition, in order to prevent systemic risk, a central bank must take control of the ensemble average.

**MS-Mo-E-53-2 16:30–17:00**

**Mean Field Stackelberg Games**

Chau, Man Ho  
The Univ. of Hong Kong
Abstract: In this work, we present the accurate error estimates for three state-of-the-art algorithms of long-range electrostatic interaction in inhomogeneous and correlated molecular systems. They are the Ewald summation, the smooth particle Ewald (SPME) and the staggered mesh Ewald methods. Two branches of fast reciprocal force calculation, namely the ik- and analytical difference, are considered. The error is decomposed and estimated in three additive components: the homogeneity error, the inhomogeneity error and the correlation error. The effectiveness and the computational feasibility of the proposed estimates are demonstrated and discussed in example systems. We further show that the inhomogeneity and the correlation errors play a non-trivial and important role in inhomogeneous and correlated molecular systems. In addition, a long-range correction for the inhomogeneity error is presented.
that of the PB equation when the channel width is much larger than the Debye length.

**MS-Mo-E-55-3 17:00–17:30**

*Continuum Simulation of Macromolecular System in Ionic Solution: from Equilibrium to Non-equilibrium Processes*

*Lu, Benzhou*

Acad. of Mathematics & Sys. Sci., CAS

**Abstract:** An overview will be given for our recent work on continuum modeling of macromolecular system: Poisson-Boltzmann electrostatic simulation, and its current developments toward model improvements at higher level of accuracy and generalization for treatment of non-equilibrium ionic flow. A current issue is that many technical difficulties in these modeling prevent their applications. Therefore, we are also making efforts to develop a convenient web server for continuum modeling, and demonstrations will be presented.

**MS-Mo-E-55-4 17:30–18:00**

*Self-consistent Field Model for Strong Electrostatic Correlations and Inhomogeneous Dielectric Media*

*Ma, Manman*

Shanghai Jiao Tong Univ.

*Xu, Zhenli*

Shanghai Jiao Tong Univ.

**Abstract:** We propose a continuum electrostatic model for the treatment of electrostatic correlations and variable permittivity of electrolytes in the framework of the self-consistent field theory. The model incorporates a space-or field-dependent dielectric permittivity and an excluded ion-size effect for the correlation energy. Numerical results for symmetric and asymmetric electrolytes demonstrate that the model is able to predict the charge inversion at high correlation regime and strong effects due to the inhomogeneous permittivity.

**MS-Mo-E-56 16:00–18:10 403**

*Computational Techniques in Geological Disasters and Environment Pollutions*

*Organizer: Yuan, Li*

ICMSEC, Acad. of Mathematics & Sys. Sci., CAS

**Abstract:** Landslides, avalanches, and debris flows are dangerous natural hazards to human beings. Environment pollutions like subsurface wastewater flow problems degenerate our life and cause disease. Although these phenomena have been studied extensively by numerous searchers in various disciplines, the inhomogeneous, multiphase, polydisperse, and phase variable materials and their interactions with surface-er fluids are hard to describe both qualitatively and quantitatively. Mathematical simulation technologies for geological disasters and environment problems are still under development. The objective of this mini-symposia is to provide a forum for researchers from applied mathematics, numerical algorithms, and geomechanics to exchange the related research progress.

**MS-Mo-E-56-1 16:00–16:30**

*Wave Simulation in Three Dimensional Poropelastic Media by the Finite Volume Method*

*Zhang, Wensheng*

Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci., Beijing, 100190, P.R.China

**Abstract:** In this talk, we will present a finite volume scheme for solving the three dimensional Biot equation to simulate wave propagation in three dimensional poropelastic media. Based on the velocity-stress formulation of Biot equation, the computational scheme for cell-averaged quantities is presented. Numerical computations with the MPI parallel algorithm both for the theoretical model and the real landslide model with complex topographic changes are implemented.

**MS-Mo-E-56-2 16:30–17:00**

*Numerical Simulation of Hydraulic Fracturing*

*Liu, Changj*

Department of hydraulic engineering

*Sun, Oicheng*

Tsinghua Univ.

**Abstract:** To better understand the mechanism of hydraulic fracturing, we establish a new numerical model considering hydro-mechanical coupling. The model simulates mechanical behavior of rock formations using the combined finite-element method and uses a simplified fracture flow equation derived from the general Navier-Stokes (N-S) equations and Darcy’s law to describe fluid flow. The interaction between these media is controlled by fluid leak-off. The process of hydraulic fracturing is effectively simulated using several numerical methods.

**MS-Mo-E-56-3 17:00–17:30**

*Discrete Element Method with Dilated Polyhedral Element and Its Application in Cold Region Engineering*

*Ji, Shunying*

Dalian Univ. of Tech.

*Liu, Lu*

Dalian Univ. of Tech.

**Abstract:** To describe the geometric shapes of irregular particles and calculate their collision contacts accurately with discrete element method, the dilated polyhedral element is developed based on Minkowski sums theory. To simulate the sea ice floes in cold regions, the elements are generated with the Voronoi tessellation algorithm. The influence of ice thickness and drifting velocity on ice loads on offshore structures and ship hull are simulated with the dilated polyhedral elements.

**CP-Mo-E-56-4 17:30–17:50**

*GENERAL EQUILIBRIUM ANALYSIS OF TRADE AND ENVIRONMENT UNDER ALTERNATIVE MARKET STRUCTURE: A COMPUTABLE GENERAL EQUILIBRIUM STUDY FOR INDIA*

*Das, Koushik*

Chandidas Mahavidyalaya

**Abstract:** The purpose of the present paper is to understand general equilibrium implications of international trade and globalization on social welfare and environmental emission caused on account of energy consumption by production sectors and domestic households. We applied Computable General Equilibrium (CGE) modelling as our relevant methodology following Shoven, J.B. and Whalley, J (1984). Constructing an Energy/Environmental Social Accounting Matrix (SAM) paper attempts to purport the effects of liberalized trade over different macroeconomic aspects, energy consumption and Green House Gas (GHG) emission through an Environmental CGE model logically based on SAM. Attempts have been made to simulate various trade related policies like import liberalization, foreign capital inflow and use of energy saving technologies for examining the impact over macroeconomic variables and domestic physical environment under both Perfect and Monopolistic Competition market structure assumption.

**MS-Mo-E-57 16:00–18:05 402A**

*Recent advances in modeling, analysis, and methodology for interface and free boundary problems and applications - Part II of V*

For Part 1, see MS-Mo-D-57

For Part 3, see MS-We-D-26

For Part 4, see MS-We-E-26

For Part 5, see MS-Th-BC-26

*Organizer: Li, Zhilin*

North Carolina State Univ.

*Organizer: Liu, Ming-Chih*

National Chiao Tung Univ.

**Abstract:** In recent years, there is increasing interest in the development and application of advanced computational techniques for interface problems, problem with free boundary and moving interface, fluid-structure interactions driven by applications in physiology, fluid mechanics, material sciences, porous media flow, and biology. There are also many numerical approaches developed in recent years. The aim of this mini-symposium is to bring together scientists in the field to exchange their recent research discoveries and future directions, to stimulate novel ideas, and to nurture collaborations. The focus would be on Cartesian grid methods such as the immersed boundary/interfacial methods, the level set methods, fluid-structure interactions, and applications.

**MS-Mo-E-57-1 16:00–16:25**

*The IIM for Axis-symmetric Problems and Application to the Hele-Shaw Flow*

*Ruiz, Juan*

Alcala Univ.

*Li, Zhilin*

North Carolina State Univ.

**Abstract:** Many physical application problems are axis-symmetric. Using axis-symmetric properties, many three dimensional problems can be solved efficiently using two dimensional axis-symmetric coordinates. In this paper, the immersed interface method in axis-symmetric coordinates is developed for elliptic interface problems that have a discontinuous coefficient, solution or flux. The method is shown to be second order accurate in the infinity norm. The new IIM is applied to the Hele-Shaw flow and compared with results from the literature.

**MS-Mo-E-57-2 16:25–16:50**

*The IIM for Axis-symmetric Problems and Application to the Hele-Shaw Flow*
Low-Reynolds-number Swimming in Two-phase Viscoelastic Gels
Du, Jian Florida Inst. of Tech.

Abstract: The fluid media surrounding many microorganisms are often mixtures of multiple materials with very different physical properties. We study the classical Taylor’s swimming sheet problem within a two-fluid model, which describes a mixture of a viscous fluid solvent and a viscoelastic polymer network. Our results indicate that depending on the interactions between the swimming surface and the network, elasticity may have drastically different effects on the swimming speed.

A Second-order Changing-connectivity ALE Scheme and Its Application to FSI
Liu, Jie National Univ. of Singapore

Abstract: We propose a second-order characteristic-inclined changing-connectivity ALE scheme. It does not explicitly calculate the characteristics but allows characteristic-inclined discretization. The resulting semi-implicit scheme for Navier-Stokes equations can handle both large deformation of the domain and strong convection of the fluid. We prove its optimal convergence rate in space and time and show its application to FSI problems. Various convergence and benchmark tests are presented.

A Hybrid Immersed Boundary and Immersed Interface Method for Electrohydrodynamical Simulations
Lai, Ming-Chih National Chiao Tung Univ.

Abstract: In this talk, we introduce a hybrid immersed boundary (IB) and immersed interface method (IIM) to simulate the dynamics of a drop under an electric field in Navier-Stokes flows. Within the leaky dielectric framework with piecewise constant electric properties in each fluid, the electric stress can be treated as an interfacial force on the drop interface. Thus, both the electric and capillary forces can be formulated in a unified immersed boundary framework.

Gradient Estimates for Solution of the Lamé System with High-contrast Coefficients
Ratsch, Christian UCLA

Abstract: We establish upper bounds on the blow up rate of the gradients of solutions, containing two adjoint inclusions with infinity elastic parameters.

Variational Modeling of Dilute Dislocations in Crystals
Ortiz, Michael CALTECH

Abstract: The energetics of dilute dislocations can be understood starting from elastic models with incompatible strains and suitable core regularization. I shall discuss recent progress in the derivation of a small-lattice-spacing limit of this type of model, leading to a reduced energy of the line-tension type. The variational limiting procedure is necessarily coupled to relaxation and highlights the possible spontaneous formation of small-scale oscillations in the dislocation distribution.
**Abstract:** Since the 1950s, it has been understood that dislocations can arrange themselves into regular structures, and the analysis of these structures has become an important mathematical contribution to the theory of plasticity. This talk will summarise different mathematical methods that have been used to understand dislocation pile-ups, beginning with the results obtained in the 1950s and 1960s using orthogonal polynomials and integral equations, through to more recent work based on variational methods and asymptotic analysis.

**Kinematics of Continuum Elastoplasticity in the Regime of Large Deformations**

Reina, Celia
Univ. of Pennsylvania

Conti, Sergio
IAM, Univ. of Bonn

Abstract: The kinematic description of finite elastoplasticity based on the decomposition $F_\text{Fe}F_\text{P}$ is standard in the continuum mechanics community. Besides its current acceptance, it has been largely debated in the literature and many issues still remain unresolved. In this talk we present some advances in this direction via mathematical multiscale analyses from discrete dislocations to the continuum scale.

**Convergence of Interaction-driven Evolutions of Dislocations**

Scardia, Lucia
Univ. of Bath

Abstract: I will consider a system of $N$ interacting parallel edge dislocation in single-slip, and discuss the convergence of the evolution of the corresponding empirical measures in the limit of many dislocations. The upscaling is performed by combining Gamma-convergence methods with the theory of rate-independent systems. This is a result obtained in collaboration with M.G. Mora and M.A. Peletier.

**Mathematical Modeling and Numerical Method for the Spontaneous Potential Well-logging**

Chen, Wei
Shanghai Lixin Univ. of Commerce

Abstract: Spontaneous potential well-logging is one of the most common and useful well-logging techniques in petroleum exploitation. Based on a series of previous results and a recent research, we provide a complete theoretical and numerical framework of the mathematical modeling and numerical method together with examples and applications for the spontaneous potential well-logging. The contents consist of mathematical model and its well-posedness, limit behavior of solutions and a reduced mathematical model, efficient numerical methods, examples and applications.

**Organizer:**
- IM-Mo-E-60-4
  - Chen, Wei
    - Shanghai Lixin Univ. of Commerce
  - Ita, Benedicy
    - Univ. of Calabar

**CP-Mo-E-61-1**

**SOLUTIONS OF THE SCHRÖDINGER EQUATION WITH INVERSELY QUADRATIC YUKAWA PLUS INVERSELY QUADRATIC POTENTIAL USING PEKERIS-LIKE APPROXIMATION OF THE COULOMB TERM AND PARAMETRIC NIKIFOROV-UVAROV METHOD**

Ita, Benedicy
Univ. of Calabar

Abstract: This work solves the Schrödinger equation with superposed potential $(\text{IQYIQP})$ made up of inversely quadratic Yukawa (IQY) potential and inversely quadratic (IQ) potential using the Pekeris-like approximation of the coulomb term in the potential and parametric Nikiforov-Uvarov (NU) method. The solution gives the energy eigenvalues and the corresponding un-normalized eigen functions obtained in terms of Jacobi polynomials. Also, special cases of the potential have been considered and their energy eigen values obtained. The result of the work could be applied to molecules moving under the influence of the IQYIQP potential as negative energy eigenvalues obtained indicate a bound state system.

**CP-Mo-E-61-2**

**Inverse Problem in Resistivity Well-Logging**

Cai, Zhijie
Fudan Univ.

**Abstract:** The resistivity well-logging is one of the most common and important techniques in petroleum exploitation. The main aim of this technique is to determine some physical and geometric parameters of the layer. In this paper, the resistivities of objective layer and invaded area and the invaded depth are inversely simultaneously by measuring the potentials on several electrodes. The mathematical theories and computational methods are presented. Some numerical simulations are given to illustrate our methods.

**Organizer:**
- IM-Mo-E-60-3
  - Cai, Zhijie
    - Fudan Univ.
  - Yue, Aizhong
    - Tech. Center, CNPC Logging company
  - Feng, Linwei
    - Tech. Center, CNPC Logging company
  - He, Quli
    - Technology, CNPC Logging company
  - Lu, Tao
    - Technology, CNPC Logging company
  - Chen, Bao
    - Technology, CNPC Logging company

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**Organizer:**
- IM-Mo-E-60-4
  - Chen, Wei
    - Shanghai Lixin Univ. of Commerce
  - Ita, Benedicy
    - Univ. of Calabar

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We approach this problem by using a multi-phase segmentation method. We express $\sigma$ as

$$\sigma(x) = \sum_{m=1}^{M} \sigma_m(x) \chi_m(x),$$

where $\chi_m$ is the characteristic function of a subdomain $\Omega_m$ such that $\Omega_m \cap \Omega_n = \emptyset, m \neq n$ and $\Omega = \bigcup_{m=1}^{M} \Omega_m$. The expected number of segments of $\Omega$ is $M$. Using a calculated optimality condition, the conductivity value $\sigma_m$ is expressed as a function of $\chi_m$. The total variation is then introduced to regularize the resulting cost functional. Using a descent method, an update for $\chi_m$ is proposed. Examples using topological derivative to obtain an initial estimate for $\chi_m$ are also presented.

**Mathematical Model of Cancer Treatment via Chemotherapy in Cycles**

Mancera, Paulo
Unesp, IBB
Guiraldello, Rafael Trevisanato
Inst. of BioSci. - UNESP
Martins, Marcelo
Physics Department, VI#231;osa Federal Univ.

Abstract: We present a mathematical model with the goal of understanding tumor development and the effect of administration in cycles according two protocols of chemotherapy as well as two methods of drug delivery. A linear stability analysis is developed for the spatially homogeneous model with and without treatment, in order to understand the dynamics of the model. We conclude that the parameters of competition are the main bifurcation parameters of the system, which define the tumor progression and success of chemotherapy. With these results, we do the numerical simulations where we concluded that the metronomic protocol proves more effective in prolonging the patient’s life than the Maximum Tolerated Dose (MTD) protocol. Moreover, the uniform delivery method along with the metronomic protocol is the most efficient in reducing the density of the tumor during treatment.

**Modeling Drug Release from Polymer-free Drug-eluting Stents**

Vo, Tuo N.T.
Univ. of Limerick

Abstract: Polymer-free drug-eluting stents (DESs) are an innovative new treatment for coronary heart disease which is leading the cause of death globally. In these polymer-free stents, the drug is either sprayed directly onto a bare metal surface or infused in a metallic porous medium. They have the potential to overcome problems associated with the current best treatment: polymer-coated DESs. However with no polymer to control drug release, it is unclear how desired release rates can be achieved. In this talk, I will present the first model of drug elution from polymer-free stents which is capable of predicting the drug release from a number of polymer-free systems including those that exhibit nanoporous, nanotubular and smooth surfaces. The model is based principally on dissolution theory and the theory of diffusion in porous media. Analytical solutions are derived to determine the important parameters that control the drug release.

**Proof of A Conjecture for the One-dimensional Perturbed Gelfand Problem from Combustion Theory**

Wang, Shin-Hwa
National Tsing Hua Univ.
Huang, Shao Yuan
National Tsing Hua Univ.

Abstract: We study the global bifurcation curves and exact multiplicity of positive solutions for the one-dimensional perturbed Gelfand problem

$$u''(x) + \lambda \exp\left(\frac{-u^3}{a}\right) = 0, \quad -1 < x < 1, \quad u(-1) = u(1) = 0,$$

where $\lambda, a > 0$. We prove that there exists $a_0$ ($a_0 > 4.069$) such that, on the $(\lambda, \|u\|_{H^1})$-plane, the bifurcation curve is S-shaped for $a > a_0$, and is monotone increasing for $0 < a < a_0$. It is joint work with Shao-Yuan Hwang.

**A Variational Property on the Bifurcation Curve for A Positional Problem with Cubic Nonlinearity**

Huang, Shao Yuan
National Tsing Hua Univ.
Wang, Shin-Hwa
National Tsing Hua Univ.

Abstract: We study a variational property on the bifurcation curve for a position problem

$$u''(x) + f(u) = 0, \quad -1 < x < 1, \quad u(-1) = u(1) = 0,$$

where $\lambda, c, \sigma, \rho > 0, \tau > 0$. Precisely, we study the order relations of two degenerate positive solutions and numbers $\gamma_1, p_1, p_2$ satisfying $f''(\gamma) = 0$ and $f(p_1) - p_1 f'(p_1) = f(p_2) - p_2 f'(p_2) = 0$.

**Blow-up of Solutions of Reaction-Diffusion System Arising from Biology**

ARUMUGAM, GURUSAMY
Bharathiar Univ.

Abstract: This work is devoted to the mathematical analysis of a reaction-diffusion system with cross-diffusion modeling the dispersal of an epidemic disease. We consider the propagation of an epidemic disease in a spatially distributed population and analyze the population densities at time $t$ and the spatial location $x$ of susceptible, infectious and recovered individuals. The existence of solutions is carried out by using the Galerkin technique and a compactness argument. Under suitable assumptions the blow-up of solutions is also established.

**Explicit high-order time stepping based on componentwise application of asymptotic block Lanczos iteration**

Lambers, James
Univ. of Southern Mississippi

Abstract: This talk describes explicit time stepping methods for linear and nonlinear PDEs that are specifically designed to cope with stiffness. As stiffness is caused by the contrasting behavior of coupled components of the solution, it is proposed to adopt a componentwise approach in which each Fourier coefficient of the solution is computed using an individualized approximation of the solution operator. This is accomplished by Krylov subspace spectral (KSS) methods, which treat these Fourier coefficients as bilinear forms involving matrix functions, that can be approximated using block Gaussian quadrature rules. The required quadrature nodes can be rapidly approximated using block Gaussian quadrature rules. The effectiveness of this approach is illustrated through numerical
results obtained from the application of KSS methods to diffusion equations and wave equations, as well as nonlinear equations through combination with exponential propagation iterative (EPI) methods.

**A Robust and Contact Resolving Riemann Solver in Two Dimensional Cylindrical Geometry**

Shen, Zhijun

Inst. of applied physics & computational mathematics

Abstract: This paper reviews some critical issues for the popular cell-centered numerical algorithms written in cylindrical geometry for compressible fluid. These issues include the spherical symmetry, conservation, singularity in the geometrical source and the compatibility between the numerical flux and nodal motion manner. Based on the understanding to above issues, some new cell-centered arbitrary Lagrangian Eulerian (ALE) methods on unstructured meshes are proposed. The main new feature of these algorithms is to establish a multi-dimensional Riemann solver based on HLLC method (denoted by ALE HLLC-2D). In the Riemann solver, a node-based discretization of the numerical fluxes is obtained through the computation of the time rate of change of the cell volume. It allows to derive finite volume numerical schemes that are compatible with the geometric conservation law (GCL). By employing the Riemann solver, the Eulerian ALE and Lagrangian formulations are written as a unified form and can be transformed freely.

**The Growth of the Vorticity Gradient for the Two-dimensional Euler Flow on A Symmetric Domain with A Corner**

Itoh, Tsubasa

Tokyo Inst. of Tech.

Yoneda, Tsuyoshi

Department of Mathematics, Tokyo Inst. of Tech.

Miura, Hideyuki

tokyo Inst. of Tech.

Abstract: We consider the two-dimensional Euler equation in a sector under a simple symmetry condition. It is shown that the growth of the vorticity gradient is depending on the angle of the sector. Moreover we generalize this result to the case of a symmetric domain with a corner.

**A New Fourth-Order Difference Method for Solving the System of Two-dimensional Non-linear Elliptic PDEs with Variable Coefficients**

Setia, Nikita

Univ. of Delhi

Abstract: A new fourth-order difference method for solving the system of two-dimensional non-linear elliptic PDEs with variable coefficients is proposed. The difference scheme referred to as off-step discretization is applicable directly to the singular problems and problems in polar coordinates. Stability analysis of the method applied to steady-state Convection-Diffusion equation is discussed. The methods are applied to many physical problems of interest including the steady-state Navier-Stokes equations of motion.

**Analysis of a Mixed Formulation of a Bilateral Obstacle Problem**

MERMRI, El Bekkaye

Faculty of Sci., Univ. Mohammed Premier

Bouchlaghem, Mohammed

Univ. Mohammed Premier - Faculty of Sci. in Oujda

Abstract: We consider a variational inequality problem called bilateral obstacle problem. Based on the reformulation of the bilateral obstacle problem presented by Mermri et al. (2003), we transform the problem into a saddle point problem of a Langrangian function $\mathcal{L}(u, \mu)$, where $u$ is the solution of the problem and the Lagrange multiplier $\mu$ is a function which characterizes the non-contact domain of the problem. Then we consider a discretization of the problem based on finite element method. In this paper we present the analysis of the continuous and the discrete problem. Then we show the convergence of the approximate solutions $(u_n, \mu_n)$ to the exact one $(u, \mu)$ and provide an error estimate. To solve the mixed formulation, we apply an iterative method and prove its convergence.

**High-order Accurate Difference Potentials Methods for 2-D Parabolic Interface Problems**

Co-authors: Yekaterina Epshteyn, University of Utah Qing Xia, University of Utah

Abstract: Designing high-order accurate numerical methods for interface problems or problems on arbitrary-shaped domains is a challenging area. The Difference Potentials Method (DPM) can be viewed as a discrete analog of the method of generalized Calderon potentials and Calderon boundary equations with projections. Recently, DPM was developed for parabolic interface problems. We will present our high-order accurate DPM approach and highlight its performance with several 2-D examples.

Co-authors: Yekaterina Epshteyn, University of Utah Qing Xia, University of Utah

**Finite Volume Approximation of Leaky Integrate-and-fire Model with Levy Noise**

Singh, Paramjeet

Thapar Univ., Patiala

Abstract: We investigate the numerical analysis of leaky integrate-and-fire model with Levy noise. We consider a single neuronal model and write the probability density function in the form hyperbolic conservation laws. Levy noise is included due to jumps caused by excitatory and inhibitory impulses. Due to these jumps the resulting equation have two integrals in right side (jumps). We design, implement, and analyze numerical methods based on Gudunov finite volume approximation. Some numerical examples are also included.

**Application of Vector Variance without Duplication for Testing Hypothesis of Equality Covariance Matrix**

Herdiari, Erna Tri

Hasanuddin Univ.

Sunusi, Nuriti

Hasanuddin Univ.

Abstract: Testing hypothesis of equality covariance matrix has been studied by researchers, either data or engaged in health economics. The usual
Effective Path Tracking in Polyhedral Homotopy Continuation Method
Lee, Tsung-Lin
National Sun Yat-sen Univ.
Abstract: When solving polynomial systems by polyhedral homotopy continuation method, many curves may diverge in the end. Tracking divergent solution curves will not reach solution of target system and its computation is costly. The curve expression theory will be considered. The leading term of the series expansion can be used to identify the multiplicity of solutions and to determine whether a homotopy curve diverges, which leads to a more efficient method.

On A Linear Finite Volume Scheme to the Keller-Segel System Modeling Chemotaxis
Zhou, Guanyu
University of Tokyo
Abstract: We are concerned with the finite volume approximation for the Keller-Segel system, which describes the aggregation of slime moulds resulting from their chemotactic features. We study a linear finite-volume scheme satisfies both positivity and mass conservation properties. Under some assumptions on mesh, we establish error estimates in $L^p$-norm with a suitable $p > d$, where $d$ is the dimension of a spatial domain. We apply the analytical semi-group theory of the discrete Laplace operator to the error analysis. We derive the discrete version of Lyapunov functional for the finite volume solution, where the Lyapunov functional play important role in studying the global behavior of solution of Keller-Segel system. Some numerical experiments are performed to verify the theoretical results.

An Adaptive Clustering for Functional Data
Lue, Heng-Hui
Tung hauli Univ.
Abstract: We propose a new adaptive approach for clustering functional data. The data-adaptive searching method based on dimension reduction theory, where the Lyapunov functional play important role in studying the global behavior of solution of Keller-Segel system. Some numerical experiments are performed to verify the theoretical results.

On the N–dimensional Oseen–Brinkman Flow Around An (n-1)–dimensional Solid Obstacle
Wendland, Wolfgang
IANS Univ. Stuttgart
Abstract: We propose a new adaptive approach for clustering functional data. The data-adaptive searching method based on dimension reduction theory, where the Lyapunov functional play important role in studying the global behavior of solution of Keller-Segel system. Some numerical experiments are performed to verify the theoretical results.

Materials and Science Code
Canning, Andrew
Lawrence Berkeley National Laboratory, UC Davis
Abstract: In recent years ab initio density functional theory (DFT) based materials science codes based using plane waves (PW) have become the largest user (by method) of computer cycles at scientific computer centers around the world. We present a hybrid OpenMP/MPI Conjugate Gradient based iterative eigensolver that allows this approach to scale to tens of thousands of cores on modern many core parallel computers. Performance results will be presented on Cray many core architectures.

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Abstract: We propose a new adaptive approach for clustering functional data. The data-adaptive searching method based on dimension reduction theory, where the Lyapunov functional play important role in studying the global behavior of solution of Keller-Segel system. Some numerical experiments are performed to verify the theoretical results.
Abstract: We present a layer potential analysis in order to show the well-posedness of modeling a transmission problem for the Oseen and Brinkman systems in open sets in $\mathbb{R}^m$ ($m = 2$ or $3$) with compact Lipschitz boundaries and around an $(m - 1)$-dimensional solid obstacle when the data belong to some $L^q$ spaces.

Current Trends in Wavelet Methods - Part II of II

For Part 1, see MS-Mo-D-66

Organizer: Manchanda, Pammy
Guru Nanak Dev Univ., Amritsar

Organizer: Siddiqi, Prof., Abul
Sharda Univ., NCR

Abstract: A formal development of wavelet methods was initiated by a geophysicist Morlet and subsequently Meyer, Mallat, Daubechies, Donoho, Cofman et al played important role in providing a solid mathematical foundation of this theme. Several variants of wavelets such as wavelet packets, wave packets, complex wavelets, curvelets, shearlets, framelets, vector valued wavelets have been studied along with their interesting applications. Relevance of wavelet methods to computerized tomography specially to the Radon transform and its variants have been studied in the recent years. It is well known by now that radon transform plays a significant role in medical imaging. In this mini symposium, updated results in the above mentioned fields will be presented including the results of the speakers in this area.

A Review of Certain Variants of Wavelets

Manchanda, Pammy
Guru Nanak Dev Univ., Amritsar

Abstract: Wavelet packets, Wave packets, Walsh type wavelets, Framelets, Complex Wavelets, Curvelets, Shearlets, Alpha-molecules, Haar-Vilenkin Wavelet, Wavelets associated with nonuniform multi resolution analysis and vector valued wavelets are some of the typical variants of wavelets which have been extensively studied in the recent past. In this talk a resume of some of the results particularly in the area of Nonuniform multi resolution analysis and associated wavelets, Haar-Vilenkin wavelet, obtained by us will be discussed.

Estimation of Radar Targets Satisfying the Wide Sense Stationary with Uncorrelated Scattering Assumption

Pfender, Goetz
Jacobs Univ.

Abstract: Many radar targets possess randomly varying parts which are described by a random process known as spreading function. Recent developments in operator sampling theory suggest novel channel sounding procedures that allow for the determination of the targets’ scattering function given complete statistical knowledge of the operator response to a single weighted pulse train. The presented results apply whenever the scattering function is supported on a compact subset of the time-frequency plane of arbitrary large
methods. We show the flexibility of our approach by proposing and analyzing their solution: a priori and a posteriori error analyses, adaptivity and multilevel for problems involving fractional powers of elliptic operators. Starting from nature, its accurate numerical approximation is delicate. We survey our re-

Abstract:

Fractional diffusion has become a fundamental tool for the modeling of multiscale and heterogeneous phenomena. However, due to its nonlocal nature, its accurate numerical approximation is delicate. We survey our research program on the design and analysis of efficient solution techniques for problems involving fractional powers of elliptic operators. Starting from a localization PDE result for these operators, we develop local techniques for their solution: a priori and a posteriori error analyses, adaptivity and multilevel methods. We show the flexibility of our approach by proposing and analyzing local solution techniques for a space-time fractional parabolic equation.

Tuesday, August 11, 2015

IL-Tu-1 8:30–9:30 Ballroom A
Invited Lecture
Chair: Kako, Takashi
Abstract:

Seismic full waveform inversion and the Monge-Ampère equation
Engquist, Björn
University of Texas at Austin

Abstract:

IL-Tu-2 8:30–9:30 Ballroom B
Invited Lecture
Chair: Strang, Gilbert
Abstract:

From phenomena of synchronization to exact synchronization and approximate synchronization for hyperbolic systems
Li, Tatsien
Fudan University

Abstract: In this talk the synchronization will be initially studied for infinite di-

mensional dynamical systems of partial differential equations instead of finite dimensional systems of ordinary differential equations, and will be connected with the control theory via boundary controls in a finite time interval. More precisely, various kinds of exact boundary synchronization and approximate boundary synchronization will be introduced and realized by means of fewer boundary controls for a coupled system of wave equations with Dirichlet boundary controls. Moreover, as necessary conditions for various kinds of approximate boundary synchronization, Criteria of Kalman’s type are obtained. Finally some prospects will be given.

IL-Tu-3 8:30–9:30 Ballroom C
Invited Lecture
Chair: Otto, Felix
Abstract:

An Applied Math Perspective on Climate Science, Turbulence, and Other Complex Systems
Majda, Andrew J.
Courant Institute at New York University

Abstract:

IL-Tu-4 10:00–11:00 Ballroom A
Invited Lecture
Chair: Ma, Zhiming
Abstract:

Covering the Uncertainty of Distributions by Nonlinear Expectation, Nonlinear PDE and BSDE
Peng, Shige
Shandong University

Abstract: The uncertainty of probability distributions can be described and calculated by nonlinear expectation. Nonlinear parabolic PDE plays a cru-

cially important role in the modeling and calculation of this model uncertainty problem. The theoretical foundation is our new law of large numbers and central limit theorem in the framework of nonlinear expectation. We also discuss the corresponding continuous time frameworks.

IL-Tu-5 10:00–11:00 Ballroom B
Invited Lecture
Chair: Huang, Yunqing
Abstract:

A PDE Approach to Numerical Fractional Diffusion
Nochetto, Ricardo
University of Maryland

Abstract: Fractional diffusion has become a fundamental tool for the modeling of multiscale and heterogeneous phenomena. However, due to its nonlocal nature, its accurate numerical approximation is delicate. We survey our research program on the design and analysis of efficient solution techniques for problems involving fractional powers of elliptic operators. Starting from a localization PDE result for these operators, we develop local techniques for their solution: a priori and posteriori error analyses, adaptivity and multilevel methods. We show the flexibility of our approach by proposing and analyzing local solution techniques for a space-time fractional parabolic equation.

IL-Tu-6 10:00–11:00 Ballroom C
Invited Lecture
Chair: Grandine, Thomas A.
Abstract:

Grid and Grid Control Optimization in Europe
Sax, Ludger
Grid Optimization Europe – System Planning Gas & Water

Abstract: Until the end of the last millennium the gas industry was an inte-

grated business. The integration of trading, network and gas storage facilities within a single enterprise guaranteed firstly the security of supply and lastly comfortable profits for the companies operating in this business. These high profits were a thorn in the eyes of the EU which tried to bring down energy prices by liberalizing and regulating the energy market.

Regulation meant that companies had to unbundle the trading arm from the network. This disintegration almost allowed the issue of security of supply to fall by the wayside because this role was now split between two different market players with divergent interests.

Newly established Transport System Operators (TSOs) had to simplify the system of tariffication, introducing an entry and exit system that allows cus-

tomers to be supplied from any grid entry point without this being linked to a specific route. For these TSOs, network planning has become much more complex. They rely on engineers and mathematicians to apply contemporary mathematics and state-of-the-art technology to establish modern mathemati-

cal methods in the planning and control of gas transport networks. This is so as to maximize grid capacity at minimum cost, thereby safeguarding security of supply. In other words, more “Mathematics to Gas Industry”, M2GI, the only way of maximizing the provision of capacity that can be freely allocated, of optimizing the grid and grid control to handle this and of reinstating security of supply.

IL-Tu-7 11:10–12:10 Ballroom A
Invited Lecture
Chair: E, Weinan
Abstract:

Modeling Rare Transition Events
Vanden-Eijnden, Eric
New York University

Abstract: Dynamics in nature often proceed in the form of rare transition events: The system under study spends very long periods of time at var-

ious metastable states; only very rarely it hops from one metastable state to another. Understanding the dynamics of such systems requires us to s-

tudy the ensemble of transition paths between the different metastable states. Transition path theory is a general mathematical framework developed for this purpose. It is also the foundation for developing modern numerical algorithm-

s such as the string method for finding the transition pathways. We review the basic ingredients of the transition path theory and discuss connections with the more classical transition state theory. We also discuss how the string method arises in order to find approximate solutions in the framework of the transition path theory.

IL-Tu-8 11:10–12:10 Ballroom B
Invited Lecture
Chair: Chayes, Jennifer
Abstract:

Explorations in the biofluid dynamics of locomotion
Fauci, Lisa
Tulane University

Abstract: In the past decade the study of the fluid dynamics of swimming or-

ganisms has flourished. With the possibility of using fabricated robotic micro swimmers for drug delivery, the need for a full description of flow properties is evident. At a larger scale, the swimming of a simple vertebrate, the lamprey, can shed light on the coupling of neural signals to muscle mechanics and pas-

sive body dynamics in animal locomotion. We will present recent progress in the development of a computational model of a lamprey with proprioceptive feedback and examine the emergent swimming behavior of the coupled fluid-

muscle-body system. At the micro scale, we will examine the swimming of a flagellum in a viscoelastic network. We hope to demonstrate that even when body kinematics at zero Reynolds number are specified, there are still inter-

esting fluid dynamic questions that have yet to be answered.
Abstract: A small random sample of rows/columns of any matrix is a decent proxy for the matrix, provided sampling probabilities are proportional to squared lengths. Since the early theorems on this from the 90’s, there has been a substantial body of work using sampling (random projections and probabilities based on leverage scores are two examples) to reduce matrix sizes for Linear Algebra computations. The talk will describe theorems, applications and challenges in the area.

For Part 1, see EM-Mo-D-01
For Part 2, see EM-Mo-E-01
For Part 3, see EM-Tu-E-01
For Part 5, see EM-We-D-02
For Part 6, see EM-We-E-01
For Part 7, see EM-Th-BC-01
For Part 8, see EM-Th-D-01

Organizer: Griesbrecht, Mark
Univ. of Waterloo

Organizer: Kaltofen, Erich
North Carolina State Univ.

Organizer: Saley El Din, Mohab
Univ. Pierre & Marie Curie

Organizer: Zhi, Li Hong
Acad. of Mathematics & Sys. Sci.

Abstract: Hybrid symbolic-numeric computation methods, which first appeared some twenty years ago, have gained considerable prominence. Algorithms have been developed that improve numeric robustness (e.g., in quadrature or solving ODE systems) using symbolic techniques prior to, or during, a numerical solution. Likewise, traditionally symbolic algorithms have seen speed improvements from adaptation of numeric methods (e.g., lattice reduction methods). There is also an emerging approach of characterizing, locating, and solving “interesting nearby problems”, wherein one seeks an important event (for example a nontrivial factorization or other useful singularities), that in some measure is close to a given problem (one that might have only imprecisely specified data). Many novel techniques have been developed in these complementary areas, but there is a general belief that a deeper understanding and wider approach will foster future progress. The problems we are interested are driven by applications in computational physics (quadature of singular integrals), dynamics (symplectic integrators), robotics (global solutions of direct and inverse problems near singular manifolds), control theory (stability of models), and the engineering of large-scale continuous and hybrid discrete-continuous dynamical systems. Emphasis will be given to validated and certified outputs via algebraic and exact techniques, error estimation, interval techniques and optimization strategies.

Our workshop will follow up on the seminal SIAM-MSRI Workshop on Hybrid Methodologies for Symbolic-Numeric Computation held in November 2010 and the Fields Institute Workshop on Hybrid Methodologies for Symbolic-Numeric Computation, November 16-19, 2011 at the University of Waterloo, Canada. We will provide a forum for researchers on all sides of hybrid symbolic-numerical computation.

Abstract:

**Spherical \( \ell_p \) Designs and Numerical Approximations on the Sphere**

Chen, Xiaojun
Department of Applied Mathematics, The Hong Kong Polytechnic Univ.

Abstract: Spherical \( \ell_p \)-designs with \( \ell \in [0,1) \) provide positive weight quadrature rules for the sphere which are exact for polynomials up to degree \( \ell \). Spherical \( \ell_p \)-designs with \( \ell = 1 \) are spherical \( \ell_p \)-designs which provide equal weight quadrature rules. In this talk, we introduce a computational algorithm based on interval arithmetic which, for given \( \ell \), upon successful completion, will have proved the existence of a \( \ell \)-design with \( (\ell + 1)^2 \) nodes on the unit sphere \( S^2 \subset \mathbb{R}^3 \) and will have computed narrow interval enclosures which are known to contain these nodes with mathematical certainty. Since there is no theoretical result which proves the existence of a \( \ell \)-design with \( (\ell + 1)^2 \) nodes for arbitrary \( \ell \), our method contributes to the theory because it was tested successfully for \( \ell = 1, 2, \ldots, 100 \). The \( \ell \)-design is usually not unique; our method aims at finding a well-conditioned one. The method relies on computing an interval enclosure for the zero of a highly nonlinear system of dimension \( (\ell + 1)^2 \). Moreover, we show that any point set in the interval enclosures is a spherical \( \ell_p \) design. Numerical results illustrate good performance of spherical \( \ell_p \) designs for numerical integration and function approximation on the sphere.
MS-Tu-D-03 13:30–15:30 306A
Applied Integrable Systems - Part III of V
For Part 1, see MS-Mo-D-03
For Part 2, see MS-Mo-E-03
For Part 4, see MS-Tu-E-03
For Part 5, see MS-We-D-03
Organizer: Hu, Xing-Biao Inst. of Computational Mathematics, Chinese Acad. of Sci. (CAS), China
Organizer: Kajiwara, Kenji Kyushu Univ.
Organizer: Kakei, Saburo Rikkyo Univ.
Organizer: Maruno, Kenichi Waseda Univ.
Abstract: In recent years, there have been major developments in applications of integrable systems. Originally, integrability has been recognized through solitons, which are particle-like nonlinear waves in various physical systems. Thanks to rich mathematical structure of integrable systems, recent applications of integrable systems extend to a wide range of pure/applied mathematics and physical sciences, such as algebraic geometry, combinatorics, probability theory, numerical algorithms, cellular automata, (discrete) differential geometry, computer visualizations, statistical physics, nonlinear physics and so on. The purpose of this minisymposium is to bring together researchers to discuss recent advances on various aspects of applied integrable systems.

- **MS-Tu-D-03-1** 13:30–14:00
  - **Ultradiscrete Inverse Scattering and Combinatorics**
  - Wilcox, Ralph the Univ. of Tokyo Kakei, Saburo Rikkyo Univ.
  - Abstract: A novel, inverse scattering-type, technique for solving Cauchy problems for integrable cellular automata will be presented for the case of the ultradiscrete KdV equation, defined over the real numbers. The action-angle variables that arise naturally in this approach turn out to be related in a rather simple way to those that can be obtained from a slightly modified version of an algorithm proposed by Takagi for calculating the Kerov – Kirillov – Reshetikhin map in the context of rigged-configurations.

- **MS-Tu-D-03-2** 14:00–14:30
  - **Jeu De Taquin Slide and Ultra-discrete KP Equation**
  - Kakei, Saburo Rikkyo Univ.
  - Abstract: Jeu de taquin is a combinatorial operation on skew Young tableaux. We consider difference equations that describe a Jeu de taquin slide and their relation to the discrete KP equation.

- **MS-Tu-D-03-3** 14:30–15:00
  - **Determinantal Structures in the O’Connell-Yor Polymer**
  - Imamura, Takashi Chiba Univ.
  - Abstract: O’Connell-Yor polymer is a typical directed polymer model in 2-dimensional random media which belongs to the KPZ universality class and has nice integrable structures related to the quantum Toda lattice and the Macdonald processes. In this talk, we will report novel determinantal structures in this model. This is a joint work with Tomohiro Sasamoto.

- **MS-Tu-D-03-4** 15:00–15:30
  - **Biorthogonal Polynomials, the Discrete Two-dimensional Toda Molecule and Plane Partitions**
  - Kamioka, Shuhei Kyoto Univ.
  - Abstract: A connection between biorthogonal polynomials and plane partitions is discussed. For a combinatorial problem of counting plane partitions in a rectangular box, or for an equivalent problem of counting rhombus tilings of a hexagonal region, a product formula of MacMahon type is derived by means of biorthogonal polynomials including the little q-Jacobi polynomials. Another proof by using a special solution to the discrete two-dimensional Toda molecule is also shown.

**IM-Tu-D-04** 13:30–15:30 308
Mathematics and Algorithms in Computer-Aided Manufacturing, Manufacturing Systems and Numerical Control - Part III of VI
For Part 1, see IM-Mo-D-04
For Part 2, see IM-Mo-E-04
For Part 4, see IM-Tu-E-04
For Part 5, see IM-We-D-04
For Part 6, see IM-We-E-04
Organizer: Li, Hongbo Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Organizer: Shpitalkin, Moshe Technion, Israel
Abstract: The fast development of advanced manufacturing technology has witnessed the growing importance of mathematical methods and algorithms, ranging from algebraic geometry, discrete geometry and differential geometry to differential equations, computational mathematics and computer mathematics. Conversely, problems arising from the field of advanced manufacturing have also stimulated the development of such branches in pure and applied mathematics as computational geometry and mathematics mechanization.

Mathematics and Algorithms for Computer-Aided Manufacturing, Engineering and Numerical Control is intended to be an interdisciplinary forum focusing on the interaction between the side of mathematical methods and algorithms, and the other side of computer-aided manufacturing (CAM), computer-aided engineering (CAE) and computer numerical control (CNC). It concentrates on (but is not restricted to) the following topics: tool path planning, multiscale simulation, feature-based process chain with CAM/CNC coupling, interpolation for CNC controllers.

The proposed industrial mini-symposium of 20 talks will provide an excellent platform for the participants to get acquainted with new research results, to exchange new ideas, and to create new collaboration.

To ensure full success of the proposed mini-symposium, we have invited 8 speakers from abroad. All are knowledgeable world experts in their fields, with impressive records of research, publications and awards, as well as solid background of mathematics. The invited speakers are from various countries and represent different aspects in Manufacturing, Manufacturing Systems and Computer Numerical Control.

**IM-Tu-D-04-1** 13:30–14:15
Modeling Multi-Stage Assembly Systems for Quality and Productivity
Hu, S. Jack Univ. of Michigan
Abstract: Assembly systems for consumer products are usually consisted of many machines arranged into various configurations. Variability and reliability at the machines can impact the system performance in terms of product quality and system throughput. In this talk, we present models on the propagation of quality variation in multi-stage assembly systems. In particular, the role of part compliance is considered in modeling non-rigid part assembly. We also present analytical models for system throughput prediction.

**IM-Tu-D-04-2** 14:15–15:00
Simulation Based Machine and Process Development
Uhlmann, Eckart Fraunhofer Inst. for Production Sys. & Design Tech. IPK
Abstract: In competitive markets, it is essential to improve the productivity, which can be achieved by raising the material removal rate. Yet, the dynamic behavior of the machine tool structures, process parameters and the complexity of the process itself can give rise to instabilities which restrict the performance of machines. Simulation models for machining processes and simulation-based machine development can help to optimize process planning and control. These models need to be parameterized and validated.

**IM-Tu-D-04-3** 15:00–15:30
On the Approximate Expression of Scallop Height under High-Order Contact
Li, Hongbo Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Abstract: In milling path designing, the scallop height is a key concept. Traditionally, the approximate expression of the scallop height for flat-end cutter is obtained by projecting everything onto a plane perpendicular to the tool path in the space. This is correct for first-order contact, but not for high-order contact. In this talk, we present our recent work on finding the approximate expression of the scallop height for flat-end cutter under high-order contact.

**MS-Tu-D-05** 13:30–15:30 215
Compressed Sensing, Extensions and Applications - Part III of III
For Part 1, see MS-Mo-D-05
For Part 2, see MS-Mo-E-05
Organizer: Kutyniok, Gitta Technische Universitat Berlin
Organizer: Holger, Rauhut RWTH Aachen Univ.
Abstract: Compressed sensing has been an enormous research activity in recent years. The key principle is that (approximately) sparse signals can be recovered efficiently from what was previously believed to be vastly incomplete information. For this reason, compressed sensing and its algorithms (often convex optimization approaches) have a large range of applications such as magnetic resonance imaging, radar, wireless communications, and more. Remarkably, all provably optimal measurement schemes are based on randomness and therefore, compressed sensing connects various mathematical fields such as random matrix theory, optimization, approximation theory, and harmonic analysis. Recent developments have extended the theory and its algorithms to the recovery of low rank matrices from incomplete informa-
tion, to the phaseless estimation problem, and to low tensor recovery. The minisymposium aims at bringing together experts in the field and to provide an overview of its most recent results.

- **MS-Tu-D-05-1**
  13:30–14:00
  **The State of Quantum Applications of Compressed Sensing and Low-rank Methods**
  Gross, David
  Univ. of Freiburg
  **Abstract:** Early developments in the theory of low-rank matrix recovery sparked significant interest from the physics community. Certain quantum-mechanical estimation problems are well-described in terms of low-rank models. Despite a successful exchange between physics and applied math on the conceptual level of low-rank recovery, experimental implementations were slow to appear. However, this has been changing over the past year. I will report on these developments, explain the initial obstacles and mention remaining open problems (mostly statistical).

- **MS-Tu-D-05-2**
  14:00–14:30
  **Co-Sparse Tomographic Image Recovery: Performance Estimates and Large-Scale Programming**
  Petra, Stefania
  Univ. of Heidelberg
  **Abstract:** We investigate the reconstruction problem of discrete tomography and present a relation between image co-sparsity and sufficient number of tomographic measurements for exact recovery similar to the settings in Compressed Sensing. Further, known quantisation levels are used as prior knowledge to improve recovery using techniques from the field of discrete graphical models. Finally, regarding recovery algorithms, we focus on decomposition schemes that exploit the problem structure and scale up to large problem sizes.

- **MS-Tu-D-05-3**
  14:30–15:00
  **Quantitative MRI Using Model-based Compressed Sensing**
  Davies, Mike
  Univ. of Edinburgh
  **Abstract:** We develop a model-based compressed sensing framework for fully quantitative MRI. That is the simultaneous acquisition of multiple MR physical parameters. The key components are: a random excitation sequence, a random EPI subsampling strategy, and an iterative projection algorithm imposing consistency with the Bloch equations. As long as the excitation sequence possesses persistent excitation, we are able to achieve accurate recovery of the density, T1, T2 and off-resonance maps simultaneously from limited samples.

- **MS-Tu-D-05-4**
  15:00–15:30
  **Cross Validation for Function Approximation: Quantitative Guarantees and Error Estimates**
  Ward, Rachel
  Univ. of Texas at Austin
  **Abstract:** Using tools from compressive sensing and matrix concentration, we provide quantitative guarantees for the accuracy of leave-p-out cross validation towards model selection and error estimation in function interpolation and approximation problems. The guarantees are with high probability with respect to the stochastic sampling points. This is joint work with Holger Rauhut.

- **MS-Tu-D-06**
  13:30–15:30
  **Divergence-free elements, grad-div stabilization, and related methods for incompressible flow problems - Part I of II**
  For Part 2, see MS-Tu-E-06
  **Organizer:** Linke, Alexander
  Weierstrass Inst.
  **Organizer:** John, Volker
  Weierstrass Inst.
  **Organizer:** Rebholz, Leo
  Clemson Univ.
  **Abstract:** Description In recent years, great progress has been achieved in the construction and understanding of divergence-free methods for incompressible flow problems, and in understanding the role of related stabilization methods for mixed finite elements like the grad-div stabilization. Especially, a lack of robustness of classical mixed methods with respect to large irrotational forces makes divergence-free methods appear attractive. The idea of the minisymposium is to gather researchers from around the world, who are active in this field, in order to discuss new ideas and to reflect on possible application fields, where divergence-free methods could outperform classical discretization approaches.

- **MS-Tu-D-06-1**
  13:30–14:00
  **The Divergence Constraint in Mixed Methods for Incompressible Flows: to Relax or Not to Relax?**
  Linke, Alexander
  Weierstrass Inst.
  **Abstract:** The divergence constraint of the incompressible Navier-Stokes equations is revisited in mixed finite elements. Classical stable and convergent mixed elements relax the divergence constraint and only enforce the condition discretely. As a result, these popular methods introduce a pressure-dependent consistency error which can potentially pollute the computed solution. This numerical error is harmful, wherever large and complicated pressures arise, like in large-scale ocean modeling (Coriolis force), coupled flow problems or flows around obstacles. Novel robust mixed methods are discussed, which allow for pressure-independent velocity errors.

- **MS-Tu-D-06-2**
  14:00–14:30
  **Optimal L2 Error for A Modified Crouzeix-Raviart Stokes Element**
  Wollner, Winnifried
  Univ. of Hamburg
  Linke, Alexander
  Weierstrass Inst.
  Merdon, Christian
  Weierstrass Inst. for Applied Analysis & Stochastics
  **Abstract:** The talk is concerned with optimal L2 error estimates for the velocity approximation in a nonconforming finite element approximation for the incompressible Stokes equation as proposed in [1]. The contribution of this presentation is to show that also optimal velocity estimates in L2, independent of the pressure, can be derived.

- **MS-Tu-D-06-3**
  14:30–15:00
  **Cochain-complex Based Multigrid for Stokes and Darcy-Stokes Problems**
  Kanschat, Guido
  Universität Heidelberg
  **Abstract:** Divergence-conforming discontinuous Galerkin methods for incompressible flow have been applied to different kinds of coupled flow problems during the last years. Here, we demonstrate how cochain-complex based multigrid methods can be used to obtain robust and efficient preconditioners for such methods. We present convergence estimates for the Stokes problem and present numerical results for coupled flow problems.

- **MS-Tu-D-06-4**
  15:00–15:30
  **Flux-preserving Boundary Conditions for Navier-Stokes and Grad-Div Stabilization**
  Heister, Timo
  Clemson Univ.
  **Abstract:** We discuss how incorrect interpolation of boundary conditions in numerical computations especially with Grad-Div stabilization can lead to accuracy issues and present a flux-preserving interpolation operator that fixes the problem.

- **MS-Tu-D-07**
  13:30–15:30
  **Mathematics of Climate: From the Tropics to Antarctica - Part III of III**
  For Part 1, see MS-Mo-D-07
  For Part 2, see MS-Mo-E-07
  **Organizer:** Steichmann, Samuel
  Univ. of Wisconsin-Madison
  **Organizer:** Golden, Kenneth
  Univ. of Utah
  **Abstract:** The Earth offers a multitude of modeling challenges, from the dynamics of the atmosphere and oceans, to the melting of the polar ice caps. To understand and model these climate processes, a wide range of mathematics is needed, such as differential equations, multiscale modeling, and stochastic processes. In this minisymposium, the presentations span a broad range of climate processes and mathematical areas, and will be accessible to a more general audience. They include a blend of modeling, experiments, and data analysis, and demonstrate how mathematics is being employed to address fundamental problems of climate science.

- **MS-Tu-D-07-1**
  13:30–14:00
  **Modeling the Melt: What Math Tells Us about the Shrinking Polar Ice Caps**
  Golden, Kenneth
  Univ. of Utah
  **Abstract:** The precipitous loss of Arctic sea ice has far outpaced expert predictions. We will discuss how mathematical models of composite materials and statistical physics are being used to study key sea ice processes and advance how sea ice is represented in climate models. This work is helping to improve projections of the fate of Earth’s ice packs, and the response of polar ecosystems.

- **MS-Tu-D-07-2**
  14:00–14:30
  **A Minimal Model for Precipitating Convection**
  Smith, Leslie
  Univ. of Wisconsin, Madison
  **Abstract:** We consider a minimal model of precipitating, turbulent convection. Cloud microphysics is included assuming fast condensation, auto-conversion and evaporation. The conservation laws for momentum, energy, moist entropy, and total water are retained in simple nontrivial form. We demonstrate that the model is able to capture general features of tropical squall lines. Lin-
ear stability analysis in a saturated environment predicts that the unstable scales depend on rainfall speed, a feature not captured by parcel theory.

**Abstract:** We develop stochastic models for temperature, precipitation and humidity for arid climates in order to simulate drought index values and model drought risk so as to improve food security. We validate the models by using historical weather data from Qatar and simulate the price of hypothetical drought derivative contracts designed to protect Qatari agricultural producers from the negative financial impacts associated with drought.

**MS-Tu-D-07-3 14:30–14:50**

**Modelling and Simulating Drought Risk in Arid Climates**

Pollanen, Marco

Trent Univ.

Paek, Jayeong

Trent Univ.

Abdella, Kenzu

Trent Univ.

Huda, SamFuel

Univ. of Western Sydney

Kaijie, Simoen

Qatar Univ.

Goktepe, Ipek

Qatar Univ.

Moustafa, Ahmed

Al Sulateen Agricultural & Industrial Complex (SAIC)

**Abstract:** We develop stochastic models for temperature, precipitation and humidity for arid climates in order to simulate drought index values and model drought risk so as to improve food security. We validate the models by using historical weather data from Qatar and simulate the price of hypothetical drought derivative contracts designed to protect Qatari agricultural producers from the negative financial impacts associated with drought.

**CP-Tu-D-07-4 14:50–15:10**

**Acceleration of A High Order CFD Solver with Optimized OpenACC Directives**

Gong, Jing

KTH Royal Inst. of Tech.

**Abstract:** Nek5000 is an open-source code for the simulation of incompressible flows. Nek5000 is widely used in a broad range of applications, including the study of thermal hydraulics in nuclear reactor cores, the modeling of ocean currents and the simulation of combustion in mechanical engines. We have previously introduced a case study of partially porting to parallel GPU-accelerated systems using OpenACC. In this presentation, we follow on from our previously developed work and take advantage of the optimized results to port the full version of Nek5000 to GPU-accelerated systems. The presentation focuses on porting and optimizing the most time-consuming parts of Nek5000 to the GPU systems, namely the matrix-matrix multiplication and the preconditioned CG linear solvers. The gather-scatter method with MPI operations is redesigned to decrease the amount of data transferred between the host and accelerator.

**MS-Tu-D-08 13:30–15:30**

**Inverse Problems for Medical Imaging - Part I of II**

For Part 2, see MS-Tu-D-08

**Abstract:** We develop stochastic models for temperature, precipitation and humidity for arid climates in order to simulate drought index values and model drought risk so as to improve food security. We validate the models by using historical weather data from Qatar and simulate the price of hypothetical drought derivative contracts designed to protect Qatari agricultural producers from the negative financial impacts associated with drought.

**MS-Tu-D-08-3 14:30–15:00**

**Tissue Characterization at Variable Depth Using Localized Planar EIT**

Kwon, Hyeuknam

Yonsei Univ.

**Abstract:** This paper presents a multi-scale method of measuring admittivity spectra using the bioimpedance spectroscopy (BIS) having a probe of 64x64 miniaturized electrodes. The proposed method evaluates the average admittivity values of voxels with varying their sizes with suitable combination of BIS data. This method allow to evaluates depth dependent admittivity distribution.

**MS-Tu-D-08-4 15:00–15:30**

**Reconstruction of EIT Images via Patch Based Sparse Representation over Learned Dictionaries**

Qi, Wang

Tianjin Polytechnic Univ.

**Abstract:** This paper presents the study of a new sparse reconstruction method for electrical impedance tomography (EIT). The EIT images are reconstructed based on adaptive patch-based sparse representation. Furthermore, the sparse dictionary is optimized during iteration. Simulation results are provided and compared with that of traditional reconstruction methods.
Efficient Numerical Methods for Solving Inverse Optimal Control Problems and Recent Computational Results for Modeling Human Locomotion
Bock, Hans Georg
IWR, Univ. of Heidelberg

Abstract: We present an efficient direct all-at-once - or simultaneous - optimization approach for solving inverse optimal control problems. These are complex bi-level optimization problems arising, e.g., in the identification of models for autonomous dynamical behavior. The performance of the method is demonstrated by identifying the parameters of a bio-mechanical optimal control model for the gait of cerebral palsy patients from real-world motion capture data provided by the Motion Lab of the Orthopedic University Hospital Heidelberg.

MS-Tu-D-10 13:30–15:30 206B
Propogation, destruction and recovery dynamics for localized patterns in dissipative systems Part I
Organizer: Nishiura, Yasumasa
Tohoku Univ., WPI-AIMR
Organizer: Ilma, Makoto
Hiroshima Univ.

Abstract: Spatially localized patterns arise ubiquitously in many fields including nerve systems, chemical reaction, binary fluids and bio-convection. This minisymposium especially highlights issues concerning wave-particle duality of the traveling spots, destruction of photo sensitive BZ waves, self-recovery property of multi-state network dynamics, and collective motion of self-propelled particles as well as emerging patterns in bioconvection of Euglena gracilis. All these problems are related to the interactive dynamics among the localized species and/or with external environments so that our goal is to extract the underlying common mechanism behind those variety of dynamics. In part I we will focus on the destruction and recovery properties of traveling spots and pulses in reaction diffusion systems. In part II more physical and biological aspect of localized pattern dynamics will be discussed.

MS-Tu-D-10-1 13:30–14:00
Wave-particle Duality in Dissipative Systems
Nishiura, Yasumasa
Tohoku Univ., WPI-AIMR

Abstract: Localized traveling spots with oscillatory tails have two different types of dynamic characteristics: one is a localized particle-like behaviors and the other is wave-like dynamics coming from the oscillatory tails. We will discuss about the wave-particle duality in reaction diffusion setting and try to understand a quantum-like behaviors in macroscopic level similar to Couder’s experiments of bouncing droplets. This is a joint work with Gao Zhijun.

MS-Tu-D-10-2 14:00–14:30
An Autonomous Distributed System for the Pathfiding Problem with Self-recovery Property
Ueda, Keiichi
Univ. of Toyama

Abstract: Self-recovery of function is one of the remarkable properties of biological systems, and its implementation in autonomous distributed systems is highly desirable. In this study, we propose an autonomous distributed system which is capable of finding a path connecting two specified vertices which are connected by unidirectional edges. The system has a self-recovery property, i.e., the system can find a path when one of the connections in the existing path breaks. We propose such a system, and demonstrate it by experiments.

MS-Tu-D-10-3 14:30–15:00
Where is the Achilles Heel of the BZ Traveling Pulse?
Nishi, Kei
Department of Mathematics, Hokkaido Univ.
Nishiura, Yasumasa
Tohoku Univ., WPI-AIMR

Abstract: It is known that the traveling pulse moving in photo-sensitive BZ media disappears when the photo-intensity is increased uniformly in space. Our questions are, “Can we make the pulse die out by a localized beam of light in space and time?” and “Where is the Achilles heel of it, the most vulnerable part of the pulse beam?” We numerically give an answer to these questions, and demonstrate it by experiments.

MS-Tu-D-11 13:30–15:30 203B
Recent developments on Electrochemical Interface Modeling
Organizer: Landstorfer, Manuel
WIAS

Abstract: A model based understanding of electrochemical interfaces is a key issue for a variety of new technological developments, such as the formulation of charge transfer reactions in electrochemical systems such as modern batteries, fuel cells.

MS-Tu-D-11-2 14:00–14:30
Ionic Specific Effects Beyond the Poisson-Boltzmann Theory: Electrolytes, Surfaces & Membranes
Andelman, David
Tel Aviv Univ.

Abstract: In aqueous solutions, dissolved ions interact strongly with the surrounding water and surfaces, thereby modifying solution properties in an ion-specific manner. The Poisson-Boltzmann description of ionic solutions has been successfully used in predicting charge distributions and interactions between charged macromolecules. However, when dealing with various aspects of real physical, chemical and biological systems, the Poisson-Boltzmann has several noticeable shortcomings. In the talk I will describe several such effects that we have considered recently. I will review how this strategy has been used to predict some of the ways ion-specific effects can modify the forces acting within and between charged interfaces immersed in salt solutions. Among others, they include steric effects due to finite ion size close to interfaces, decrement of the solution dielectric constant due to the presence of ions, mixed solvent effects, and a new ion-specific model for surface tension of electrolytes that takes into account direct surface-ion interactions.

MS-Tu-D-11-3 14:30–15:00
Theory, Structure and Experimental Justification of the Metal/electrolyte Interface
Landstorfer, Manuel
WIAS

Abstract: In this talk we will provide insight to our new electrolytic mixture theory which explicitly accounts for solvation and adsorption. We will show that this model is the very basis for a qualitative and quantitative understanding of the capacitive behaviour of a variety of electrodes and electrolytes. We will further show that our approach is also the very basis for a model based understanding of cyclic voltammetry and thus a key tool for analytical electrochemistry.

MS-Tu-D-11-4 15:00–15:30
Combined Electrical Double Layer and Ion Transport Modeling in Water Desalination
Dykstra, Jouke
Keesman, Karel
Van Der Wal, Albert
Biesheuvel, Maarten

Abstract: Capacitive deionization is a novel electrochemical desalination technology. Salt water flows between two oppositely polarized porous carbon electrodes and is desalinated. Ions are adsorbed into porous carbon electrodes, where two processes occur: the desorption of ions in Electrical Double Layers and the transport of ions subject to diffusional and migrational forces. We theoretically describe and animate the time-dependent salt concentration profiles across the electrodes and show the development of very steep “shocks” in salt concentration.

MS-Tu-D-12 13:30–15:30 208B
Extremal Combinatorics, Probabilistic Combinatorics, and their applications - Part III of III
For Part 1, see MS-Mo-D-12
For Part 2, see MS-Mo-E-12
Organizer: Ma, Jie
Univ. of Sci. & Tech. of China
Organizer: Huang, Hao
Inst. for Mathematics & its Applications, Univ. of Minnesota

Organizer: Chen, Guantao
Georgia State Univ.

Abstract: Combinatorics is a fundamental discipline of modern mathematics which studies discrete objects and their properties. This minisymposium we propose will focus on the subfield of extremal and probabilistic combinatorics, which has witnessed an exciting development over the past decades, and also has many striking practical applications in mathematical optimization, computer science, statistical physics and voting society. We aim to bring together researchers to the minisymposium, where they will present the recent progress, discuss open challenges, exchange research ideas, and initiate new collaborations. We expect a minisymposium of this nature to have a lasting

Revision of the Butler-Volmer Equations in the Context of Thermodynamics of Irreversible Processes
Guhlike, Clemens
Weierstrass Inst.

Abstract: In the lecture we show that a thermodynamically consistent choice of reaction rates in addition to any asymptotic analysis of the double layer leads to a generalized Butler-Volmer equation. One important result is that the formulation of the BV equation is coupled to the transport equations of the electrode and electrolyte. The generalized BV equation forms the basis for modeling of electron transfer reactions in electrochemical systems such as modern batteries, fuel cells.

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Organizer: Chen, Weierstrass Inst.

Revision of the Butler-Volmer Equations in the Context of Thermodynamics of Irreversible Processes
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impact on the future of the subject.

MS-Tu-D-12-1 13:30–14:00  
A Simple Removal Lemma for Large Nearly-intersecting Families  
Das, Shagnik  
Freie Universit"at Berlin  

Abstract: We give a simple proof of a removal lemma for large intersecting families, showing that a k-uniform set family on \([n]\) with close to \((\binom{n}{k}-1)\) sets and few disjoint pairs can be made intersecting by removing few sets. We then apply the lemma to resolve a question of Bollobas, Narayanan and Raigorodski regarding transference of the Erdos-Ko-Rado theorem to sparse random Kneser subgraphs.  
Joint work with Tuan Tran.

MS-Tu-D-12-2 14:00–14:30  
Circular Flow of Highly Edge Connected Signed Graphs  
Zhu, Xuding  
Zhejiang Normal Univ.  

Abstract: This paper proves that if a signed graph is \((12k-1)\)-edge connected and is essentially\((k-1)\)-unbalanced, then its circular flow number is \(2+1/k\).

MS-Tu-D-12-3 14:30–15:00  
Fractional Chromatic Number of Subgraphs  
Wu, H refriger UniveMississippi  

Abstract: In 1970’s, Erd"os and Hajnal conjectured that for every numbers \(k\) and \(g\), there exists a number \(f(k, g)\), such that every graph with chromatic number at least \(f(k, g)\) contains a subgraph with chromatic number at least \(k\) and girth at least \(g\). We prove that fractional chromatic number version of the conjecture for \(k = 4\).  
Bukh conjectured that a random subgraph \(G_{1/2}\) has chromatic number \(\chi(G_{1/2})\) is \(\Omega(\log(n))\), we proved the fractional version of this conjecture.

MS-Tu-D-12-4 15:00–15:30  
Computing with Voting Trees  
Iglesias, Jennifer  
Carnegie Mellon Univ.  
Ince, Nathaniel  
Carnegie Mellon Univ.  
Loh, Po-Shen  
Carnegie Mellon Univ.  

Abstract: One well-studied election procedure specifies a complete binary tree with leaves labeled by the candidates, and evaluates it by running pairwise elections between the pairs of leaves, sending winners to successive rounds of pairwise elections which ultimately terminate with a single winner. We exhibit a new construction which always produces a winner who could defeat at least sqrt(N) other candidates, significantly improving the previous log(N) bound.  
Joint work with Jennifer Iglesias and Nate Ince.

MS-Tu-D-13 13:30–15:50  
Analysis and algorithm for coupling of kinetic and fluid equations - Part III of III  
For Part 1, see MS-Mo-D-13  
For Part 2, see MS-Mo-E-13  
Organizer: Lu, Jianfeng  
Duke Univ.  
Organizer: Sun, Weiran  
Simon Fraser Univ.  

Abstract: Kinetic equations are widely used to model complex systems occurring in gas dynamics and transport phenomena, as examples. In these applications, it is common that dense and dilute parts coexist in the system. This leads to multiple spatio-temporal scales which introduce difficulties in both analysis and numerics. Kinetic-fluid coupling hence has received intensive studies in recent years. This minisymposium aims to bring together experts in analysis and algorithm in kinetic equations to discuss the current status and future developments of the field. It also provides a platform for further interaction and collaboration for researchers in this and related areas.

MS-Tu-D-13-1 13:30–14:00  
Hydrodynamic Limits from Kinetic Equations in Bounded Domain  
Jiang, Ning  
Tsinghua Univ., Beijing  

Abstract: In this talk I will review the hydrodynamic limits from kinetic equations in domain with bounded. Incompressible Navier-Stokes equations can be derived from Boltzmann equation with Maxwell reflection boundary condition. The boundary conditions for the NS equation depends on the relative sizes of the Knudsen number and accommodation number. We also will discuss the incompressible Euler limit, in particular the relation with Prandtl boundary layer.

MS-Tu-D-13-2 14:00–14:30  
Uncertainty Quantification for Kinetic Equations  

Jin, Shi  
Univ. of Wisconsin-Madison & Shanghai Jiao Tong Univ.  

Abstract: In this talk we will study the generalized polynomial chaos (g-PC) approach to hyperbolic and kinetic equations with uncertain coefficients/inputs, and multiple time or space scales, and show that they can be made asymptotic-preserving or well-balanced, in the sense that the gPC scheme preserves various asymptotic limits in the discrete space. This allows the implementation of the gPC methods for these problems without numerically resolving (by space, time, and gPC modes) the small scales.

CP-Tu-D-13-3 14:30–14:50  
A Multilevel Monte Carlo Method for the Kinetic Equations of Plasma Dynamics  
Ricketson, Lee  
New York Univ.  

Abstract: The multilevel Monte Carlo (MLMC) method - introduced by Giles for rapid valuation of financial assets modeled by SDEs - has found numerous applications in other fields, where it frequently accelerates computations by multiple orders of magnitude. An outstanding challenge, however, is the application of the method to McKean-Vlasov equations - SDEs featuring interaction with a mean field determined by an average over the underlying stochastic dynamics. Such equations are ubiquitous in statistical models of physical phenomena. Of particular interest are kinetic equations, whose high dimensionality makes Monte Carlo particularly attractive. We present a generalization of MLMC to a class of McKean-Vlasov equations, with particular emphasis on applications to the acceleration of the particle-in-cell (PIC) codes that are ubiquitous in the kinetic plasma simulation community. Both theoretical results establishing the efficiency of the method and results from numerical tests will be discussed.

CP-Tu-D-13-4 14:50–15:10  
A Robust Numerical Method for A Multi-scale Dynamical System  
Patidar, Kailash C.  
Univ. of the Western Cape  

Abstract: In this talk, we will consider a multi-scale dynamical system arising in mathematical biology. The various parameters involved in the models that vary at different time scales makes such governing problems very difficult to be solved analytically. One can gather semi-qualitative information about the solutions using standard analytical techniques. However, a full description about the behavior of solutions is hardly obtainable. To this end, we will discuss a class of numerical methods that can better suit such models. Proposed method will be explored on a number of test examples.

CP-Tu-D-13-5 15:10–15:30  
A Kinetic Model of Wealth Distribution and Migration Phenomena  
Knooppoff, Damian  
Universidad Nacional de Cordoba  
Torres, German Ariel  
Facultad de Matematica, Astronomia y Fisica - Universidad Nacional de Cordoba - CIEM - CONICET  

Abstract: A kinetic model for wealth distribution within a population based on the kinetic theory for active particles is presented, where individuals are characterized by a microscopic variable (the activity) describing their state and are subdivided into classes, including the eventual migration of individuals between populations. In contrast to previous models, it is assumed that interactions among individuals (viewed as trades) are non-conservative and that an external agent (e.g. the State) implements certain distribution policies, since it is clear that wealth can be created and destroyed within a society and consequently the total wealth and the mean wealth per capita evolves in time. The model is stated in terms of a system of differential equations modelling the time evolution of a distribution function that represents the proportion of individuals in each class. Existence and uniqueness of solutions are shown and some selected simulations representing different scenarios and a parameter
appropriate continuum limit, the two processes are identical but interesting dif-
fferences emerge in our lattice model. The most notable phenomenon is that
the stationary parasite population generally increases with the bias, reaching a
maximum before vanishing at some critical value.

**MS-Tu-D-14**
13:30–15:30
Mathematical Theories and Computational Aspects of Complex Fluids - Part III of III
For Part 1, see MS-Mo-D-14
For Part 2, see MS-Mo-E-14
Organizer: Wang, Changyou
     Tsinghua Univ.
Organizer: Liu, Chun
     Penn State Univ.
Organizer: Lin, Fanghua
     Courant Inst./NYU
Abstract: Complex fluids, fluids with microstructure, are ubiquitous in our daily
life and modern day engineering and biology applications. We are facing new
challenges in mathematical theories and techniques in order to resolve issues
such as ensemble of micro-elements, intermolecular interactions, coupling to
hydrodynamics and applied electric or magnetic fields. The multiphysics-
multiscale nature of these complicated materials also provide the best testing
ground for new techniques and ideas. In these mini-symposium sessions, we will bring some of the most active re-
searchers in this field, together with postdocs and students. The purpose is
to present the most current results, provoking new ideas, as well as motivate the
young researchers to work in the field.

**MS-Tu-D-14-1**
13:30–14:00
Decoupled, Linear and Energy Stable Schemes for Phase-field Models of Mul-
tiphase Complex Fluids
Shen, Jie
     Purdue Univ.
Abstract: I shall present some recent work on designing efficient decoupled
energy stable schemes for phase-field models of multiphase complex fluid-
s. I shall provide ample numerical results which not only demonstrate the
effectiveness of the numerical schemes, but also validate the flexibility and
robustness of the phase-field model.

**MS-Tu-D-14-2**
14:00–14:30
Global Existence and Uniqueness Theorem to 2-D Incompressible Non-
resistive MHD System Subject to Linearly Growing Velocity
Zhang, Ting
     Zhejiang Univ.
Abstract: In this talk, we consider the 2D incompressible viscous and non-
resistive magnetohydrodynamics (MHD) system. Here, we consider the glob-
al existence and uniqueness of the solution which close to the particular so-
lation that the velocity is linearly growing at infinity.

**MS-Tu-D-14-3**
14:30–15:00
Steady Viscous Compressible Channel Flows
Jiang, Song
     Inst. of Applied Physics & Computational Mathematics
Abstract: We prove the existence and uniqueness of strong solutions to the
steady isentropic compressible Navier-Stokes equations with inflow boundary
condition in a 2-D finite channel near a uniform flow. The proof is based on the
delicate a priori estimates and exploitation of the elliptic theory. For our
result, we do not require the velocity, density, the Reynolds number and the
Mach number to be small. (joint work with Y. Guo and H. Zhou)

**MS-Tu-D-14-4**
15:00–15:30
Isotropic-Nematic Phase Transition for the Liquid Crystal
Zhang, Zhilei
     Peking Univ.
Abstract: I will talk about the derivation of the sharp interface model of the
Isotropic-Nematic phase transition from the Landau-de Gennes theory.

**MS-Tu-D-15**
13:30–15:30
Inverse problems in PDE and probability - Part I of II
For Part 2, see MS-Tu-E-15
Organizer: Helin, Tapio
     Univ. of Helsinki
Organizer: Hyvonen, Nuutti
     Aalto Univ.
Abstract: The aim of the minisymposium is to highlight new research results
in inverse problems that involve stochastic modelling and partial differential e-
quations. All aspects of such inversion are discussed, including mathematical
analysis, computational techniques, and experimental results.

**MS-Tu-D-15-1**
13:30–14:00
A Bayesian Level Set Method for Geometric Inverse Problems
Lu, Yulong
     Univ. of Warwick
Abstract: We develop a novel Bayesian level set approach for geometric in-
verse problems that arise in PDE-constrained applications. Our work con-
ists of a rigorous application of the infinite-dimensional Bayesian framework
whereby proving the measurability of the observational map that arises from
our level-set representation enables us to show existence and well-posedness of
the posterior measure. The method is applied to solve two model problems:
inverse source problem and groundwater flow problem.

**MS-Tu-D-15-2**
14:00–14:30
Spectral Approximations for Iterative Inversion Methods: A Parabolic Case
Mustonen, Lauri
     Aalto Univ.
Abstract: In the context of nonlinear inverse problems, we present an efficient
way to construct the linear subproblems of a Gauss-Newtonian iteration. The
method is based on solving the forward problem in a high-dimensional param-
eter domain by using spectral methods, resulting in a numerical solution that
depends explicitly on the parameters. As an example we study the inverse
boundary value problem of a parabolic partial differential equation.

**MS-Tu-D-15-3**
14:30–15:00
Detecting Stochastic Inclusions in Electrical Impedance Tomography
Harrach, Bastian
     Univ. of Stuttgart,
Abstract: (This is a joint work with A. Barth, N. Hyvérinen and L. Musto-
 nen.) We consider the inclusion detection problem of electrical impedance to-
mography with stochastic conductivities. We show that a conductivity anoma-
ly with a random conductivity can be identified by applying the Factorization
Method or the Monotonicity Method to the mean value of the corresponding
Neumann-to-Dirichlet map provided that the anomaly has high enough con-
trast.

**MS-Tu-D-15-4**
15:00–15:30
Edge-promoting Reconstruction of Absorption and Diffusivity in Optical To-
mography
Majander, Helle
     Aalto Univ.
Abstract: Diffuse optical tomography is an imaging modality for determining the
diffusion and absorption distributions inside a highly scattering object.
This is done by guiding near-infrared light to the surface of the object and
observing the light propagation by the detectors on the surface. In this talk
we assume that both properties contain distinct inclusions in a constant back-
ground. We introduce an iterative algorithm for simultaneously reconstructing
the diffusion and absorption using edge-prefering priors.

**MS-Tu-D-16**
13:30–15:30
Multi-scale complex flows - Part I of II
For Part 2, see MS-Tu-E-16
Organizer: Świerczewska-Gwiazda, Agnieszka
     Univ. of Warsaw
Abstract: The mini-symposium aims to present challenging problems of multi-
scale description of various phenomena including polymeric fluids, collective
behaviour, to name a few. There are different approaches to such problems -
either through kinetic equations, modelling of the microstructure by the s-
tochastic partial differential equations or by capturing macroscopic quantities
in terms of averaged macroscopic ones. Our aim is to present some of these
approaches and the recent studies, both from the point of view of mathemati-
cal analysis and numerical results.

**MS-Tu-D-16-1**
13:30–14:00
Yield Stress Fluids as Singular Limits of Viscoelastic Fluids
Renardy, Michael
     Virginia Tech
Abstract: Traditional models of yield stress fluids postulate a critical stress
where a change from solid to fluid behavior occurs. Many yield stress fluids,
have, however, exhibit much more complicated behavior such as delayed yielding,
yield stress hysteresis, and thixotropy, i.e. the long time persistence of a yield-
ed state long after flow has stopped. The lecture will review recent efforts to
model such behaviors by a viscoelastic fluid with a long relaxation time.

**MS-Tu-D-16-2**
14:00–14:30
Hydrodynamic Models for Collective Behavior
Carrillo, Jose A.
     Imperial College London
Abstract: We study the critical thresholds for the compressible pressureless
Euler equations with pairwise attractive or repulsive interaction forces and
non-local alignment forces in velocity in one dimension. We provide a com-
plete description for the critical threshold to the system without interaction
forces leading to a sharp dichotomy condition between global in time exist-
ence or finite-time blow-up of strong solutions.

**MS-Tu-D-16-3**
14:30–15:00
Deterministic Modeling of Protein Polymerization
Gabriel, Pierre
     Univ. of Versailles
Abstract: The polymerization of proteins is involved in numerous neurodegen-
erative diseases as prion or Alzheimer diseases. The growth-fragmentation
PDE provides a relevant first modeling of the elongation and breakage of the
polymers. After an overview of recent results on the long time behaviour of the linear growth-fragmentation equation, we will derive more realistic nonlinear models. These new models will be analysed by taking advantage of a self-similar change of variables.

**Stochastic and Deterministic Models for Protein Polymerization**

Dumou, Marie

Inria

Abstract: Amyloid diseases (which include Alzheimer’s, Huntington’s, Parkinson’s etc) involve the aggregation of misfolded proteins. Elucidating the intrinsic mechanisms of the chain reactions involved is a major challenge of molecular biology due to the extremely high complexity of the considered processes. I will review existing results and explain our approach, based on combined ODE-PDE and stochastic models.

**Reaction-diffusion-advection systems arising from mathematical biology modeling chemotaxis - Part I of III**

For Part 2, see MS-Tu-E-17

For Part 3, see MS-We-D-17

Organizer: Xiang, Tian

Renmin Univ. of China

Abstract: As with all living organisms, single cells and bacteria sense and respond to the environment where they live. The primary way these organisms achieve this is through the phenomenon of chemotaxis. Chemotaxis is the oriented movement of cells and organisms along chemical gradients, as a response to gradients of the concentration of chemical substances. It plays a significant role in many biological fields, and chemotaxis models have been successfully applied to the aggregation patterns in bacteria, slime molds, skin pigmentation patterns, angiogenesis in tumor progression and wound healing and many other examples. Therefore, a huge number of works, both theoretical and experimental, have been devoted to exploring and hence understanding the mechanism of chemotaxis.

In 1953, Patlak contributed the first mathematical idea to model chemotaxis. In 1970s, Keller and Segel introduced a classical and important chemotaxis model (a advection-diffusion type parabolic-parabolic quasi-linear PDE systems) to describe the aggregation process of cellular slime mold by chemical attractions. These pioneering works have initiated an intensive mathematical investigation of the (Patlak-Keller-Segel model and chemotaxis models have become one of the best study models in mathematical biology over the last 40 years. Despite its simple looking, the Keller-Segel model exhibits the phenomenon of cell aggregation, which is usually modeled by time-dependent solutions blow-up in finite or infinite time. Thus, the issue whether or not the solutions of the proposed chemotaxis models are globally bounded or blow-up becomes the main concern in studying K-S type models. It is a very active research subject; up to now, there are at least 5 beautiful survey papers, Horstmann [1,2], Hillen and Painter [3], Wang [4] and Blanchet [5], where one is provided with a good survey on the progress of various chemotaxis models as well as with a rich selection of references. The key phenomena are: no blow-up in 1-D, except in some extreme nonlinear diffusion models, critical mass blow-up in 2-D, and generic blow-up in ≥ 3-D, a breakthrough made in Winkler [6]. Chemotaxis phenomenon has been also successfully applied to other equations, for instance, Navier-Stokes equations, see [7] for a glimpse. Thus, in our mini-symposium, our topics center mainly on reaction-diffusion-advection systems modeling chemotaxis arising from mathematical biology. We bring together active researchers to share and discuss our very recent results on boundedness versus blow-up, critical mass blow-up, global existences, stability and large time behavior so as to understand more insights on the mechanism of chemotaxis. This mini-symposium will definitely stimulate more inspirations.

In 1970, D. Horstman introduced the first mathematical idea to model chemotaxis. Since then the Keller-Segel system has been extensively studied and generalized in various ways. For example, the models with nonlinear diffusion have been extensively studied. In particular, the Keller-Segel model with nonlinear diffusion is closely related to the so-called chemotaxis-Navier-Stokes equations, which are known to be a mathematical model for the chemotaxis of bacteria.

In this talk, we investigate the asymptotic behavior of solutions to the Keller-Segel model with nonlinear diffusion. We establish the global existence, compactness theorem. The behavior of the solutions is also investigated, as the chemotactic coefficient goes to infinity. The existence of spiky steady states is shown by using Ladyzhenskaya’s compactness theorem.
problem has a unique nonnegative classical solution. Moreover, the asymptotic convergence to the solution of the heat equation is proved. Finally, numerical results in the super critical case show that solution exists globally.

**Gamma-convergence of the Discrete Internal Energy and Application to Gradient Flows**

Patacchini, Francesco Saverio Imperial College London

Abstract: We approximate diffusion equations with finite numbers of particles. As the 2-Wasserstein energy is not defined for point-masses, we spread uniformly the mass of each particle in some ball around it. This “tessellation” gives a discrete energy defined on point-masses, which Gamma-converges in the Wasserstein topology to its continuum version as the particles’ number increases. For the linear diffusion case, we show the convergence of the resulting discrete gradient flow to the standard heat equation.

**Aggregation Equation with Density Constraint**

Yao, Yao Univ. of Wisconsin Madison

Abstract: In this talk, we discuss an aggregation equation with a constraint on the maximum density. We will discuss the relationship between this equation and the Keller-Segel equation with degenerate diffusion. We will also show that in 2D, if the initial data is a characteristic function, it will converge to the characteristic function of a disk as the time goes to infinity. This is a joint work with Katy Craig and Inwon Kim.

**Multiscale methods with applications in fluid mechanics and materials modeling**

For Part 1, see MS-Mo-D-19

For Part 2, see MS-Mo-E-19

Organizer: Brown, Donald Univ. of Bonn
Organizer: Henning, Patrick Univ. of Muenster

Abstract: With this Minisymposium we aim to gather leading researchers in the field of numerical multiscale methods, i.e. methods that are construct-ed to efficiently tackle differential equations with a large spectrum of length scales. The speakers present a wide range of different applicable methods and approaches resulting in an extensive exchange of ideas. Among others, parabolic and hyperbolic multiscale problems are discussed, as well as Maxwell’s equations or the two-phase flow equations in porous media. The minisymposium focuses on the practical aspects of the methods, as well as on questions regarding a corresponding numerical analysis.

**Cloud Based Interactive Simulations of Maxwell’s Equations Using the Localized Reduced Basis Method**

Buhr, Andreas Univ. of Muenster
Ohlberger, Mario Univ. of Muenster
Rave, Stephan Univ. of Muenster

Abstract: Engineers manually optimizing a structure using simulation software often employ an iterative approach where in each iteration they change the structure and recompute. ArbLoMod, a method designed for this manual, iterative workflow will be shown. It allows fast recomputation after arbitrary local modifications. It employs a domain decomposition and a localized, certified form of the Reduced Basis Method for model order reduction. The reduced model is adapted when necessary, steered by a localized error indicator.

**An Efficient Hierarchical Multiscale Finite Element Method for Stokes Equations in Slowly Varying Media**

Hoang, Viet Ha Nanyang Technological Univ.

Abstract: We develop an efficient numerical method to compute effective properties for media with varying microstructures. We achieve essentially equal accuracy to that for the full resolution of every local cell problem but require essentially equal complexity to that for solving only one problem. Solutions of cell problems at different macroscopic points are solved with different levels of accuracy and used to correct each other (joint work with Donald Brown (Bonn) and Yalchin Efendiev (Texas A&M)).

**Reduced Order Models for the Optimization of a Material Microstructure**

Legoli, Frederic ENPC

Abstract: We present an approach for the optimization of the microstructure of a material in order to minimize its compliance. The current microstructure is modelled as a macroscopic deformation, to be optimized upon, of a reference periodic microstructure. In this talk, we describe the approach and show how to use reduced order models to keep the computational load limited. Joint work with V. Ehrlacher, C. Le Bris, G. Leugering and M. Stingl.
iments show the efficiency of the proposed algorithm for finding zeros of a system of polynomial equations with high degrees on the sphere and solving differential variational inequalities.

**MS-Tu-D-21**  13:30–15:30  309B

**Minisymposium on discontinuous Galerkin method: recent development and applications - Part I of VIII**

- For Part 2, see MS-Tu-E-21
- For Part 3, see MS-We-D-21
- For Part 4, see MS-We-E-21
- For Part 5, see MS-Th-BC-21
- For Part 6, see MS-Th-D-21
- For Part 7, see MS-Th-E-21
- For Part 8, see MS-Fr-D-21

**Organizer:** Xu, Yan  
**University of Science & Technology of China**

**Abstract:** Over the last few years, discontinuous Galerkin (DG) methods have found their way into the mainstream of computational sciences and are now being successfully applied in almost all areas of natural sciences and engineering. The aim of this minisymposium is to present the most recent developments in the design and theoretical analysis of DG methods, and to discuss relevant issues related to the practical implementation and applications of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

**MS-Tu-D-21-1**  13:30–14:00

**DG Methods for Convection-dominated Problems: Survey and Recent Developments**

- Shu, Chi-Wang  
  **Brown University**

**Abstract:** We give a short survey of high order accurate discontinuous Galerkin (DG) methods for solving convection-dominated problems. We will then review some of their recent developments, including DG methods for Hamilton-Jacobi equations with obstacles, efficient IMEX time discretization for DG methods solving convection-diffusion equations, and other topics.

**MS-Tu-D-21-2**  14:00–14:30

**Nonstandard Discontinuous Galerkin Methods for Fully Nonlinear Second Order PDEs**

- Feng, Xiaobing  
  **University of Tennessee**

**Abstract:** In this talk, I shall present some recent developments in discontinuous Galerkin (DG) methods for fully nonlinear second order PDEs, such as the Monge-Ampere equation and Hamilton-Jacobi-Bellman equations, in high dimensions. The focus of the talk will be on introducing two families of nonstandard DG methods, namely, mixed IP-DG (interior penalty DG) methods and LDG (local discontinuous Galerkin) methods, for these fully nonlinear PDEs. The main ideas and formulations of the proposed DG methods will be explained in details, numerical experiments will also be presented to show the performance of the proposed DG methods. The challenges and open questions will be discussed as well at the end. This is a joint work with Tom Lewis of the University of North Carolina at Greensboro, U.S.A.

**MS-Tu-D-21-3**  14:30–15:00

**Simulating Steady State Solutions of Some 1D Kinetic Models**

- Li, Fengyan  
  **Rensselaer Polytechnic Inst.**

**Abstract:** In this work, we investigate how well the discontinuous Galerkin discretizations can capture the steady state solutions of some one-dimensional linear kinetic models, with examples including electron-phonon scattering models arising from the design of low-dimensional semiconductor devices. Mathematical properties will be examined for the discrete operators, and this is complemented by the numerical experiments. This work is jointly with Y. Chen, Z. Chen, Y. Cheng and A. Gillman.

**MS-Tu-D-21-4**  15:00–15:30

**Stormer-Numereov HDG Methods for Acoustic Waves**

- Ji, Liangyue  
  **University of Minnesota**

**Abstract:** In this work, we first propose a semi-discretization conserving HDG method for the acoustic wave equation and prove that the displacement and gradient converge with the optimal order of $k+1$ in the L2-norm uniformly in time. If the spatial dimensions of degree $k$ greater than or equal to 0 are used. Then, we use a local postprocessing technique to obtain a new approximation of the displacement converging with order $k+2$ for $k>0$. In this work, we first propose a semi-discretization conserving HDG method for the acoustic wave equation and prove that the displacement and gradient converge with the optimal order of $k+1$ in the L2-norm uniformly in time. If the spatial dimensions of degree $k$ greater than or equal to 0 are used. Then, we use a local postprocessing technique to obtain a new approximation of the displacement converging with order $k+2$ for $k>0$. We propose low-rank stationary iterations for the solution of generalized Lyapunov equations, which are coupled linear eigenvalue problems.

**MS-Tu-D-22**  13:30–15:30  208A

**Iterative Methods and Preconditioning - Part I of II**

- For Part 2, see MS-Tu-E-22

**Organizer:** Pestana, Jennifer  
**University of Manchester**

**Organizer:** Syzdyk, Daniel  
**Temple University**

**Abstract:** The solution of large sparse linear systems is at the core of most problems in science and engineering. Iterative methods, in conjunction with the use of preconditioning, are among the leading techniques for their solution. Development and analysis of known and new methods and preconditioners continues to be at the forefront of research, with new applications and new outlooks for larger problems and new computer architectures. In this minisymposium current developments are showcased, illustrating recent advances and the wide range of applications including tensor equations, matrix equations, shifted systems, PDE-constrained optimization, and nonlinear eigenvalue problems.

**MS-Tu-D-22-1**  13:30–14:00

**Iterative Methods for Tensor Linear Equations**

- Chu, King-wah Eric  
  **Monash University**

**Abstract:** We consider the numerical solution of linear equations in the tensor product space, arising from the discretization of elliptic partial differential operators in high dimension. We apply the classical GMRES and BICGSTAB methods, and a new iterative method, without any tensor toolboxes. It is critical to control the growth of ranks of the iterates and the associated insatiable demand on computing resources. Good data structures and preconditioning will be vital for any algorithm.

**MS-Tu-D-22-2**  14:00–14:30

**On Operator and Matrix Descriptions of Iterative Methods**

- Strakos, Zdenek  
  **Charles University in Prague**

**Abstract:** This contribution deals with coupling the infinite dimensional operator, discretization and algebraic computation levels in iterative solution of problems modeled by PDEs. We will focus on distribution of the error over the domain, convergence behavior and the interplay between discretization and acceleration of convergence.

**MS-Tu-D-22-3**  14:30–15:00

**Parallel Preconditioning for Time-dependent PDE-constrained Optimisation**

- McDonald, Eleanor  
  **University of Oxford**

**Abstract:** All-at-once schemes aim to solve all time-steps of parabolic PDE-constrained optimization problems in one coupled computation, leading to exceedingly large linear systems requiring efficient iterative methods. We present a new block diagonal preconditioner which is both optimal with respect to the mesh parameter and parallelizable over time, thus can provide significant speed-up. We will present numerical results to demonstrate the effectiveness of this preconditioner.

**MS-Tu-D-22-4**  15:00–15:30

**Classical Iterative Methods for the Solution of Generalized Lyapunov Equations**

- Syzdyk, Daniel  
  **Temple University**

**Abstract:** We propose low-rank stationary iterations for the solution of generalized Lyapunov equations. At each step, we solve a Lyapunov equation using Galerkin projection with extended Krylov subspaces. One of the advantages of this classical approach is that only the data and the low-rank factors of the old and new iterates need to be kept in storage. Numerical experiments show the competitiveness of the proposed approach. Joint work with S. Shank and V. Simoncini.
Abstract: The EC fp7 Integrating Project www.iqmulus.eu addresses the representation and processing of big geospatial data in the Cloud. One of the objectives is to address smooth ocean floor and provide LR-spline algorithm for accurate and compact approximation of hundreds of millions of data points acquired by LiDAR. The results provide a platform on which to build IGA solutions for geospatial problems, and a bridge from reverse engineering of human made shapes to IGA.

Efficient Isogeometric Analysis-reuse Method for Complex Objects with Topology-consistent Volumetric Parameterization

Xu, Gang
Hangzhou Dianzi Univ.

Abstract: Volumetric spline parameterization and computational efficiency are two main challenges in isogeometric analysis. In this talk, we propose the concept of analysis-reuse for three-dimensional models with similar semantic features, by which the computational efficiency can be improved significantly. Given a template domain, a CSRBF-based elastic function method is proposed to construct topology-consistent volumetric B-spline parameterization for models with similar semantic features. Several examples are presented to show the effectiveness of the proposed method.

Discussions on the Dimensions of the Spline Spaces Defined on T-meshes

Li, Chong-Jun
Dalian Univ. of Tech.

Abstract: The T-meshes are local modification of rectangular meshes which allow T-Junctions. The dimension of a spline space is a basic problem for the theories and applications of splines. However, the problem of determining the dimension of a spline space is difficult since it heavily depends on the geometric properties of the partition. In many cases, the dimension is unstable. In this talk, we study the dimensions of the spline spaces defined on T-meshes.

Analysis-suitable T-splines

Li, Xin
ustc

Abstract: This talk provides the basic mathematical properties for a sub-class of T-splines, analysis-suitable T-splines, and their applications in isogeometric analysis.

Time integration of partial differential equations

Organizer: Ostermann, Alexander
Univ. of Innsbruck

Organizer: Einkemmer, Lukas
Univ. of Innsbruck

Abstract: In recent years there has been much progress in the construction and analysis of new time discretization schemes for partial differential equations. As important developments, we mention exponential integrators and operator splitting methods. The former rely on the variation-of-constants formula and solve linear problems exactly. They are thus particularly suited for stiff and highly oscillatory semi-linear problems with small nonlinearity. The latter, although in use since many decades, are nowadays much better understood in terms of stability and convergence properties (e.g., order reduction due to boundary conditions). In addition, the conservation of geometric properties of solutions (i.e. the preservation of invariants and the long term behaviour of numerical approximations) is becoming increasingly important. In this regard, splitting methods have a great potential. The aim of this minisymposium is to present a stage for these ideas and new developments.

Toolkit for Building An Efficient Exponential Integrator

Tokman, Mayya
Univ. of California, Merced

Abstract: We will provide an overview of analytical, numerical and implementation-related issues that have to be addressed to develop efficient exponential integrators of EPIRK-type. Existing classes of such integrators for different types of problems will be discussed. We will present numerical experiments demonstrating comparative performance of several exponential and implicit schemes and describe a software package EPIC that implements these exponential methods for serial and parallel architectures.

A Semi-Lagrangian Discontinuous Galerkin Approach for the Vlasov Equation

Einkemmer, Lukas
Univ. of Innsbruck

Abstract: The numerical solution of the Vlasov equation poses a number of challenges. Among them are the high dimensional nature of the problem, the development of small scale structures in phase space, and the importance of charge conservation. The so-called semi-Lagrangian discontinuous Galerkin methods are considered an attractive alternative to more traditional approaches (such as spline interpolation). In this talk we will discuss this method, discuss its properties, and consider high performance computing aspects.

High-order Splitting Methods for Non-autonomous Parabolic Equations

Blanes, Sergio
Polytechnical Univ. of Valencia

Abstract: We consider the numerical integration of non-autonomous separable parabolic equations using high order splitting methods with complex coefficients. Splitting methods with complex coefficients with positive real part have been successfully proposed in the literature. A straightforward application to non-autonomous problems requires the evaluation of the time-dependent operators at complex times. We propose new time-averaging high order methods with half the coefficients being real and positive (for the time-averaging) and tailored for several classes of problems.

New Preconditioned Exponential Time Integrators for Stiff Differential Equations

Luan, Vu Thai
Univ. of California, Merced
Tokman, Mayya
Univ. of California, Merced
Rainwater, Greg
Univ. of California, Merced

Abstract: We propose two new classes of time integrators for stiff DEs: the implicit-explicit exponential (IMEXP) and the hybrid exponential methods. In contrast to the existing exponential schemes, the new methods offer significant computational advantages when used with preconditioners. Any preconditioner can be used with any of these new schemes. This leads to a broader applicability of exponential methods. The proof of stability and convergence of these integrators and numerical demonstration of their efficiency are presented.

Stiffly Accurate Efficient Exponential Integrators of EPIRK-type

Rainwater, Greg
Univ. of California, Merced
Tokman, Mayya
Univ. of California, Merced

Abstract: The theory of stiff order conditions originally proposed for Exponential Rosenbrock methods (EXPRB) in [1,2] is extended to the class of exponential propagation iterative methods of Runge-Kutta type (EPIRK). We show how the structural flexibility inherent in the coefficients of the EPIRK methods can be exploited to derive more efficient integrators then previously proposed EPIRK and EXRB schemes. We illustrate this approach for the stiffly accurate EPIRK methods coupled with the adaptive Krylov methods.


A Backward Error Analysis for the Leja Method

Kandolf, Peter
Univ. of Innsbruck
Ostermann, Alexander
Univ. of Innsbruck

Abstract: The Leja method is a well established scheme for computing the action of the matrix exponential. We present a new backward error analysis allowing a more efficient method. From a scalar computation in high precision we predict the necessary number of scaling steps based only on a rough estimate of the field of values or norm of the matrix and the desired backward error. The efficiency of the approach is shown in numerical experiments.

Isogeometric methods and design-through-analysis tools in CAD/CAE - Part I of III

For Part 1, see MS-Mo-D-25
For Part 2, see MS-Mo-E-25

Organizer: BUFFA, Annalisa
IMATI "E. Magenes", CNR
Organizer: Giannelli, Carlotta
INDAM c/o Univ. of Florence

Abstract: The development process of industrial digital products relies on geometrical and numerical technologies provided by computer aided applications. The computational models are usually designed through commercial Computer Aided Design (CAD) systems and subsequently processed and approximated with Computer Aided Engineering (CAE) software tools. In order to drastically improve the efficiency and robustness of this process, a deep interaction among scientists from geometric modeling and numerical analysis is needed. An active area of research in this context is related to isogeometric analysis, an emerging paradigm for the solution of partial differential equations which combines and extends finite element techniques with CAD methods related to spline technologies. The isogeometric perspective provides an attractive alternative to more traditional approaches (such as spline interpolation). In this talk we will discuss this method, discuss its properties, and consider high performance computing aspects.

New Preconditioned Exponential Time Integrators for Stiff Differential Equations
outlines new paths of research for the identification of geometric representations suitable for numerical simulation.

Indeed, isogeometric analysis is based on the idea that the exact geometry of the model should be preserved throughout the overall design-through-analysis process and numerical methods should be able to simulate physical phenomena directly on the CAD model. This is possible only if new, spline based numerical techniques are designed and innovative schemes for geometric design are developed.

The minisymposium will address theoretical and computational issues that arise in the identification, characterization and use of advanced geometric and analytical methods that share the goal of promoting new paradigms for a better CAD/CAE integration.

Abstract:
The rise of isogeometric analysis is increasingly demanding the standardization of geometric design framework at MTU, the integration of adaptive spline technologies and isogeometric approaches will show paths to improve the overall design-tough-analysis processes within an industrial environment.

MS-Tu-D-25-2
14:00–14:30
A Natural Framework for Isogeometric Fluid-structure-interaction: Coupling BEM and Shell Models
Heltai, Luca
SISSA
Abstract: We propose an iso-geometric FSI method for the coupling of thin structures and viscous flows, entirely based on surface CAD representations. This is made possible by a shell formulation for the structure and a boundary integral representation for the fluid. We couple a nonlinear isogeometric Kirchhoff-Love formulation with an isogeometric BEM formulation of three dimensional Stokes flows. This allows the treatment of infinite computational domains, and it is entirely based on surface NURBS descriptions.

Abstract:

TriGA: Generalization of Isogeometric Analysis to Unstructured Triangular and Tetrahedral Discretizations
Evans, John
Univ. of Colorado Boulder
Luke, Engvald
Univ. of Colorado Boulder
Abstract: In this talk, we present the TriGA software framework which generalizes the isogeometric design-through-analysis methodology to unstructured triangular and tetrahedral discretizations. TriGA is capable of automatically creating high-quality triangular meshes that exactly match arbitrary 2D geometries defined by NURBS curves, and it enables semi-automatic 3D mesh generation for most classes of geometries. We demonstrate the utility of the TriGA framework in the context of continuous and discontinuous Galerkin methods with a suite of numerical examples.

Abstract:

Design and Convergence of Adaptive Isogeometric Methods
Giannelli, Carlotta
InDAM c/o Univ. of Florence
BUFFA, Annalisa
IMATI “E. Magenes”, CNR
Abstract: The rise of isogeometric analysis is increasingly demanding the study of reliable and adaptive schemes that combine suitable spline technologies which provide local refinement possibilities with the design of a posteriori error estimators. The talk will present an adaptive isogeometric method that exploits the potential of hierarchical B-spline constructions, in connection with admissible mesh configurations. The derivation of error bounds for residual-type estimators will be presented and used for the convergence analysis of the scheme.

Abstract:

Poromechanics studies the interactions between fluid motion and solid deformation. It has important applications including consolidation, subidence due to fluid withdrawal, and hydraulic fracturing. Many discretizations and solver schemes have been developed for poromechanics but the design of effective simulation techniques for handling the coupling between fluid motion and solid deformation is still a challenging task. The main theme of the minisymposium is on the advanced numerical algorithms for sim-
ululating poromechanics. The focus is on robust discretizations, adaptivity and efficient nonlinear and linear solvers for various poromechanical models and their applications.

**On Dimension Reduction Approach for Simulations of Poromechanical Deformations in Pleated Filters**
Illiev, Dimitar
Fraunhofer Inst. for Industrial Mathematics ITWM
Kirsch, Ralf
Fraunhofer ITWM

Abstract: Approach for solving poromechanics for thin porous media is considered. The particular application is filtration, flat and pleated porous media are considered. Reduction of the 3D poromechanics equations to poreelastic plate and poroeleastic shell models, done by Mikelic is the starting point. Weak coupling approach between Navier-Stokes-Brinkman and the poroeleasticity is exploited. Validation results, results demonstrating the computational efficiency of the approach, and simulations in realistic geometries will be presented.

**Efficient Preconditioners for Finite Element Discretizations of Biot Consolidation Model**
Bin, Zheng
Pacific Northwest National Laboratory

Abstract: In this work we construct efficient block preconditioners for solving the linear systems resulting from finite element discretizations of Biot model. We show that the preconditioned Krylov iterative methods converge uniformly with respect to both the discretization parameters and the model parameters. Numerical examples are given to verify the theoretical results. This is a joint work with (in alphabetical order) Luoping Chen, Xiaozhe Hu, Lu Wang, and Jinchao Xu.

**Phase-field Modeling for Hydraulic Fracturing in Porous Media**
Wheeler, Mary F
UT-Austin

Abstract: We discuss phase-field modeling of a fluid-driven fracture in a poroelastic medium. The mathematical model consists of a linear elasticity system with fading elastic moduli as the crack grows, coupled with an elliptic variational inequality for the phase field variable and with a pressure equation. Two approaches of coupled are considered, both fully coupled and one based on stress splitting. Computational results are presented. This work is in collaboration with Andro Mikelic, Thomas Wick, and Shanghyun Lee.

**Weak Galerkin Method and Its Applications - Part III of III**
For Part 1, see MS-Mo-D-28
For Part 2, see MS-Mo-E-28
Organizer: Chen, Long
Univ. of California at Irvine
Organizer: Ye, Xiuxi
Univ. of Arkansas at Little Rock
Organizer: Zhang, Ran
Jilin Univ.

Abstract: The Weak Galerkin method is an extension of the standard Galerkin finite element method where classical derivatives were substituted by weakly defined derivatives on functions with discontinuity. As such, the WG methods have the flexibility in handling complex geometry and low regularity solutions, the simplicity in analyzing real-world physical problems, and the symmetry in reformulating the original PDEs. The aim of this mini-symposium is to bring together specialists in order to ex-change ideas regarding the development of WG-FEMs and its industry and research applications. Since women is an underrepresented group in mathematics and engineering, we pay a particular attention to attract female participants.

**Equivalence of Weak Galerkin Methods and Virtual Element Methods for Elliptic Equations**
Chen, Long
Univ. of California at Irvine

Abstract: We propose a modification of the weak Galerkin methods and show its equivalence to a new version of virtual element methods. We also show the original weak Galerkin method is equivalent to the non-conforming virtual element method. As a consequence, ideas and techniques used for one method can be transferred to another. The key of the connection is the degree of freedoms.

**A Divergence-free Weak Galerkin Finite Element**
Zhang, Shangyou
Univ. of Delaware

Abstract: A weak Galerkin finite element is designed so that the computed velocity is divergence-free. The significance of such a method is shown by solving a low-viscosity Stokes problem. The traditional finite elements, weak Galerkin finite elements and discontinuous Galerkin finite elements fail to produce a meaningful solution in solving such a test problem.

**Minisymposium’s Code “ycGz6P”: Modified Weak Galerkin Methods for Convection-diffusion Problem**
Gao, Fuzheng
Shandong Univ.

Abstract: Minisymposium’s code “ycGz6P”: In modern numerical simulation of problems in energy resources and environmental science, it is very important to develop efficient numerical methods for convection – diffusion problems. Based on modified weak gradient operator and weak divergence operator, we present a modified weak Galerkin finite element method (MGW-FEM) on arbitrary meshes. Some techniques, such as calculation of the virtual transmission operator and the theory of prior error estimates and techniques, are adopted. Optimal order error estimates for the corresponding MGW-FEM approximations in both a discrete $H^1$ norm and the standard $L^2$ norm are derived to determine the errors in the approximate solution. Numerical results are presented to demonstrate the robustness, reliability, and accuracy of the MGW-FEM.
Multilevel Monte Carlo methods and applications - Part III of III

For Part 1, see MS-Mo-D-31
For Part 2, see MS-Mo-E-31

Organizer: TEMPONE, RAUL
KING ABDULLAH Univ. Of Sci. & Tech.
Organizer: Giles, Michael
Univ. of Oxford
Organizer: Nobile, Fabio
MATHICSE - EPFL

Abstract: Monte Carlo methods are general, flexible sampling methods for the computation of expected values of observables arising in stochastic systems. Monte Carlo methods are very attractive since they are simple to implement and their rate of convergence is very robust. Still, in the context of random evolution of large systems arising from the discretization of differential equations subject to randomness, their cost can be too large for practical purposes.

We recently created a Multilevel Monte Carlo method extended to multiple levels, the idea of using a coarse numerical approximation as a method for control variate to a finer one, reducing the variance and the required number of samples on the finer grid. Multilevel Monte Carlo changed the computational landscape of stochastic problems described in terms of differential equations, which are commonplace, for instance, when carrying out Uncertainty Quantification in applications. In this minisymposium we intend to present the latest algorithmic and theoretical contributions to Multilevel Monte Carlo methods, focusing also on novel applications arising in, among others, stochastic social, chemical and biological modeling, wireless communication networks, computational finance, stochastic particle systems and engineering modeling with random PDEs.

Optimization of Mesh Hierarchies in Multilevel Monte Carlo Samplers

Haji Ali, Abdul Lateef
KAUST
Nobile, Fabio
MATHICSE - EPFL
TEMPONE, RAUL
KING ABDULLAH Univ. Of Sci. & Tech.

Abstract: We perform a general optimization of the parameters in the Multilevel Monte Carlo (MLMC) discretization hierarchy based on uniform discretization methods with general approximation orders and computational costs. We optimize hierarchies with geometric and non-geometric sequences of mesh sizes and show that geometric hierarchies are nearly optimal and have the same asymptotic computational complexity as non-geometric optimal hierarchies. To provide numerical grounds for our theoretical results, we test our hierarchies with the Continuation MLMC Algorithm.

MULTI-INdEX MONTE CARLO METHOD

Haji Ali, Abdul Lateef
KAUST
Nobile, Fabio
MATHICSE - EPFL
TEMPONE, RAUL
KING ABDULLAH Univ. Of Sci. & Tech.

Abstract: We propose and analyze a novel Multi-Index Monte Carlo (MIMC) method for weak approximation of stochastic PDE models, that uses high-order mixed differences to achieve variance reduction, as opposed to first-order differences as in Multi Level Monte Carlo (MLMC).

We present complexity results which increase, with respect to MLMC, the set of parameters for which optimal convergence $1/\tau^2$ is achieved, and propose a systematic construction of optimal sets of indices based on properly defined profits.

Multilevel Monte Carlo Simulations of Stochastic McKean-Vlasov Equations

Lukasz, Szpruch
Univ. of Edinburgh

Abstract: During this talk I will discuss Multilevel Monte Carlo simulation techniques for stochastic McKean-Vlasov equations. These are non-linear stochastic equations whose coefficients depend on the on the state variable and the law of its solution. Propagation of Chaos theory states that the solution to stochastic McKean-Vlasov equations can be approximated by system of interacting particles. Practical implementations of particle systems are computationally very costly - the issue I’m going to address in this talk.

A MUltiple LEVEL ADAPTIVE REACTION-SPLITTING SIMULATION METHOD FOR STOCHASTIC REACTION NETWORKS

TEMPONE, RAUL
KING ABDULLAH Univ. Of Sci. & Tech.
Moraes, Alvaro
KAUST
Vilanova, Pedro
KAUST

Abstract: We develop novel hybrid Multilevel Monte Carlo methods for kinetic simulation of stochastic reaction networks. The ML hybrid algorithms adaptively switch between the Stochastic Simulation Algorithm and the Tau Leap method. They also control the global exit probability of any simulated path using a Chernoff-type bound and obtain accurate and computable estimates of the expected value of any smooth observable of the process with minimal computational work. Our numerical examples show substantial computational gains.

Numerical Analysis of Stochastic Differential Equations - Part I of II

For Part 2, see MS-Tu-E-30

Organizer: Neuenkirch, Andreas
Univ. of Mannheim
Organizer: Jentzen, Arnulf
ETH Zurich

Abstract: This session is devoted to the numerical analysis of all kinds of stochastic differential equations (SDEs) and related approximation problems. Among the studied equations, there will be SDEs with irregular coefficients, backward SDEs (BSDEs), stochastic partial differential equations (SPDEs) and SDEs with other driving noises than Brownian motion. The goal of this session is to present recent developments in the area of computational SDEs. Particular focus will be given to the interplay of the different topics in this area and to the identification of new research questions.

Approximating Irregular SDEs via Iterative Skorokhod Embeddings

Ankirchner, Stefan
Univ. of Jena

Abstract: We provide a new method for approximating the law of a diffusion M solving a stochastic differential equation with possibly irregular coefficients. To this end we construct Markov chains whose laws can be embedded into the diffusion M with a sequence of stopping times that have expectation 1/N, where N is a discretization parameter. We show that the Markov chains converge in distribution and we illustrate our results with several examples.

Renormalization and Stochastic PDEs

Shen, Hao
Univ. of Warwick

Abstract: I will discuss some examples of stochastic nonlinear PDEs of parabolic type driven by Gaussian or more general noise. The solutions of these equations are very singular, so that it is hard to interpret what solutions mean. The naive approximations to these equations do not converge to non-trivial limits. I will explain Hairer’s theory of regularity structures which provides solutions to these equations, in particular the renormalization techniques in this theory.

Finite Element Approximations for Fourth Order Stochastic Parabolic Equations

Zouraris, Georgios
Univ. of Crete

Abstract: We consider an initial- boundary- value problem for a fourth order stochastic parabolic equation, forced by a space-time white noise or its space derivative. First, we propose an approximate stochastic parabolic problem discretizing the noise using linear splines. Then we construct fully-discrete approximations to the solution of the approximate problem combining a finite element method based on $H^1$-piecewise polynomials with several options for time stepping, and analyze its approximation.

N-term Galerkin Wiener Chaos Approximations of Elliptic PDEs with Lognormal Gaussian Random Inputs

Hoang, Viet Ha
Nanyang Technological Univ.

Abstract: We consider diffusion equations with a log-normal coefficient. The weak solution is represented as Wiener-Ito Polynomial Chaos series of Hermite Polynomials of a countable number of i.i.d standard Gaussian random variables. We establish sufficient conditions on the random inputs for the norms of the chaos coefficients to be $p$-summable for some $0 < p < 1$. We prove rates of nonlinear, best N-term chaos approximations, and of their Finite Element approximations. (Joint work with Christoph Schwab (ETH, Zurich)).

Numerical Computation with Functions and Chebfun - Part III of III

For Part 1, see MS-Mo-D-31
For Part 2, see MS-Mo-E-31

Organizer: Trefethen, Lloyd N.
Univ. of Oxford
Organizer: Guettel, Stefan
The Univ. of Manchester

Abstract: A recent theme in algorithms and software is efficient numerical computation with functions in a manner that “feels symbolic” since the accuracy is high and underlying discretizations (Chebyshev, Fourier,..) are hidden from the user. Projects of this kind include Chebfun, pychebfun, ApproxFun, and PaCAL. A pervasive theme in this work is the use of continuous analogues of familiar discrete mathematical objects and algorithms. This min-
isymposium will present new developments in the areas of (1) differential and integral equations, (2) working with functions, and (3) rootfinding and linear algebra.

Computing with Pencil Representations of Rational Functions

Guettel, Stefan  The Univ. of Manchester

Abstract: The newly developed MATLAB Rational Krylov Toolbox (available from http://guettel.com/rktbox) implements a class called RKFUN for representing and working with rational functions. In this talk I will explain the pencil representation underlying RKFUN and some of the methods we have implemented. This is joint work with Mario Berljafa.

Stability of Rootfinding in Chebyshev and Other Orthogonal Bases

Vanni, Noferini  Univ. of Manchester
Nakatsukasa, Yuji  Univ. of Tokyo
Perez Alvaro, Javier  Univ. of Manchester

Abstract: The roots of a polynomial expressed in the Chebyshev basis can be computed as the eigenvalues of its colleague linearization. Applying the QZ algorithm to the colleague pencil yields a backward stable rootfinder, where-as applying the QR algorithm to the colleague matrix is backward stable only under certain assumptions on the polynomial. We discuss the implication of our results for Chebfun roots algorithm, and present some generalizations to other polynomial bases.

A Practical Framework for Infinite-dimensional Linear Algebra

Olver, Sheehan  The Univ. of Sydney

Abstract: We describe a framework for solving a broad class of infinite-dimensional linear equations, consisting of almost banded operators, which can be used to reseprsent linear ordinary differential equations with general boundary conditions and singular integral equations. In addition, special tensor product equations, such as partial differential equations on rectangles, can be solved by truncating the operator along one dimension and using a generalized Schur decomposition.

Numerical Computation with Periodic Functions

Montanelli, Hadrien  Univ. of Oxford

Abstract: Algorithms and underlying mathematics are presented for numerical computation with periodic functions via approximations to machine precision by trigonometric polynomials. Applications include the solution of nonlinear stiff PDEs and the computation of choreographies.

Probability, Finance and Management Science, Simulation and Modeling

Chair: Conrad, Patrick  Univ. of Warwick

Probability Measures on Numerical Solutions of ODEs for Uncertainty Quan-
tification and Inference

Conrad, Patrick  Univ. of Warwick
Giorlami, Mark  Univ. of Warwick
Stuart, Andrew  Univ. of Warwick

Abstract: Deterministic ODE solvers are widely used, but characterizing the error in numerical solutions within a coherent statistical framework is chal-
 lenging. We successfully address this problem by constructing a probability measure over functions consistent with the ODE solution that provably con-
tacts to a Dirac measure on the unique solution at rates determined by an underlying deterministic solver. The measure straightforwardly derives from
important classes of numerical solvers and is illustrated on uncertainty quan-
tification and inverse problems.

Investigation of Doubling-Time Probability Densities for Growth Processes

Allen, Edward  Texas Tech Univ.

Abstract: The doubling-time probability density for a growth process is the probability density of times for the initial magnitude to double. Doubling-time probability densities are useful in studying growth rates, for example, of organ-
isms, populations, financial products, or chemical reactions. Three stochastic models of growth are investigated for their doubling-time probability densities. Two of the stochastic models have doubling-time probability densities which are inverse Gaussian. The third stochastic model’s doubling-time density has no simple analytical form but it is approximately inverse Gaussian under a reasonable assumption on the model’s parameters.

Uncertainty Quantification and Safety Boundary Analysis for Complex System

Using Bayesian Statistics

He, Yuning  UARC

Abstract: Safe separation between all aircraft at all times in the controlled airspace is an extremely important safety requirement. Because the airspace near an airport is much more challenging, the Terminal Tactical Separation Assured Flight Environment (TTSAFE) is being developed. It tries to detect violations of separation as early as possible and make air traffic controllers aware of such situations. The separation algorithms in TTSAFE are gov-
erned by a large number of parameters. In order to ensure safe operation through verification and validation (V&V), we must analyze how uncertainties in these parameters influence the behavior of TTSAFE. Using our advanced Bayesian statistical analysis techniques we carried out an Uncertainty Quan-
tification (UQ) analysis for the system. We have also developed a new statis-
tical framework based upon sequential design of computer experiments that can incorporate domain knowledge to efficiently study safety boundaries of such complex system.

Mean-Reversion Trading under A Markov Chain Model

Zhang, Qing  Univ. of Georgia
Tie, Jingzhi  Univ. of Georgia

Abstract: This paper is concerned with a mean-reversion trading rule. In con-
trast to most market models treated in the literature, the underlying market is solely determined by a two-state Markov chain. The major advantage of such Markov chain model is its striking simplicity and yet its capability of capturing various market movements. The purpose of this paper is to study an optimal trading rule under such a model. The objective of the problem under con-
sideration is to find a sequence stopping (buying and selling) times so as to maximize an expected return. Under some suitable conditions, explicit solu-
tions to the associated HJB equations (variational inequalities) are obtained. The optimal stopping times are given in terms of a set of threshold levels. A verification theorem is provided to justify their optimality. Finally, a numerical example is provided to illustrate the results.

Spatially Explicit Modelling of European Wildfires

Baetens, Jan  Ghent Univ.
Dutta, Srabasti  Ashford Univ.
De Baets, Bernard  Ghent Univ.

Abstract: Since wildfires are causing substantial economic, ecological and so-
cial losses in many parts of the world, several fire-prone countries or regions have deployed so-called forest information systems. As a first step towards the further advancement of the European Forest Fire Information System, we show in this work how a spatially explicit model can be used to realistically simulate the propagation of wildfires in Europe.

An Accurate Simulation-based Approach to the Dynamic Portfolio Management

Problem

Cong, Fei  TU Delft
Oosterlee, Cornelis  CWI—center for mathematics & computer Sci.

Abstract: We revisit a well-known dynamic portfolio management algorithm, the BSSS algorithm, proposed by Brandt, Goyal, Santa-Claire and Stroud (Re-
view of Financial Studies, 18, 831-873, 2005). We equip this algorithm with a recently developed component, the Stochastic Grid Bundling Method, for cal-
culating conditional expectations. When solving the first-order conditions for an optimum, we implement a Taylor series expansion based on a nonlin-
ear decomposition to approximate the utility functions. In the numerical tests, we show that our algorithm is more accurate and robust in approximating the optimal investment strategies compared to other simulation- and regression-
based algorithms.

Asymptotic Behavior of Randomly Weighted Sums of Dependent Heavy Tailed Random Variables

KK, Thampi  SNMC, Mahatma Gandhi Univ.

Abstract: Let X be a sequence of Weakly Negatively dependent (WND) ran-
dom variables with semi exponential varying tails. Let W be a sequence of non-negative random variables, independent of X. The weighted random sums WiX, and the tail probability of maximum of random sums, for k less than or equal to N, where N is a non-negative integer valued random variable. Under the assumption that Xi, Wi and N are mutually independent with some mild conditions, this paper establishes an asymptotic relationship for the tail
Abstract:
In recent years, fractional differential equations have attracted wide attention due to the fact that they have important applications in biology, physics, chemistry and finance. While much research on the direct problems for fractional differential equations has taken place, there is much less literature on inverse problems. In this minisymposium, we will present some new research on questions of uniqueness, numerical reconstructions and regularization methods in solving various inverse problems for fractional differential equations which include the backward problem and the identification problem of fractional order, as well as some new findings on the difference between the fractional differential equations and their classical counterparts. This minisymposium will provide a good opportunity for international communications on this topic and attract wide attention to this field.

**MS-Tu-D-33-1**

**13:30–14:00**

*Inverse Problems for Space Fractional Diffusion*

Jin, Bangti

Univ. College London

Abstract: In this talk I will discuss a few inverse problems for space fractional diffusion problems, e.g., inverse eigenvalue problem and the sideways problem. I will give the motivation for the inverse problems, describe mathematical and numerical challenges, and, most importantly, show the unusual features of this class of inverse problems.

**MS-Tu-D-33-2**

**14:00–14:30**

*The Fundamental Solution for Fractional Diffusion Equations and Its Use in Various Undetermined Coefficient Problems*

Rundell, William

Texas A&M Univ.

Jin, Bangti

Univ. College London

Abstract: The role of the fundamental solution of the heat equation is very well known in both direct and inverse problems for parabolic equations. In this talk we look at the case of $\frac{t}{\alpha} - \Delta u = f_\alpha$ with $\alpha \in (0, 1)$ and consider the sequel. We will use the representation formula involving this solution to examine the behaviour and reconstruction of a few undetermined coefficient/ boundary value problems for the fractional case.

**MS-Tu-D-33-3**

**14:30–15:00**

*Inverse Problems of Determining Fractional Orders in the Fractional Diffusion Equations*

Li, Gongsheng

Shandong Univ. of Tech.

Abstract: We consider inverse problems: (I) To determine multiple orders in the multi-term time fractional diffusion equation; (II) To determine the time-space fractional orders in the Caputo-time Riesz-space fractional diffusion equation. Uniqueness for inverse problem (I) is proved on the basis of Laplace transform, and differentiation of the solution operator for inverse problem (II) is discussed with which the inverse problem is solvable under suitable initial conditions. Numerical inversions are performed by the homotopy regularization algorithm.

**CP-Tu-D-33-4**

**15:00–15:20**

*An Efficient Solver for 3D Simulations for Flow with Interface*

Weishan, Deng

Inst. of Software, CAS

Xu, Jin

Inst. of Software

Abstract: An efficient solver using finite element method for flow with interface has been developed. It is based primarily on nodal basis on unstructured grid. The numerical method and parallel model are explained in detail, and benchmark results will be shown. It has been successfully applied in simulating some flows with interface and some further applications of this solver will be presented.

**CP-Tu-D-33-5**

**15:20–15:40**

*A Model for Mountain Pine Beetle Outbreaks in An Age Structured Forest: Predicting Severity and Outbreak-Recovery Cycle Period*

Duncan, Jacob

Utah State Univ.

Powell, James

Utah State Univ.

Gordillo, Luis

Utah State Univ.

Eason, Joseph

Univ. of Utah

Abstract: The relationship between the mountain pine beetle (MPB) and lodgepole pine tree has historically been normative. However, since MPB require moderate winter and warm summer to achieve successful attacks, outbreaks have been more severe in recent decades due to increasing global temperatures. In this paper we develop an age-structured forest demographic model that incorporates temperature-dependent MPB infestation. Stability of fixed points is analyzed as a function of MPB growth rates, and indicates the existence of periodic outbreaks that intensify as growth rates increase. We devise analytical methods to predict outbreak severity and duration as well as outbreak return time. After incorporating a spatial aspect and controlling initial stand demographic variation, the model predicts cycle periods that fall within observed outbreak return time ranges. To assess future MPB impact on forests, we use our model-based approximation methods to predict potential severity of future outbreaks that reflects the effects of changing climate.

**MS-Tu-D-34**

**13:30–15:30**

*Mathematics and Algorithms in Quantum Chemistry - Part I of III*

For Part 2, see **MS-Tu-E-34**

For Part 3, see **MS-We-D-34**

Organizer: Melgaard, Michael

Univ. of Sussex

Peking Univ.

Abstract: Ab initio models of electronic structures has had an immense impact in the physics and chemistry communities, as well as the materials science community, due to the capacity for carrying out realistic computations. The mathematical formulation and the efficient numerical simulation of such models is a notoriously difficult problem for several reasons, e.g., high dimensionally-configurations spaces, multiple interactions, multiple scales, nonlinear effects, and/or degeneracies of eigenstates. Further developments in this area require the integration of physical modeling, mathematical analysis, and algorithm development in order to obtain reliable computational tools. The mini-symposium aims to bring together quantum chemists, applied and computational mathematicians, physicists and materials scientists all of whom are working in quantum chemistry to exchange ideas and to share their recent progress on the frontiers of theory and numerical methods as well as applications in material science. The mini-symposium will particularly focus on three topics: Time-dependent problems and excited states; Wave function methods; Relativistic effects.

**MS-Tu-D-34-1**

**13:30–14:00**

*Fundamentals of Relativistic Molecular Quantum Mechanics*

Liu, Wenjian

Univ. College London

Peking Univ.

Abstract: Relativistic molecular quantum mechanics (RMQM) consists of three components (i.e., Hamiltonian, wave function, and property), each of which is confronted with some fundamental issues, including, e.g., “What is the appropriate relativistic many-electron Hamiltonian?”, “How to make explicit representation of relativistic wave functions?” “How to formulate relativistic properties”, etc. In this lecture I shall try to address these fundamental issues from both conceptual and methodological standpoints, so as to establish the ‘big picture’ of RMQM.

**MS-Tu-D-34-2**

**14:00–14:30**

*Multi-scale Quantum Mechanics/Electromagnetics Method for Device Simulations*

Yam, Chi Yung

Beijing Computational Sci. Research Center

Abstract: As feature sizes of transistors inch towards 10 nanometer, simulations including quantum effects and atomistic details are inevitable. A hybrid quantum mechanics and electromagnetics method is developed to model electronic components at the nanoscale. QM and EM models are solved in different regions of the system in a self-consistent manner. The method is expected to bridge the gap between quantum mechanics calculation and circuit modeling. Applications of the method to realistic electronic devices will be presented.

**MS-Tu-D-34-3**

**14:30–15:00**

*Efficient Grid Methods for Solving Quantum Dynamics of Molecules*

Sun, Zhizheng

Dalian Inst. of Chemical Physics

Abstract: In this talk, recently developed grid methods in our group for solving time-dependent and time-independent Schrodinger equation for electronic dynamics in molecules will be introduced. These include mapped discrete variable representation (DVR), mapped finite element DVR and a new accurate propagation method for dynamics involving Coulomb singularities. Numerical illustrations for solving electronic eigenstates of H2, H2+ and H2+ in cylindrical coordinates, and the interaction dynamics between H2+ and ultrashort laser pulses will be presented.

**MS-Tu-D-34-4**

**15:00–15:30**

*Numerical Methods and Comparison for the Dirac Equation in the Nonrelativistic Limit Regime*

Bao, Weizhu

National Univ. of Singapore

Abstract: We analyze rigorously error estimates and compare numerically spatial/temporal resolution of various numerical methods for the discretization of the Dirac equation in the nonrelativistic limit regime, involving a small
mensionless parameter which is inversely proportional to the speed of light. The numerical methods include finite difference time domain (FDTD) meth-
ods, time-splitting spectral (TSSP) method and exponential wave integrator spectral (EWI-Sp) method. Extensive numerical results are reported to sup-
port our error estimates.

MS-Tu-D-35 13:30–15:30 408
Numerical Algorithms for Stochastic Model and Uncertainty Quantification in High-Dimensional Complex Systems - Part I of II
For Part 2, see MS-Tu-E-35
Organizer: Wang Peng Beihang Univ.
Organizer: Lin, Guang Purdue Univ.
Abstract: Uncertainty persists in most natural and engineering systems, from material discovery to reactive transport in porous media. Quantifying the un-
certainty associated with the parameters in complex systems is critical, which
can help us to verify our modern simulation codes and assess confidence
levels. Our aim is to use accurate computational simulations to predict the
behave of complex systems. For large number of random dimensions, ad-
vanced stochastic approximation techniques are necessary to minimize the
complexity of mathematical models. This minisymposium will explore recent
advances in numerical algorithms and applications for stochastic model, un-
certainty quantification, and model reduction in large-scale high-dimensional
complex systems.

► MS-Tu-D-35-1 13:30–14:00
Density Estimation with Transport Maps
Li, Jinglai Shanghai jiaotong university
Abstract: Many machine learning problems such as Bayesian classification-
s require the estimation of density functions from data. In such problems, the
dimensionality of the data can often pose a challenge for conventional
approaches. In this talk we present a method for estimating densities by
constructing a transport map from the parameter of interest to a multivari-
ate Gaussian. In particular our method can strictly enforce the monotonicity
of the map. Numerical examples are provided.

► MS-Tu-D-35-2 14:00–14:30
Adaptive ANOVA Based Reduced Basis Methods for Partial Differential Equations with High Dimensional Random Inputs
Liao, Qifeng ShanghaiTech Univ.
Lin, Guang Purdue Univ.
Abstract: We apply the ANOVA method to decompose high-dimensional ran-
dom parameter spaces into a union of low-dimensional spaces. For each
low-dimensional parameter space, a greedy algorithm is applied to identify
the reduced problem for the corresponding spatial approximation. Numerical
experiments suggest that this combination of parameter space decomposition
and spatial space reduced order modeling leads to an efficient novel approach
for high-dimensional uncertainty quantification problems.

► MS-Tu-D-35-3 14:30–15:00
The Hp Adaptivity of Minimum Action Method
Wan, Xiaoliang Louisiana State Univ.
Abstract: In this work, we develop an hp-adaptive minimum action method
(MAM). MAM plays a critical role to minimize the Freidlind-Wentzell action func-
tional, which is the central object of the Freidlin-Wentzell theory of large devi-
ations for transitions induced by small noise. We use the arc length constraint
to define an indicator of the effect of linear scaling, and the derivative recov-
ery technique to construct an error indicator and a regularity indicator for hp re-
finement.

► MS-Tu-D-35-4 15:00–15:30
Enhance Sparsity Through Changing the Measure
Yang, Xiu Pacific Northwest Natl Laboratory
Huan, Lei Pacific Northwest Natl Laboratory
Baker, Nathan Pacific Northwest Natl Laboratory
Lin, Guang Purdue Univ.
Abstract: Compressive sensing based uncertainty quantification method at-
tracts many attentions in recent years. We aim to find a new set of random
variables through linear/nonlinear mapping such that the representation of
the quantity of interest is much sparser with new basis functions associated with
the new random variables. At the same time we keep the property of
the measurement matrix (e.g., mutual coherence) almost unchanged, hence the
number of samples for an accurate approximation decreases.
repairable system, based on its re-liability, then built a stochastic model to describe the cost for the non-repairable system to achieve the reliability, and the optimal level of reliability that maximizes the expected system’s net present value – the financial value reliability provides by the system minus the cost to achieve this level of reliability could be founded.

**MS-Tu-D-37**
13:30–15:40
301B

A Statistical perspective of UQ: design, modeling and computations - Part III of III

For Part 1, see MS-Mo-D-37
For Part 2, see MS-Mo-E-37

**Organizer:** Wu, Jeff  
Georgia Inst. of Tech.

**Organizer:** Woods, David  
Univ. of Southampton

**Organizer:** Xiong, Shifeng  
Chinese Acad. of Sci.

**Abstract:** This minisymposium consists of three sessions. Each co-organizer will organize one session. They will address the three aspects of the title: design, modeling, and computations. The focus will be on these problems from the statistical perspective but will also bring in interface with work in applied mathematics on UQ. In design, both space-filling designs and sparse grids are considered. In modeling, both stochastic kriging and generalized polynomial chaos approximation are considered. Comparisons and contrasts between work in applied math and statistics will be emphasized. Computational challenges for high dimensions and big data are the third theme.

**CP-Tu-D-37-5**
15:20–15:40

**An Experimental Test of Several Generalized Utility Functions in Post-Decision Identification**

**Soboleva, Olena**  
Kharkiv National Univ. of Radio Electronics

**Abstract:** In this paper, we present usability analyses of different generalized utility’s models. It’s proposed to use following generalized utilities: informational entropy-type function, modified (by additional terms with inverse power)’s polynomial and mixed additive-multiplicative functions. There are given the statistical results of post-decision identification’s accuracy and difficulty for different generalized utilities.

**MS-Tu-D-38**
13:30–15:30
302A

**Mining and Analytics for Big Data**

**Organizer:** Wang, Fei  
Univ. of Connecticut

**Abstract:** We are in the era of big data. Data is everywhere, in every application, from healthcare to climate. The goal of this workshop is to bring together the researchers in the field of data mining and analytics, share their experiences and opinions on the current status, challenges and future directions of big data mining and analytics. We will invite four keynote speakers and the topic of their talks cover different aspects of big data mining and analytics, from theory to practice.

**MS-Tu-D-38-2**
14:00–14:30

**Data Analytics in Healthcare**

**Wang, Fei**  
Univ. of Connecticut

**Abstract:** Healthcare is a field that closely related to everyone’s daily life. Data driven healthcare is believed to be one of the most promising trends to transform healthcare and improve the quality of care delivery. The main goal of this talk is to briefly review the status of data analytics methods in healthcare, point out the challenges and future research directions.

**MS-Tu-D-39**
13:30–15:30

**Non-convex Optimization Problem in Machine Learning and Data Mining**

**Zhang, Changshui**  
Tsinghua Univ.

**Abstract:** In machine and data mining, optimization is a very important problem. In this talk, we introduce optimization problems in machine learning, and describe three non-convex optimization algorithms: an algorithm for decomposable non-convex regularization, an algorithm for feature selection in multi-task learning, and an adaptive algorithm for non-convex regularization.

**MS-Tu-D-39-4**
15:00–15:30

**Incremental Learning in Big Data Era**

**Zhou, Zhi-Hua**  
Nanjing Univ.

**Abstract:** In this presentation I am planning to talk about incremental learning, but not finalized yet.

**MS-Tu-D-39**
13:30–15:30
302B

Recent advances on inverse scattering problems - Part III of III

For Part 1, see MS-Mo-D-39
For Part 2, see MS-Mo-E-39

**Organizer:** Liu, Xiaodong  
Inst. of Applied Mathematics, Chinese Acad. of Sci.

**Organizer:** Liu, Hongyu  
Hong Kong Baptist University

**Organizer:** Zhang, Bo  
Acad. of Mathematics & Sys. Sci., CAS

**Abstract:** The minisymposium intends to bring together leading experts working on inverse scattering problems and their applications to discuss recent advances and new challenges in this fascinating field.

**MS-Tu-D-39-1**
13:30–14:00

**Locating Buried Objects in A Two-layered Medium**

**Liu, Xiaodong**  
Inst. of Applied Mathematics, Chinese Acad. of Sci.

**Abstract:** We develop an inverse scattering scheme to locate the multiple multiscale impenetrable anomalies buried in a two-layered medium. It makes use...
of a single far-field measurement in the half-space above the anomalies, and works independently of the physical properties of the anomalies. The proposed schemes is of a totally direct nature without any inversion involved.

**MS-Tu-D-39-2 14:00–14:30**

*On Reconstruction of Refractive Index in Inverse Scattering for Periodic Media*

Yang, Jiaqing  
Xi'an Jiaotong Univ.

Qu, Fenglong  
Yantai Univ.

**Abstract:** This talk is concerned about the inverse problem of recovering the refractive index in inverse scattering by unbounded periodic media. We prove a global uniqueness result that, if the refractive index is piecewise constant, the total structure is uniquely determined from scattered field data measured only from one side of unbounded periodic media, corresponding to a countably infinite number of downward propagating incident waves

**MS-Tu-D-39-3 14:30–15:00**

*Inverse Scattering Problem from Phaseless Far-field Data*

Zhang, Haiwen  

Zhang, Bo  
Acad. of Mathematics & Sys. Sci., CAS

**Abstract:** We consider the inverse scattering problem from phaseless far-field data. It is observed that the translation invariance property of phaseless far-field pattern can be broken down with using a superposition of several incident plane waves as incident field. Based on this, two kinds of inversion algorithms are developed to reconstruct both the location and the shape of the obstacle simultaneously. Numerical examples are carried out to illustrate the effectiveness of our algorithms.

**IM-Tu-D-40 13:30–15:30**

*Particle systems and particulate flows in environmental, social and industrial applications*

Organizer: Icardi, Matteo  
KAUST

Organizer: Elsaadawy, Ehab  
Saudia Aramco Oil Company

Organizer: Tartakovsky, Daniel  
Univ. of California, San Diego

Organizer: TEMPOLE, RAUL  
KING ABDULLAH Univ. OF Sci. & Tech.

**Abstract:** Accurate simulations of particle systems are of crucial importance in many scientific and industrial applications such as poly-dispersed multi-phase flows, social systems, colloidal particles in subsurface and microfluidics, and mixing-limited reactions. These phenomena can be described at multiple scales, many of which introduce stochastic fluctuations. For example, modeling processes, such as upsampling or coarse-graining, can account for unknown micro-scale (or fast time-scale) features by adding a random source term. These stochastic components are negligible only in the macroscopic (equilibrium) limit that is not often attainable, so a direct simulation of stochastic particle trajectories is needed. In some cases a probabilistic (or kinetic) interpretation can be used to retain some mesoscopic (mean-field) features of the system. In other problems, the stochastic particle representation is introduced purely as a computational tool to circumvent particular complexity or computationally costly partial differential equations. The random nature (or probabilistic interpretation) of these systems poses a number of computational difficulties and offers an opportunity of developing novel efficient algorithms targeting a wide class of applications. Another difficulty is often related to the coupling of the particle motion with an underlying flow, electric of force field that, in some cases, can be represented by discrete particles or by a continuum (mean-field) formulation. This mini-symposium aims to create an opportunity for researchers in different fields to share their modeling and computational approaches for: Particulate flows in chemical reactors: separators, filters, fluidized beds Colloid transport and reaction in heterogeneous porous media and subsurface flows Particle-laden turbulent flows Transport of bioactive molecules in microfluidic devices and biological flows Monte Carlo, Gillespie and Molecular Dynamics methods for reactive particle systems Efficient simulation of Stochastic Differential Equations (Langevin, drift-diffusion processes) Kinetic and PDF methods for turbulent flows and population balance models Particle methods for complex flows and PDEs (Discrete Element Method, Smoothed Particle Hydrodynamics, etc.) Applications to social dynamics

**MS-Tu-D-41 13:30–14:00**

*Four-dimensional Tomography Based on A Level Set Method*
Abstract: A novel time-dependent tomographic imaging modality is discussed. The aim is to reconstruct a moving object, such as running engine, a mouse, or a beating human heart, from time-dependent radiographic sparse data ( "X-ray videos" ). The dynamic three-dimensional structure is reconstructed from projection data using a new computational method. Time is considered as an additional dimension in the problem, and a generalized level set method [Kolehmainen, Lasass, Siltanen, SIAM J Scientific Computation 30 (2008)] is applied.

Structural Optimization Methods to Design Light Weight Automatic Transmissions of Vehicles
Toda, Kentaro
Scientific Analysis Engineering Department, Aisin AW CO., LTD
Ide, Takanori
Aisin AW CO., LTD

Abstract: We propose design process to achieve light weight structure for automatic transmissions of vehicles. Structural optimization method is commonly used to improve automobile performance such as NVH (Noise, Vibration and Harshness), durability and fuel consumption. Light weight structure is the essential factor to improve fuel consumption and protect environment. As the industrial application of structural optimization, we consider light weight gear box of FF (Front engine Front drive) type automatic transmission.

Highly Parallel Eigenvalue Computation in Vibration Analysis Using A Complex Moment Based Eigensolver
Futamura, Yasunori
Univ. of Tsukuba
Sakurai, Tetsuya
Univ. of Tsukuba
Ide, Takanori
Aisin AW CO., LTD
Toda, Kentaro
Scientific Analysis Engineering Department, Aisin AW CO., LTD

Abstract: In this talk, we show an algorithm and implementation of an eigenvalue solver which efficiently solve large-scale generalized eigenvalue problems derived from vibration analysis. The presented solver is a projection method based on complex moment and contour integral and it provides high parallelism since the algorithm consists of solving independent linear systems. We show the performance of our approach on state-of-the-art supercomputers with models of automatic transmissions.

Organizer: Konotop, Vladimir
Univ. of Lisbon

Abstract: In a few recent years there was growing interest in propagation of nonlinear waves in media with gain and losses. These are systems with the parity-time (PT) symmetry, with localized gain or dissipation, with imbalance gain and dissipation but still allowing for linear real spectra, etc. Physically the respective models are relevant to optics, plasmonics, Bose-Einstein condensates, atomic gasses, mechanical systems, electric circuits, etc. This mini-symposium aims to join researches working in the related areas ranging from experimental and theoretical physics to mathematics.

Stationary States of Unidirectional Optical Wave Guides
Cartarius, Holger
Univ. of Stuttgart

Abstract: Nonlinear PT-symmetric optical wave guides have shown to exhibit the effect of unidirectionality, which is usually studied in terms of propagating waves. We investigate this effect in the context of stationary states. In a mathematically equivalent system, viz. a Bose-Einstein condensate in a PT-symmetric double-well potential, it is well known that these stationary states possess complicated stability properties influenced by the nonlinearity. The relations of these two effects are analyzed.

Organizer: Cao, Zhigang
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Chen, Xujin
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Hu, Xiaodong
Acad. of Math & Sys. Sci., CAS

Wang, Changjin
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: We completely characterize deterministic and anonymous strategy-proof and group strategy-proof mechanisms on single-dipped public policy domain, complementing the well-known results on single-peaked policy domain first investigated by Moulin (1980). Moreover, as applications of our characterization, we extend existing models and results and resolve several open questions related to the obnoxious facility location game from the algorithmic mechanism design literature.

Organizer: Chen, Xujin
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Wunner, Guenter
Inst. of Theoretical Physics, Univ. of Stuttgart

Abstract: Although originally discussed in the context of non-Hermitian quantum mechanics, PT symmetry has been demonstrated experimentally in optics and other areas. Recently, PT symmetry has also entered the experimental field of metamaterials (see, e.g., Lawrence et al., Phys. Rev. Lett 113, 093901 (2014)). Investigations so far have been restricted to linear wave propagation in metasurfaces. In this paper we will study the effects of nonlinearity on PT symmetry in metamaterials.

Organizer: Lazarides, Nikos
Univ. of Crete

Lazarides, Nikos
Univ. of Crete

Abstract: PT-symmetric nonlinear metamaterials relying on gain and loss and comprising split-ring resonators (SRRs) have been recently introduced. In the presence of nonlinearity, they support gain-driven, breather-like excitations. In most SRR-based metamaterial models, the dipole-dipole interaction between SRRs is limited to nearest neighbors. However, the nonlocal interelement interaction affects significantly both the linear and nonlinear properties PT metamaterials. In the presence of nonlinearity, it may generate novel soliton solutions not appearing in locally coupled metamaterials.

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Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

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In this symposium, the five speakers will present their latest research in this area. We believe that the coordinated scheduling problems of production and transportation in the iron and steel industry in order to achieve equipment utilization and reduce energy consumption. Depending on specific characteristics of production operations, this paper includes three parts: the problems in steelmaking-continuous casting stage, the problems in continuous casting-hot rolling stage, and the problems in hot rolling-cold rolling stage. For each of these problems, we analyze their computational complexity, and provide the corresponding algorithms.

**Abstract:** We present the coordinated scheduling problems of production and transportation in the iron and steel industry in order to achieve equipment utilization and reduce energy consumption. Depending on specific characteristics of production operations, this paper includes three parts: the problems in steelmaking-continuous casting stage, the problems in continuous casting-hot rolling stage, and the problems in hot rolling-cold rolling stage. For each of these problems, we analyze their computational complexity, and provide the corresponding algorithms.

**Abstract:**

We consider the single machine scheduling problem with families of jobs and delivery coordination. For each problem, we propose a fast heuristic and show that the heuristic has a tight worst-case bound of 2.

**Abstract:**

We study the Stackelberg variant of the repeated prisoner’s dilemma game. In our work, the two players are asymmetric. One player (the leader) chooses a strategy for the repeated games firstly and her strategy and then the other player (the follower) chooses his strategy after seeing the leader’s strategy. Assuming complete rationality, we find (i) the sub-game perfect equilibrium payoff profile is unique; (ii) the leader has optimal strategies that are one-step memory.

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of a linear semi-infinite programming problem. Working with this reduced pair, we reproduce all the theorems that lead to the full eleven possible duality state classification theory. Establishing classification results with the Fourier-Motzkin method means that the two classification theorems for linear semi-infinite programming, 1969 and 1974, have been proved by this new and exciting method.

**MS-Tu-D-45**

13:30–15:30

13A

Triangular decomposition of polynomial systems: solvers and applications - Part III of IV

For Part 1, see MS-Mo-D-45

For Part 2, see MS-Mo-E-45

For Part 4, see MS-Tu-E-45

Organizer: Chen, Changbo Chinese Acad. of Sci.

Abstract: The Characteristic Set Method of Wen Tsun Wu has freed Ritt’s decomposition from polynomial factorization, opening the door to a variety of discoveries in polynomial system solving. In the past three decades the works of Wu have been extended to more powerful decomposition algorithms and applied to different types of polynomial systems or decompositions: differential systems, difference systems, real parametric systems, primary decomposition, cylindrical algebraic decomposition. Today, triangular decomposition algorithms provide back-ends for computer algebra system front-end solvers, such as Maple’s solve command and have been applied in various areas both in the academy and in the industry. In this proposed workshop, we hope to gather researchers who have applied and extended the works Joseph Fels Ritt and Wen Tsun Wu. Our goals are, first, to disseminate the techniques and software tools which have been developed by this vibrant community and, second, to stimulate further developments and applications of polynomial system decomposition by means of characteristic sets.

At the International Congress on Mathematical Software (ICMS 2014), a satellite conference of the International Congress on Mathematics, in Seoul (South Korea), a session on the same topics as the proposed one had gathered 9 talks, see [http://www.csd.uwo.ca/~moreno/ICMS_Triangular_Decomposition_Session.html](http://www.csd.uwo.ca/~moreno/ICMS_Triangular_Decomposition_Session.html)

About another 30 researchers had expressed interest in participating to this session but were not able to do so at that time the year or in that location. Moreover, three other sessions of ICMS 2014 had talks on this subject of polynomial system decomposition by means of characteristic sets.

In a sum, the proposed workshop for ICIAM 2015 is expected to be well attended and to generate rich interactions. At the same time, the available software such as the RegularChains library (see [http://www.regularchains.org](http://www.regularchains.org)) will support software demonstration of the applications of the Characteristic Set Method.

**MS-Tu-D-45-1**

13:30–14:00

A Numeric Method for Solving Parametric Polynomial Systems with Constraints

Wu, Wenyuan

Chen, Changbo

CIGIT

Chinese Acad. of Sci.

Abstract: In this paper we introduce a numerical approach based on homotopy continuation methods to solve square polynomial systems with two parameters. For various applications these parameters are restricted in some finite region and we are interested in exploring the properties of real solutions when parameters are chosen in the region. This paper aims to decompose the region into finitely many cells such that some property is unchanged for parameters in the region. This property is local equational constraints. At the same time, the available software such as the RegularChains library will support software demonstration of the applications of the Characteristic Set Method.

**MS-Tu-D-45-2**

14:00–14:30

A New Triangular Decomposition Algorithm for Differential Polynomial Systems

Gao, Xiao-Shan

Zhu, Wei

Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

AMSS, Chinese Acad. of Sci.

Abstract: In this talk, a new triangular decomposition algorithm will be presented for ordinary differential polynomial systems, which has triple exponential computational complexity. The key idea is to eliminate one algebraic variable from a set of polynomials in one step using the theory of multivariate resultant. This seems to be the first differential triangular decomposition algorithm with elementary computation complexity.

**MS-Tu-D-45-3**

14:30–15:00

Better Handling of Equational Constraints in Cylindrical Algebraic Decomposition

Davenport, James

Univ. of Bath

Abstract: Traditionally, a Cylindrical Algebraic Decomposition (CAD) was sign-and-order-invariant for the polynomials, meaning it could answer all questions about those polynomials, for the given variable order. More recently, McCallum showed we can do better if there is a global equational constraint, and produce a CAD invariant for all the polynomials only where the equational constraint is satisfied. In this talk, we describe work to do similar with only local equational constraints.

**MS-Tu-D-45-4**

15:00–15:30

Modelling and Verification for Stochastic Hybrid Systems

Zhan, Naijun

Peng, Yu

Wang, Shuling

Inst. of Software, Chinese Acad. of Sci.

Inst. of Software, Chinese Acad. of Sci.

Inst. of Software, Chinese Acad. of Sci.

Abstract: Stochastic hybrid systems exist in many real embedded systems that operate in the presence of uncertainty and randomness. They are so complex with interacting discrete computation, continuous and stochastic dynamics, thus it is very hard to analyze and verify their behavior. In this paper, we propose a deductive approach for modelling and verification of stochastic hybrid systems. First, we define a variant of Hybrid CSP (HCSP), called stochastic HCSP, as the formal modelling language of stochastic hybrid systems, in which the determinstic differential equations for the continuous flows of HCSP are replaced by the stochastic differential equations and the non-deterministic choice by probabilistic choice. We then define a compositional logic for reasoning about stochastic HCSP processes and prove its soundness. In the logic, we present the proof rules for each process construct to specify the probability with which the properties hold before and after the corresponding process is executed.

**MS-Tu-D-46**

13:30–15:30

306B

Theoretical and Computational Aspects of Geometric Shape Analysis - Part I of II

For Part 1, see MS-Tu-E-46

For Part 2, see MS-Tu-T-46

Organizer: Narayan, Akil

Univ. of Massachusetts Dartmouth

Organizer: Micheli, Mario

Univ. of San Francisco

Organizer: Kushnarev, Sergey

Singapore Univ. of Tech. & Design

Abstract: The analysis, classification, and processing of geometric shapes is a timel and increasingly important problem in engineering, computer science, and mathematics. Modern strategies for shape analysis span several disciplines: statistical cluing, differential geometry, data processing, and numerical optimization. The aim of this minisymposium is to present state-of-the-art methods for geometric shape analysis, and to discuss open problems, applications, and future directions for research of interest to the imaging science community. This minisymposium brings together researchers from diverse backgrounds to foster collaboration between the fields of computer vision, image processing, and mathematical shape analysis.

**MS-Tu-D-46-1**

13:30–14:00

A Class of Riemannian Metrics for Shape Deformation Analysis

Micheli, Mario

Univ. of San Francisco

Abstract: In this talk we explore a class of matrix-valued kernels that induce Riemannian translation- and rotation-invariant metrics on the group of diffeomorphisms. Once such metrics are established, they can be used to compute distances in shape spaces (i.e. between curves in two or three dimensions, surfaces, images, tensor fields, or sets of feature points). We discuss metrics whose geodesics are generated by curl-free or divergence-free vector fields, and discuss applications.

**MS-Tu-D-46-2**

14:00–14:30

Multiscale Covariance Fields, Local Scales, and Shape Transforms

Memoli, Facundo

The Ohio State Univ.

Abstract: In this talk we explore the notion of multiscale covariance tensor fields associated with a probability measure on Euclidean space and use these fields to define local scales at a point and to construct shape transforms. Local scales at x may be interpreted as scales at which key geometric features of the data organization around x are revealed. Shape transforms are employed to identify points that are most salient in terms of the local-global shape of a probability.

**MS-Tu-D-46-3**

14:30–15:00

Deformable Shape Tracking by Using A New Region-Based Sobolev Metric

Sundaramoorthy, Ganesh

KAUST

Abstract: In this talk, we discuss the problem of segmentation and tracking of objects in videos. This problem is central to computer vision and remains a challenge because of nuisances in image formation that generate infinite vari-
ations and shape and appearance of the object. We present a new approach that seeks to model nuisances arising from occlusions and viewpoint change or object deformations. We will show a new optimization technique based on a new shape metric.

**Intrinsic Statistical Framework for Biological Shape Analysis**

Joshi, Shantanu

UCLA

Abstract: We present a statistical framework for characterizing and comparing morphological variation in biological shapes. The statistical framework makes use of the tangent principal component approach to achieve dimension reduction on the space of infinite-dimensional, non-linear, quotient space of shapes and enables computation of shape averages and covariances on the shape space in an intrinsic manner (adapted to the shape space). We will present applications to biomedical imaging, computer vision, paleontology, and brain morphometry.

**Flow patterns in high-Reynolds numbers - Part I of II**

13:30–15:30 108

MS-Tu-D-47

Flow patterns in high-Reynolds numbers - Part I of II

For Part 2, see MS-Tu-E-47

Organizer: Okamoto, Hisashi Kyoto Univ.

Abstract: Recent increase of computer power enables us to have good understanding and prediction of fluid flows if the Reynolds number is not very large. However, flows display singular phenomena if the Reynolds number is very large. Here we need, in addition to computer power, a good combination of mathematical analysis and accurate numerical methods. In this mini-symposium we present singular or strange characters of fluid flows at high Reynolds numbers. For instance, we report on our recent discovery of large scale structures which appear only in 2D high Reynolds number flows and called unimodal patterns. Streamlines of the unimodal solutions are topologically simple, but under its apparent simplicity there lie internal layers, which results from the singular perturbation nature of the Navier-Stokes equations. We propose an asymptotic analysis which agrees with the numerical data. Also some of our review applications to geophysics. In particular solutions of the 2D Navier-Stokes equations or Euler equations are computed on a sphere or a sphereoid. They are compared with atmospheric data. We show that what is called a zonal flow, which is observed in fluid motion in planetary scale, can be reproduced in our computations.

**Unimodal Patterns Appearing in the 2D Navier-Stokes Equations at Large Reynolds Numbers**

13:30–14:00

Okamoto, Hisashi

Kyoto Univ.

Abstract: We consider Kolmogorov’s problem for the 2D Navier-Stokes equations. We study numerically stability and bifurcation of stationary and time-periodic solutions. Specifically we look for a unimodal solution, which is characterized by having a large, topologically simple patterns of stream-lines. A new version of conjecture about unimodal solutions is presented. We will present evidence that such patterns emerge at large Reynolds.

**Unimodal Patterns Appearing in the 2D Navier-Stokes Equations at Large Reynolds Numbers II**

14:00–14:30

Kim, Sun-Chul

Chung-Ang Univ.

Okamoto, Hisashi

Kyoto Univ.

Abstract: This second part deals with some asymptotic and numerical results on a self-similar Navier-Stokes flows (Proudman-Johnson flows) confirming the unimodality for this simpler case. Also, for the general 2D Navier-Stokes flows, we present some numerical computation of the continuation of a time periodic solution emerging from the Hopf bifurcation.

**On the Numerical Detection for Blow-up**

14:30–15:00

Cho, ChienHong

Chung Cheng Univ.

Abstract: The problem concerning global existence and finite-time blow-up for solutions of differential equations is an important issue in many mathematical models and physical problems. Although there are many mathematical methods used for establishing blow-up, we would like to explore the phenomenon in this talk from a numerical point of view. Our recent results will be reported.

**Stability of One-directional Flow on A Rotating Sphere**

15:00–15:30

Yamada, Michio

Kyoto Univ.

Abstract: Linear and nonlinear stability of a zonal flows on a rotating sphere is discussed numerically and analytically. The problem is similar to the traditional stability problem of plane parallel flows, but the rotation which has no effect in the case of non-divergent two-dimensional flows plays an important role in the spherical case. It is shown that fast rotation strongly stabilizes the zonal flow under a zonal forcing even at high Reynolds numbers.

**Regularization of Inverse Problems in Imaging Sciences: Theoretical and Numerical Aspects - Part I of II**

13:30–15:30 212B

MS-Tu-D-48

For Part 2, see MS-Tu-E-48

Organizer: Fadili, Jalal CNRS & ENSICAen

Organizer: Peyre, Gabriel CNRS & Universite Paris-Dauphine

Organizer: Zhang, Xiaojun Shanghai Jiao Tong Univ.

Abstract: Inverse problems have become a central theme in various fields of sciences and engineering such as imaging sciences. This field draws from various mathematical disciplines including linear algebra, differential geometry, harmonic analysis, functional analysis, mathematical physics, numerical analysis, optimization, PDE’s, stochastic and statistical methods. The fields of application encompass medical and astronomical imaging, radar, optics, etc. The goal of the mini-symposium is to present recent theoretical, numerical and applicative advances in these fields. It will focus on ill-posed inverse problems, variational regularization theory, recovery guarantees, and numerical algorithms to solve the corresponding optimization problems.

**Disparity and Optical Flow Partitioning Using Extended Potts Priors**

13:30–14:00

Fitschen, Jan Henrik

Univ. of Kaiserslautern

Abstract: This talk addresses the problems of disparity and optical flow partitioning. We investigate new variational approaches to these problems using Potts priors and propose a modified alternating direction method of multipliers. This iterative algorithm requires the computation of global minimizers of classical univariate Potts problems. Global and local minimality of the resulting model are investigated as well as convergence of the proposed algorithm. Numerical examples demonstrate the very good performance of our partitioning method.

**Edge-preserving Regularization for Electrical Impedance Tomography**

14:00–14:30

Siltanen, Samuli

Univ. of Helsinki

Abstract: The D-bar method provides a non-iterative solution to the full nonlinear problem of Electrical Impedance Tomography, based on a low-pass filter in the (nonlinear) frequency domain. However, the D-bar reconstructions are smooth. A new “TV-Enhanced D-bar Method” is introduced, producing reconstructions with sharper edges and improved contrast while still solving the full nonlinear problem. This is achieved by using the Total Variation-induced edges to increase the truncation radius of the nonlinear transform.

**Rates for Coordinate and Block-descent Algorithms**

14:30–15:00

Chambolle, Antonin

CMAP, Ecole Polytechnique, CNRS

Abstract: This work is based on very simple (old) observations relating Dykstra’s like alternating minimization algorithms and forward-backward splitting. Based upon these remarks, we discuss some cases where it is possible to use standard accelerated descent algorithms based on over-relaxation to improve the rate of convergence. This is a joint work with Thomas Pock from T.U. Graz.

**Multiscale Adaptive Learning Algorithms for High-dimensional Data**

15:00–15:30

Liao, Wenjing

Duke Univ. & SAMSI

Maggioni, Mauro

Duke Univ.

Abstract: Many data sets in image analysis are in a high-dimensional space but exhibit a low-dimensional structure. We will discuss a multiscale geometric method for building a dictionary which provides sparse representations for these data. Our method is based on a multiscale partition of the data and then constructing piecewise affine approximations. It features adaptivity in the sense that our algorithm automatically learns the distribution of the data and chooses the right partition to be used.
Abstract: Calculation of transition states on energy landscape is very important when folded gives rise to evolutionary coupling between the traits of protein adaptation, investigating how the fact that most proteins can only demonstrate the approach on simple examples, I will apply it to the problem of constructing the quasi-potential energy landscape of the considered model. It is also successfully applied to the budding yeast cell cycle system.

MS-Tu-D-49-1 13:30–14:00 Rare Events and Energy Landscape for the Chemical Reaction Kinetics Li, Tiejun Peking Univ.

Abstract: Rare event study attracts much attention in the chemical reaction kinetics recent years. It is also intimately related to the so-called energy landscape construction for biological systems. We start from a genetic switching system with positive feedback to develop rigorous two-scale large deviations. Based on the obtained results, we construct the quasi-potential energy landscape of the considered model. It is also successfully applied to the budding yeast cell cycle system.

MS-Tu-D-49-2 14:00–14:30 Statistical Mechanics of Random Walks, with Application to Molecular Evolution Morozov, Alexandre Rutgers Univ.

Abstract: Understanding transport in complex media is crucial for many areas of science. I will describe an efficient recursive approach to studying random walks on weighted networks and landscapes with arbitrary structure. After demonstrating the approach on simple examples, I will apply it to the problem of protein adaptation, investigating how the fact that most proteins can only function when folded gives rise to evolutionary coupling between the traits of folding stability and binding strength.

MS-Tu-D-49-3 14:30–15:00 Iterative Minimization Formulation and Algorithm for Transition State Calculation Zhou, Xiang City Univ. of Hong Kong

Abstract: Calculation of transition states on energy landscape is very important in computational chemistry, material sciences, etc. These transition states are indeed saddle points. We present a mathematical formulation for the min-mode methodology: Iterative Minimization Formulation (IMF) as well as their numerical implementations. IMF is a generalization of the Gentlest Ascent Dynamics (GAD), with quadratic iterative rate. The computational efficiency of the resulting iterative minimization algorithm will be demonstrated versus other methods.

MS-Tu-D-49-4 15:00–15:30 Stochastic Surface Walking Method for Global Structure Search and Pathway Sampling Liu, Zhipan Fudan Univ.

Abstract: The algorithm and the extension of stochastic surface walking method will be overviewed. In particular, the latest progress of the automated pathway sampling in solid-solid phase transition will be presented.

MS-Tu-D-50 13:30–15:30 Nonlinear Subdivision Schemes and Applications - Part I of II

For Part 2, see MS-Tu-E-50

Organizer: Donat, Rosa Universitat de Valencia
Organizer: LIANDRAT, Jacques Centrale Marseille/I2M

Abstract: Subdivision schemes and their associated multiscale algorithms have led, over the past 20 years, to important breakthroughs in scientific computing including computer-aided geometric design, signal analysis, harmonic analysis and numerical analysis. Non-linearities appear rapidly in data dependent approaches or in connection to nonlinear constraints of the framework. Applications of, and mathematical approaches to, non-linear subdivision schemes are wide and diverse. The goal of the minisymposium is to gather mathematicians covering the different approaches, in order to discuss the challenges in applications and establish links with ongoing work.

MS-Tu-D-50-1 13:30–14:00 Kriging Theory: A Flexible Framework to Construct Data-dependent Subdivision Schemes Baccou, Jean IRSN

Abstract: This work lies in the intersection of stochastic data modelling and multiscale approximation. It is devoted to the construction of data-dependent kriging subdivision schemes. The originality of such schemes stands in their mask which takes into account the spatial dependence of the data and in the possibility to switch from an interpolatory to a non-interpolatory prediction. A full analysis is performed and applications to the reconstruction of discontinuous and noisy signals are provided as well.

MS-Tu-D-50-2 14:00–14:30 Nonlinear Subdivision Schemes, An Overview LIANDRAT, Jacques Centrale Marseille/I2M

Abstract: Since their definition in the 80th, subdivision schemes have evolved adapting to various appeals from approximation theory, data compression, geometric design and statistical approach. From linear and translation invariant operators at the beginning, they evolved towards position-dependent, data-dependent and non-linear operators. Analysis tools have been developed to control their properties, mainly convergence and stability. We will review these evolutions and their motivations through some examples and their applications.

MS-Tu-D-50-3 14:30–15:00 Nonlinear Thresholding of Multiresolution Decompositions Adapted to the Presence of Discontinuities II: the Cell-average Case Amat, Sergio U.P. Cartagena

Abstract: A new nonlinear representation of cell-average multiresolution decomposition and new thresholding adapted to the presence of discontinuities are presented and analyzed. They are based on a nonlinear modification of the multiresolution details coming from an initial (linear or nonlinear) scheme and on a data dependent thresholding. Stability results are derived. Numerical advantages are demonstrated on various numerical experiments.

MS-Tu-D-50-4 15:00–15:30 Analysis of Geometric Subdivision Schemes Ewald, Tobias TU Darmstadt

Abstract: Geometric subdivision schemes are characterized by the fact that the refinement rules commutate with similarities. If such schemes reproduce linear polygons, as Dodgson-Sabin’s circle preserving scheme does, C1,C2-regularity can be established automatically and rigorously by means of numerical computations. For the important subclass of locally linear schemes, C2-regularity is inherited from a related linear scheme. This talk is based on a joint work with Ulrich Reif and Malcolm Sabin.

MS-Tu-D-51 13:30–15:30 Lyapunov Function Method in Mathematical Biology - Part II of II

For Part 1, see MS-Mo-E-51

Organizer: Shuai, Zhisheng Univ. of Central Florida
Organizer: Wang, Chuncheng Harbin Inst. of Tech.
Organizer: Wang, Jiliang Heilongjiang Univ.

Abstract: The method of Lyapunov functions is a standard tool to analyze the existence of Discontinuities II: the Cell-average Case

For Part 2, see MS-Mo-E-51

Organizer: Baccou, Jean IRSN

Abstract: This work lies in the intersection of stochastic data modelling and multiscale approximation. It is devoted to the construction of data-dependent kriging subdivision schemes. The originality of such schemes stands in their mask which takes into account the spatial dependence of the data and in the possibility to switch from an interpolatory to a non-interpolatory prediction. A full analysis is performed and applications to the reconstruction of discontinuous and noisy signals are provided as well.

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MS-Tu-D-50-4 15:00–15:30 Analysis of Geometric Subdivision Schemes

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of gene regulation by formulating master equations for traffic-like collective movements of polymerases and ribosomes on their respective nucleic acid tracks.

- **MS-Tu-D-52-3**
  - **Chemotaxis, Velocity Jump Processes, and the Keller-Segel Equation**
  - Xue, Chuan
  - Ohio State Univ.
  - Abstract: Chemotaxis of a run-and-tumble bacterium is most accurately modeled by a velocity jump process, with internal dynamics representing intracellular signaling. At the population level, velocity jump models reduce to the Keller-Segel chemotaxis equation when the external signal changes slowly, but the latter becomes inadequate when the signal changes fast. The analysis yields representations of macroscopic parameters in terms of measurable microscopic parameters, and elucidates the molecular origin of logarithmic sensitivity of chemotaxis.

- **MS-Tu-D-52-4**
  - **Fluctuation Models for Suspensions of Swimming Microorganisms**
  - Kramer, Peter
  - Rensselaer Polytechnic Inst.
  - Abstract: The collective dynamics of swimming microorganisms (“microswimmers”) such as bacteria and algal cells have been of considerable recent interest, both as paradigms of collective patterns arising from individual autonomous agents and for their relevance to technological issues such as biofilm formation and power sources for microdevices. We will discuss some recent efforts to incorporate stochastic fluctuations and correlations into a continuum “mean field” partial differential equation framework for the effective microswimmer dynamics in a suspension.

**Organizer:** Kramer, Peter
**Rensselaer Polytechnic Inst.**

**Abstract:** An age-infection model is presented for the delay SEIR epidemic model, such that the properties of global asymptotic stability of the equilibria of the age-infection model imply the same properties for the original delay-differential epidemic model. By introducing suitable Lyapunov functions, we study the global stability of the disease-free equilibrium and the endemic equilibria of the age-infection model, which infer the corresponding global properties for the delay SEIR model.

- **MS-Tu-D-54-1**
  - **Modeling HIV-1 Dynamics with Both Cell-Free Virus Infection and Cell-to-cell Transmission**
  - Lai, Xiulan
  - Renmin Univ. of China
  - Abstract: Direct cell-to-cell transfer of HIV-1 is found to be a more potent and efficient means of virus propagation than virus-to-cell infection. In this talk, we propose a mathematical model to consider these two modes of viral infection and spread, in which infection age is also incorporated. By applying Lyapunov method, we show that the model demonstrates a global threshold dynamics, fully described by the basic reproduction number, which is identified explicitly.

- **MS-Tu-D-52**
  - **Stochastic Dynamics in Cellular-Scale Biology: Part I of II**
  - For Part 2, see **MS-Tu-E-52**
  - Organizer: Kramer, Peter
  - **Rensselaer Polytechnic Inst.**
  - **Abstract:** Many physical processes involving cells and associated entities such as viruses involve inherent irregularities due to thermal fluctuations or other noisy aspects of protein function, arising from the small scales, flexible structures, and/or reliance on diffusive transport of small numbers of biomolecules. The quantitative study of such systems generally relies on stochastic models which incorporate the uncertain noisy aspect in a physically, or sometimes phenomenologically, motivated manner. The speakers in this minisymposium will illustrate how stochastic models can be deployed and analyzed to obtain insights on a broad variety of cellular processes.

- **MS-Tu-D-52-2**
  - **Stochastic Models of Collective Force Generation and Information Processing in a Living Cell**
  - Chowdhury, Debashish
  - Indian Inst. of Tech., Kanpur
  - Abstract: A living cell has strong similarities with a micro-factory where spatially temporally coordinated operation of molecular machines sustains, and prop-up, life. We analyze stochastic models based on the Keller-Segel equation to describe the kinetics of collective force generation by polymerizing-depolymerizing microtubule bundles. We also account for some modes of gene regulation by formulating master equations for traffic-like collective movements of polymerases and ribosomes on their respective nucleic acid tracks.

- **MS-Tu-D-52-3**
  - **Chemotaxis, Velocity Jump Processes, and the Keller-Segel Equation**
  - Xue, Chuan
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  - Abstract: Chemotaxis of a run-and-tumble bacterium is most accurately modeled by a velocity jump process, with internal dynamics representing intracellular signaling. At the population level, velocity jump models reduce to the Keller-Segel chemotaxis equation when the external signal changes slowly, but the latter becomes inadequate when the signal changes fast. The analysis yields representations of macroscopic parameters in terms of measurable microscopic parameters, and elucidates the molecular origin of logarithmic sensitivity of chemotaxis.

- **MS-Tu-D-52-4**
  - **Fluctuation Models for Suspensions of Swimming Microorganisms**
  - Kramer, Peter
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  - Abstract: The collective dynamics of swimming microorganisms (“microswimmers”) such as bacteria and algal cells have been of considerable recent interest, both as paradigms of collective patterns arising from individual autonomous agents and for their relevance to technological issues such as biofilm formation and power sources for microdevices. We will discuss some recent efforts to incorporate stochastic fluctuations and correlations into a continuum “mean field” partial differential equation framework for the effective microswimmer dynamics in a suspension.
Stochastic utility maximization models can be used for the pricing of financial derivatives and related financial products. The motivation for this linear and nonlinear problems arising from the mathematical theory of pricing financial derivatives and related financial products. The motivation for this minisymposium is to exchange and discuss current insights and ideas, and to lay groundwork for future collaborations. Finally, it should serve as a kick-off for the special interest group (SIG) Computational Finance within ECMO (European Consortium for Mathematics in Industry).

**MS-Tu-D-54-1 13:30–14:00**

*Pricing Derivatives with Transaction Costs with Non-constant Risk-aversion*

Polvora, Pedro  
Comenius Univ.

Abstract: Stochastic utility maximization models can be used for the pricing of derivatives under transaction costs. We present a study on different type of utility functions and derivatives payoffs. In these models, the price of the derivative will be the solution of HJB variational inequalities. We present some results on the numerical solution of the HJB Equations arising from the model.

**MS-Tu-D-54-2 14:00–14:30**

*High Order ADI Scheme for Option Pricing in Stochastic Volatility Models*

Miles, James  
Univ. Of Sussex

Abstract: This presentation combines high-order compact finite difference approximations with an Alternating Direction Implicit method to obtain numerical solutions to the convection diffusion equation with mixed second-order derivative terms. This method has useful applications in financial option pricing problems which I shall demonstrate by solving the stochastic volatility Heston model as an example. In this case, the problem reduces to a convection diffusion equation with non-constant coefficients in two spatial dimensions.

**MS-Tu-D-54-3 14:30–15:00**

*Calibration of Local-stochastic Volatility Models to Barrier Options Using A Dupire-type PDE*

Reisinger, Christoph  
Oxford Univ.

Abstract: We derive a forward equation for arbitrage-free barrier option prices in terms of Markovian projections of a stochastic volatility process. This provides a Dupire-type formula for the coefficient derived by Brunick and Shreve for their mimicking diffusion and can be interpreted as the canonical extension of local volatility for barrier options. Alternatively, a forward partial-integro differential equation (PIDP) is introduced which provides up-and-out call prices for the complete set of strikes, barriers and maturities.

**MS-Tu-D-54-4 15:00–15:30**

*The Volatility Factors Analysis of the International Crude Oil Futures*

Chen, Xiaoguo  
Guangdong Univ. of Petrochemical Tech.

Abstract: In this paper, starts from the actual market datas, uses Logarithmic - log-linear regression model, Grange model, ARCH model to study the influence of various factors on the crude oil futures price volatility. And then using bivariate regression model with linear feature to establish the model of crude oil futures prices only considering the dollar index volatility, the EIA of crude oil inventory changes. Finally, offers some risk aversion strategies to the company which need

**MS-Tu-D-55 13:30–15:30**

Theoretical Understanding of Charged Particles in Complex Environments - Part II of II

For Part 1, see MS-Mo-E-55

Organizer: Xu, Zhenli  
Shanghai Jiao Tong Univ.

Organizer: Liu, Benzhuo  
Acad. of Mathematics & Sys. Sci., CAS

Abstract: Theoretical understanding of ion interaction and transport has been attracting longstanding interest in different branches of mathematics, such as potential theory, numerical PDEs, computational physics and mathematical biology. Complex environments, including interfaces, dielectric inhomogeneities, many-body and dynamic interactions, have led to recent wide attention in math community. This mini-symposium will bring together of active researchers to discuss recent progress in this exciting field of disciplinary areas for computational and modeling issues of particle and interface motion in complex environments. There will be mathematical and numerical issues, such as variational approaches, finite element methods, high-performance computing, mesh generation, various coarse-grained techniques, and asymptotic analysis.

**MS-Tu-D-55-1 13:30–14:00**

*Stability Analysis of A Solute-Solvent Interface: Effect of Geometry, Hydrodynamics, and Electrostatics*

Chen, Minxin  
Soochow Univ.

Abstract: Recently, with the developments of advanced mathematical modeling in the field of implicit solvent modeling and simulation, providing surface meshes with good qualities efficiently for large real biomolecular systems becomes an urgent issue. In this talk, I will introduce our recently developed method and tool, TMSmesh, for meshing molecular Gaussian surface. The meshes generated by TMSmesh have been successfully tested in BEM and FEM computations of the implicit solvent model for large biomolecular systems.

**MS-Tu-D-55-2 14:00–14:30**

*TMSmesh: A Robust Method for Meshing Large Biomolecular Gaussian Surface and Its Applications in Implicit Solvent Modeling*

Sun.  
Acad. of Mathematics & Sys. Sci., CAS

Abstract: In this talk, we study the stability analysis of the equilibrium solute-solvent interface under the influence of geometry, hydrodynamics, and electrostatics. This is a joint work with Dr. Bo Li and Dr. Hui Sun.

**MS-Tu-D-55-3 14:30–15:00**

*Biomolecular System Modeled by PNP Equations and Its Modified Versions, Size-modified PNP and FMT-PNP*

Chen, Xiaoguo  
Guangdong Univ. of Petrochemical Tech.

Abstract: Theoretical understanding of ion interaction and transport has been attracting longstanding interest in different branches of mathematics, such as potential theory, numerical PDEs, computational physics and mathematical biology. Complex environments, including interfaces, dielectric inhomogeneities, many-body and dynamic interactions, have led to recent wide attention in math community. This mini-symposium will bring together of active researchers to discuss recent progress in this exciting field of disciplinary areas for computational and modeling issues of particle and interface motion in complex environments. There will be mathematical and numerical issues, such as variational approaches, finite element methods, high-performance computing, mesh generation, various coarse-grained techniques, and asymptotic analysis.

**MS-Tu-D-55-4 15:00–15:30**

*Binding Coarse Grained Molecular Dynamics of Proteins and Continuum Deformation of Protein Complexes*

Zhou, Yongcheng  
Colorado State Univ.

Abstract: Here we propose to compute the strain-stress constitutive relation from steered coarse-grained molecular dynamics simulations of proteins. These relations will be applied to the solution of three-dimensional continuum elastic equations for large scale deformations of proteins or protein complexes. We expect our approach will greatly reduce the computational complexity in simulating the related biological procedures.

**MS-Tu-D-56 13:30–15:30**

*Modeling Techniques for Complex Biological Systems*

Organizer: Tran, Hien  
North Carolina State Univ.

Abstract: Mathematical models when used in conjunction with data can be powerful tools in uncovering mechanisms in complex biological systems. These data-oriented mathematical models require modeling techniques such as sensitivity analysis, generalized sensitivity functions, and parameter subset selection for the model building process. In addition, application of models to data from multiple subjects requires that the model must be integrated into
a statistical framework to recognize within subject variation, as well as vari-
ation across the population. In this mini-symposium, invited speakers will
discuss these mathematical and statistical modeling concepts in the context
of biological applications such as malignant brain tumor, pharmacokinetic-
of Metformin, cardiovascular system, and drug delivery in the nasal passages.

**MS-Tu-D-56-1**
13:30–14:00
**Modeling Surgical Outcomes and Drug Delivery in the Nasal Passages**
Frank-Ito, Dennis
Duke Univ.
Abstract: Outcomes from nasal surgery are sometimes difficult to predict a
priori in treatment of nasal diseases; and little is known if topical medications
are reaching targeted sites inside the human nasal airway. This in part is due
to the complexity of the nasal passage. This talk will focus on computational
fluid dynamics modeling of fluid flow and transport of particulate matter in the
nose before and after surgical therapy in the treatment of nasal diseases.

**MS-Tu-D-56-2**
14:00–14:30
**Mathematical Modeling of Malignant Brain Tumor with Immunostimulatory G-
glycoprotein, T11 Target Structure.**
Banerjee, Sandip
Indian Inst. of Tech. Roorkee
Abstract: T11 Target structure, a membrane glycoprotein isolated from sheep
erythrocytes, reverses the immune suppressed state of brain tumor induced
animals by boosting the functional status of the immune cells. This study aim-
as at aiding in the design of more efficacious brain tumor therapies with T11
target structure as a potent immune stimulator. We propose a mathematical
model for brain tumor (glioma) and the immune system interactions, which
aims in designing effective brain tumor therapy.

**MS-Tu-D-56-3**
14:30–15:00
**A Stochastic Approach to Nonlinear Mixed Effects Modeling: Applications to
Pharmacokinetics Modeling of Metformin**
Tran, Hien
North Carolina State Univ.
Abstract: Nonlinear mixed effects modeling (NLME) is a statistical framework
involving both fixed-effects and random effects for population parameters in-
corporating uncertainty associated with intra- and inter-subject variability. Us-
ing stochastic differential equations (SDE) within the NLME framework allows
the decoupling of the measurement error from the model misspecification.
In this talk, we will compare the model development results using an SDE
approach to common practice of using ordinary differential equations for the
Metformin clinical pharmacokinetic data.

**MS-Tu-D-56-4**
15:00–15:30
**Generalized Sensitivity Functions and Parameter Subset Selection for A Model
of the Cardiovascular System**
Kappel, Franz
Univ. of Graz
Abstract: Demands on accuracy of models, particularly in life sciences, lead to
models involving large numbers of parameters. Moreover, clinical application-
s require to adapt models to individual patients. Limited data available require
systematic methods, like parameter subset selection (PSS) and generalized
sensitivity functions (GSF), to select parameters which can be identified with
sufficient accuracy on the basis of available data. We present PSS and GSF-
together with applications to a compartment model for the cardiovascular system.

**MS-Tu-D-57**
13:30–15:30
402A
**Advances in Numerical Methods for Porous Media Flow - Part I of IV**
For Part 2, see MS-Tu-E-57
For Part 3, see MS-We-D-57
For Part 4, see MS-We-E-57
Organizer: Wang, Hong
Univ. of South Carolina
Organizer: Sun, Shuyu
King Abdullah Univ. of Sci. & Tech.
Organizer: Rui, Hongxing
Department of Mathematics, Shandong Univ.
Abstract: Porous media flow has wide applications in many areas, including
environmental, energy, biological and engineering applications. They lead to
strongly coupled transport processes also with nonlinear chemical reactions,
which are computationally challenging, for it demands high accuracy and local
mass conservation. Porous media manifest dramatically different at differen-
tial spatial and temporal scales. Heterogeneity, anisotropy, and discontinuity of
medium properties require special treatment. The aim of this minisymposium is
to bring together researchers in the aforementioned field to highlight the
current developments, to exchange the latest research ideas, and to promote
further collaborations in the community.

**MS-Tu-D-57-1**
13:30–14:00
**An Improved Polymer Model for 3D Reservoir Simulators**
Wheeler, Mary Fannett
THE Univ. OF TEXAS AT AUSTIN
Abstract: A three-dimensional, shear-thinning polymer model is described for use
in reservoir simulators. The viscosity calculations are based upon direc-
tion dependent shear-rates. This provides an accurate representation of the
non-Newtonian flow behavior in a three dimensional porous medium. This
model is implemented in a reservoir simulator IPARS (Integrated Parallel Ac-
curate reservoir Simulator) to evaluate mobility control scenarios during field
scale polymer flooding. A number of numerical results including field scale
studies are presented to demonstrate model.

**MS-Tu-D-57-2**
14:00–14:30
**Studies of Hybrid Steam-Solvent Processes for Oil Recovery**
Chen, Zhangxin
Xi’an Jiaotong Univ. & Univ. of Calgary
Abstract: The main drawbacks associated with steam based recovery pro-
cesses for oil reservoirs, such as steam flooding, cyclic steam stimulation (CSS)
and steam assisted gravity drainage (SAGD), are their high energy de-
mand and significant environmental impacts. The current research focuses on
co-injection of steam and solvent as one of the alternative recovery processes
to reduce the energy intensity and environmental impacts of pure steam
processes. The co-injection has been studied under various commercial names
such as solvent aided process (SAP), solvent aided SAGD (SA-SAGD), ex-
panding solvent-SAGD (ES-SAGD) and liquid addition to steam enhanced re-
covery (LASER). Improved oil production rates and ultimate recovery factors
as well as lower steam demand in co-injection, compared to the pure steam
processes, have been reported in the literature.
The oil recovery in co-injection involves complex interactions of multiphase
mass and energy flow with effects of gravity and phase behavior. Although
various laboratory and numerical experiments and filed pilot tests are report-
ed in the literature, their results are specific to the experimental conditions
or reservoir properties considered. The main objectives of this research are:
1) to identify the key mechanisms of co-injection that are responsible for oil
rate improvement, ultimate recovery factor improvement and steam demand
reduction, 2) to develop a sound mathematical model to capture these mech-
anism and to predict the performance of co-injection, and 3) to improve the
economics of the processes by providing key guidelines on making an op-
timum choice of solvent, its concentration, and co-injection strategy. This
presentation will address these issues.

**MS-Tu-D-57-3**
14:30–15:00
**New Analysis of Characteristics Type FEMs for Nonlinear Convection-
dominated Diffusion Equations**
Sun, Weiwei
City Univ. of Hong Kong
Abstract: The method of characteristics type is especially effective for
convection-dominated diffusion problems. Due to the nature of characteristic
temporal discretization, the method often allows one to use a large time step
in many practical computations, while all previous theoretical analyses always
required certain restrictions on the time stepsize. In this talk, we present our
recent work on establishing unconditionally optimal error estimates for modi-
fied methods of characteristics for N-S equations and miscible displacement
problem.

**MS-Tu-D-57-4**
15:00–15:30
**Physics-preserving Numerical Methods for Compositional Multiphase Flow**
Sun, Shuyu
King Abdullah Univ. of Sci. & Tech.
Kou, Jisheng
Huibei Univ. of Engineering
Abstract: We consider numerical simulation of compositional multiphase flow
in porous media, and we show the importance and significance in preserv-
ing certain physics. We demonstrate in particular that local conservation is a
necessary condition for many scenarios if one wants to ensure both accuracy
and global conservation. We propose new algorithms to address the loss of
accuracy and/or loss of global conservation which can occur when flow and
transport schemes are not compatible.

**MS-Tu-D-58**
13:30–15:30
401
**Surface diffusion and related problems and flows. - Part III of III**
For Part 1, see MS-Mo-D-58
For Part 2, see MS-Mo-E-58
Organizer: Novick-Cohen, Amy
Technion IIIT
Abstract: Motion by surface diffusion, in which the normal velocity of an e-
volving surface is proportional to minus the surface Laplacian of its mean
curvature, constitutes a geometric motion which plays a critical role in many
 technological applications, from thin film drug delivery, optical coatings, print-
ing and spray technology. While surface diffusion has been discussed in the
material science literature to 1950s, much concerning its mathematical theory
remains to be developed. The aim of the proposed minisymposium is consid-
By means of a suitable Phase-Field approach we investigate the anisotropy to demonstrate the usefulness of our approach.

**MS-Tu-D-58-1**
13:30–14:00
Some Consequences of New Local Regularity for the Surface Diffusion Flow
Wheeler, Glen
Univ. of Wollongong

Abstract: Recently new local regularity for the curve diffusion flow has become available, giving strong local space-time control of the (hyper)surface diffusion flow in dimensions one (curves), two (surfaces) and three (3-manifolds). This local control is significantly different in each case, as the character of the flow, and the lack (or abundance) of good scale-invariant functionals influences the analysis in a fundamental way. In the talk we discuss some consequences of these new estimates.

**MS-Tu-D-58-2**
14:00–14:30
The Method of Viscosity Solutions for Analysis of Singular Diffusion Problems Appearing in Crystal Growth Problems
Rybak, Piotr
The Univ. of Warsaw

Abstract: We use the methods of viscosity solutions, to study singular parabolic equations arising in crystal growth problems. These problems may be viewed as a weighted mean curvature flow. We present a few consequences of this theory and the comparison principle: 1) uniqueness of evolution of simple closed curves driven by wmc; 2) preservation of vertexes; 3) behavior of a system with two competing singular slopes, arising when we localize the wmc near a vertex.

**MS-Tu-D-58-3**
14:30–15:00
Numerical Approximation of Multicomponent Phase-field Models for Multiphase Flow.
Banas, Lubomir
Bielefeld Univ.

Abstract: We propose finite element based numerical approximations of some phase-field models for mixtures of incompressible fluids with variable densities and viscosities. We discuss theoretical and practical issues related to the proposed numerical approximations and present some computational experiments to demonstrate the usefulness of our approach.

**MS-Tu-D-58-4**
15:00–15:30
Phase-field Modeling of Morphological Evolution for Arbitrary Surface-energy Anisotropy
Voigt, Axel
TU Dresden

Abstract: By means of a suitable Phase-Field approach we investigate the evolution towards equilibrium of three-dimensional structures characterized by arbitrary facets. A convenient and general formalization of anisotropic surface energy density is introduced and a proper regularisation is considered to treat the strong anisotropy regime. After illustrating applications yielding equilibrium crystal shapes, we focus our attention on the evolution of far-from-equilibrium morphologies for which a conventional Wulff-plot analysis would fail. The generality and numerical robustness of the approach is proved by several applications to systems of utmost interest (quantum dots, quantum wires, patterned substrates) in present material science.

**MS-Tu-D-59**
13:30–15:30
Modeling, Simulation and Analysis of Interface and Defect Problems in Solids
Part I of III

For Part 2, see MS-Tu-E-5
For Part 3, see MS-We-D-59

Organizer: Xiang, Yang
Hong Kong Univ. of Sci. & Tech.

Abstract: Interfaces or defects in crystalline materials, such as vacancies, dislocations, cracks, grain boundaries, and surfaces, play important roles in the mechanical, electronic, and plastic properties of these materials. The complexity of modeling microstructures of these defects and their evolution at various length and time scales presents new challenges for mathematical modeling and analysis. Multiphysics models are required to accurately describe the complicated interactions among various defects involved in the equilibrium and dynamics processes. The speakers in this minisymposium will discuss recent advances in the modeling approaches and new findings obtained in analysis and simulations.

**MS-Tu-D-59-1**
13:30–14:00
Continuous Framework for Dislocation Structure, Energy and Dynamics of Dislocation Arrays and Low Angle Grain Boundaries
Zhu, Xiaohong
Jinan Univ.

Xiang, Yang
Hong Kong Univ. of Sci. & Tech.

Abstract: We present a continuum framework for dislocation structure, energy and dynamics of dislocation arrays and low angle grain boundaries which may be nonplanar and nonequilibrium. We define a dislocation density potential function on the dislocation array surface or grain boundary to describe the orientation dependent continuous distribution of dislocations. The continuum formulations incorporate both the long-range dislocation interaction and the local dislocation line energy, and are derived from the discrete dislocation model.

**MS-Tu-D-59-2**
14:00–14:30
Numerical Methods for Modeling Dynamic Interfaces
Leung, Shingyu
Hong Kong Univ. of Sci. & Tech.

Abstract: The talk summarizes several new numerical approaches for modeling dynamic interfaces. We present algorithms including the Grid Based Particle Method (GBPM), the Cell Based Particle Method (CBPM) and some other recent progress based on the Level Set Method. This is a joint work with Sean Hon, Ka Wah Wong, Hongkai Zhao and John Lowengrub.

**MS-Tu-D-59-3**
14:30–15:00
Homogenisation of A Row of Dipoles
Zhu, Yichao
The Hong Kong Univ. of Sci. & Tech.

Abstract: The collective behaviour of a row of dislocation dipoles is here studied with the matched asymptotic techniques. The discrete-to-continuum transition is facilitated by introducing two field variables, one describing macroscopic density distribution of dipoles and the other depicting the local patterns of dipoles. The evolution of the two fields is found diachronic in time, and such findings may shed light on the incorporation of dislocation-dipole-like structures (small but non-vanishing) into macroscopic models of plasticity.

**MS-Tu-D-59-4**
15:00–15:30
The Relaxation of A General Family of Broken Bond Crystal Surface Models.
Marzoula, Jeremy
UNC, Chapel Hill

Abstract: With Jon Weare (Chicago), we study the continuum limit of a family of kinetic Monte Carlo models of crystal surface relaxation that includes both the solid-on-solid and discrete Gaussian models. With computational experiments and theoretical arguments we are able to derive several partial differential equation limits identified (or nearly identified) in previous studies and to clarify the correct choice of surface tension appearing in the PDE.
mand from industry for applied and computational mathematics; the agenda will include both the mechanisms for academic/industrial collaboration and the areas where it will be most fruitful.

IM-Tu-D-60-1 13:30–14:00  
**Industrial Mathematics in Europe - the First 50 Years**  
Ockendon, John  
Univ. of Oxford  
**Abstract:** Although industrial mathematics in Europe started in the 1960s there was an explosion in the 1980s which nucleated many new initiatives including the first continental network of academic and industrial mathematicians (ECMI). This talk will focus on (1) the key mechanisms that have underpinned this new interface for mathematicians and (2) on the intellectual impact that it has had, with special reference to the pantograph equation and the theory of free boundary problems.

IM-Tu-D-60-2 14:00–14:30  
**An Overview over the Successful Mathematical Technology Transfer in Spain and the Added Value for Both Companies and Research Groups**  
Quintela, Peregrina  
Spanish Network for Mathematics & Industry; Univ. of Santiago de Compostela  
**Abstract:** The advantages, disadvantages and difficulties arising in the mathematical technology transfer, both from the point of view of researchers, technicians and businesses, will be discussed. In particular, the solution provided by the Spanish mathematicians to promote the transfer, launching of the Spanish Network for Mathematics and Industry, and how companies can get access to it will be shown. Through some successful cases, the added value for both companies and research groups involved will be displayed.

IM-Tu-D-60-3 14:30–15:00  
**New Developments in the Danish Study Group Activity**  
Hjorth, Poul G.  
Technical Univ. of Denmark  
**Abstract:** In Denmark, Study Groups have been conducted for more than 15 years, alternating location between Technical University of Denmark, and University of Southern Denmark. I will highlight a few cases of mathematics impacting on Danish companies, and also discuss a recent extension of the activity, into a ‘Flying Corps’, which can with short notice assemble an ad hoc team of mathematicians, and perform a quick assessment of an industrial maths problem.

IM-Tu-D-60-4 15:00–15:30  
**The Need for A Successful European Strategy in Supporting Industrial Mathematics**  
Guenther, Michael  
Bergische Universität Wuppertal  
**Abstract:** In my talk I will try to explain in which sense we consider it mandatory that the EU policy towards mathematics recognizes that mathematical modelling-simulation-optimization (MOS) is a key tool for innovation and for increasing competitiveness of European industry. In this sense MOS should be considered as a KET (key enabling technology) and funded accordingly. Some recent and ongoing attempts that European mathematicians have done will be described.

CP-Tu-D-61 13:30–15:30  
**Real and Complex Analysis**  
Chair: AGARWAL, PRAVEEN  
Anand International College of Engineering  
**Abstract:**  

**CP-Tu-D-61-1** 13:30–13:50  
**SOME GENERAL PROPERTIES OF A FRACTIONAL SUMUDU TRANSFORM IN THE CLASS OF BOEHMIANS**  
AGARWAL, PRAVEEN  
Anand International College of Engineering  
**Abstract:** In literature, there are several works on the theory and applications of integral transforms of Boehmian spaces, but fractional integral transforms of Boehmian have not yet been reported. In this paper, we investigate the fractional Sumudu transform of arbitrary order on some space of integrable Boehmians. The fractional Sumudu transform of an integrable Boehmian is well-defined, linear and sequentially complete in the space of continuous functions. Two types of convergence are also discussed in details.

**CP-Tu-D-61-2** 13:50–14:10  
**Trends in Polar Orthogonal Polynomials**  
Abdelhamid, Rehouma  
Department of Mathematic Univ. of Eloued Algeria  
**Abstract:** We aim studying a new corresponding set of monic polynomials corresponding to a General orthogonal polynomials with called polar general orthogonal polynomials. We speaking some open question relating to asymptotic behavior and recurrence relations and other comparison question between this general orthogonal polynomials and its polar polynomials. More special cases was taken into account as: polar monic orthogonal polynomials with respect to the measure supported on the unit circle.

**CP-Tu-D-61-3** 14:10–14:30  
**From Dirichlet space to Bergman space: A Bernstein-Szego inequality**  
Artes, Rosalio  
Mindanao State Univ.- Iligan Inst. of Tech.  
Arco, Roxanne  
Mindanao State Univ.- Iligan Inst. of Tech.  
**Abstract:** The Dirichlet space and the Bergman space are reproducing kernel Hilbert spaces (RKHS) of analytic functions on the unit disk. In this paper, we establish a Bernstein-Szego inequality on the Dirichlet space by taking bounded linear operators from the Dirichlet space into the Bergman space and obtain an estimate using the Gram-Schmidt Orthonormalization Process and Bessel’s inequality.

**CP-Tu-D-61-4** 14:30–14:50  
**Monotonicity Properties of Orthogonal Laurent Polynomials**  
Das, Sourav  
Indian Inst. of Tech. Roorkee  
Swaminathan, Anbhu  
Indian Inst. of Tech. Roorkee  
**Abstract:** The zeros of Szego polynomials are all lie in the unit disc, whereas the corresponding Para orthogonal polynomials on the unit disc are interesting because their zeros lie on the unit circle and useful in quadrature formulae. Orthogonal Laurent polynomials defined on the unit disc are obtained by the three term recurrence relation involving Szego polynomials. In this work, certain monotonicity properties of these orthogonal polynomials are obtained that are useful in discussing their zeros. Further certain continued fraction expressions are also obtained and investigated to discuss the behaviour of these polynomials in relation with certain self analytic maps on the unit disc. Several interesting applications in this direction for these polynomials are obtained.

CP-Tu-D-62 13:30–15:30  
**Partial Differential Equations**  
Chair: Kannappan, Karuppih  
Bharathiar Univ.  
**Abstract:**  

**CP-Tu-D-62-1** 13:30–13:50  
**Inverse Source Problem, Coupled Hyperbolic-parabolic System, Quasisolvent**  
Kannappan, Karuppih  
Bharathiar Univ.  
**Abstract:** In this paper we study the inverse problem of determining two source terms in the coupled hyperbolic-parabolic system. Apart from the initial and Dirichlet boundary conditions, we consider the additional Dirichlet type output measured data. Further we provide several necessary and sufficient results to prove the existence of a quasi-solution of the considered inverse problem.

**CP-Tu-D-62-2** 13:50–14:10  
**Lifespan of Classical Discontinuous Solutions to General Quasilinear Hyperbolic Systems of Conservation Laws with Small BV Initial Data**  
Shao, Zhiqiang  
Fuzhou Univ.  
**Abstract:** In the present paper, the author investigates the global structural stability of Riemann solutions for general quasilinear hyperbolic systems of conservation laws under small BV perturbations of the initial data, where the Riemann solution contains rarefaction waves, while the perturbations are in BV but they are assumed to be $C^1$-smooth, with bounded and possibly large $C^1$-norms. Combining the techniques employed by Li-Hong with the modified Glimm’s functional, the author obtains a lower bound of the lifespan of the piecewise $C^1$ solution to a class of the generalized Riemann problem, which can be regarded as a small BV perturbation of the corresponding Riemann problem. This result is also applied to the system of traffic flow on a road network using the Aw-Rascle model.

**CP-Tu-D-62-3** 14:10–14:30  
**Boundness of Solutions to A Quasilinear Parabolic–parabolic Keller–Segel System with Supercritical Sensitivity and Logistic Source**  
Zheng, Jiashan  
Beijing Inst. of Tech.  
Wang, Yifu  
Beijing Inst. of Tech.  
**Abstract:** We study global solutions of a class of chemotaxis systems

$$ u_t = 
\nabla \cdot (\phi(u) \nabla u - \chi \nabla \cdot (\phi(u) \nabla v)) + au - bu^r, \quad x \in \Omega, t > 0, 
\nabla \cdot (\Delta v + u) = 0, \quad x \in \Omega, t > 0, 
\n\phi(u) = (u+1)^{r-1}, \quad (u,v)(0) = \varphi(x), \quad (u,v) \in H^1(\Omega) \times L^2(\Omega), \quad r > 1, \quad a, b > 0, \quad \chi > 0 
\n$$

in a bounded convex domain $\Omega \subset R^N (N \geq 1)$ with smooth boundary $\partial \Omega$. Parameters r > 1, a > 0, b, $\chi$ > 0 and $\alpha, \beta \in \mathbb{R}$. There are three nonlinear mechanisms included in the model: the nonlinear diffusion, aggregation and logistic absorption. The interaction among the triple nonlinearities shows that together with the nonlinear
diffusion, the logistic absorption will dominate the aggregation such that the unique classical solution of the system has to be global in time and bounded, regardless of the initial data, whenever $\frac{\alpha}{N} \leq \alpha + \beta < 1$, which enlarges the parameter range $\alpha + \beta < 1$ (see L. Wang, Y. Li, C. Mu (Discrete Contin. Dyn. Syst. Ser. A., 34(2014), 789–802) and Y. Tao, M. Winkler, J. Dif. Eqns., 252(2012), 692–715).

► CP-Tu-D-62-4 13:40–14:50
On Bounds and Non-existence in the Problem on Bounds and Non-existence in the Problem of Steady Waves with Vorticity
Kozlov, Vladimir
Link “Opying Univ.
Abstract: For the problem describing steady gravity waves with vorticity on a two-dimensional unidirectional flow of finite depth the following results will be presented. (i) Bounds are found for the free-surface profile and for Bernoulili’s constant. (ii) If only one parallel shear flow exists for a given value of Bernoulili’s constant, then there are no wave solutions provided the vorticity distribution is subject to a certain condition. Applications of these results will be given. In particular, it will be obtained non-existence results for solitary and Stokes waves.

► CP-Tu-D-62-5 14:50–15:10
Elliptic and Parabolic Equations in Fractured Media
Yeh, Li-Ming
National Chiao Tung Univ.
Abstract: The elliptic and the parabolic equations in fractured media are considered. The fractured media consist of a periodic connected high permeability sub-region and a periodic disconnected matrix block subset with low permeability. Let $e^2 \in [0,1]$ denote the size ratio of the matrix blocks to the whole domain and let $\omega \in [0,1]$ denote the permeability ratio of the disconnected subset to the connected sub-region. It is proved that the $W^{1,p}$ norm of the elliptic and the parabolic solutions in the high permeability sub-region are bounded uniformly in $e^2, \omega$. However, the $W^{1,p}$ norm of the solutions in the low permeability subset may not be bounded uniformly in $e^2, \omega$. For the elliptic and the parabolic equations in periodic perforated domains, it is also shown that the $W^{1,p}$ norm of their solutions are bounded uniformly in $e^2$.

► CP-Tu-D-62-6 15:10–15:30
Floquet Theory Solution for A Highly Nonlinear Earth-Satellite Pitch Attitude Liberation Equation
Aido, Anthony
Eastern Connecticut State Univ.
Abstract: We derive the dynamical equations that characterize the pitch librations of an earth-satellite. To obtain analytical solution of the resulting highly nonlinear equation, we adopt a scheme that successively augments the nonlinearity level of the equation by adding nonlinear terms. This leads to the use of Floquet theory version of linear systems theory. The nonlinear solution is expressed in terms of series, enabling it to be expressed more accurately in terms of periodic functions.

► CP-Tu-D-63 13:30–15:30
Numerical Analysis
Chair: Kaur, Harpreet
Lovely Professional Univ.,Jalandhar(Punjab)
Abstract:
► CP-Tu-D-63-1 13:30–15:30
Haar Wavelet Based Time Discretization Scheme for Solving Benjamin Bona-Mahony Equation
Kaur, Harpreet
Lovely Professional Univ.,Jalandhar(Punjab)
Mishra, Vinod
SLIET, Longowal
Mittal, R.C.
IIT Roorkee
Abstract: In this paper, a numerical scheme is developed to find the numerical solutions of general nonlinear partial differential equations. The time discretization scheme is developed using the properties of uniform Haar wavelets with quasi-linearization process. In order to test the efficiency of the scheme well known nonlinear Benjamin Bona-Mahony equation is solved for different values of parameter. The plots of and show efficiency of proposed method at different time level. The quasi-linearization is iterative process but after combining with wavelet based proposed technique gives excellent numerical results without any iteration. Results are compared with available results by finding and errors. It is shown that the proposed method is working well and produces the satisfactory results.

► CP-Tu-D-63-2 13:50–14:10
A Fifteenth-Order Convergent Method for Solving Non-local Elliptic Model with Strong Allee Effect
Akanksha, Srivastava
Indian Inst. of Tech. Gandhinagar
Abstract: The paper deals with a non-local elliptic model of population growth arising in computational biology satisfying strong Allee effect growth pattern defined on a bounded polygonal domain. The non-local term involved in the strong formulation essentially increases the complexity of the problem and the necessary total computational work. The non-linear weak formulation of the problem is reduced to a linear one suitable for applications of Newtonian type iterative methods. A discrete problem is obtained by the finite element method. A fast and stable iterative method with fifteenth-order of convergence is applied for solving the discrete problem. The iterative algorithm is described by pseudo-code. The method is computer implemented and the approximate solutions are presented graphically for varying the dispersal of the population. Numerical simulations are performed to demonstrate the superiority of our method with comparisons.

► CP-Tu-D-63-3 14:10–14:30
On Fifth Order Runge-Kutta Methods
Butcher, John
Univ. of Auckland
Abstract: Methods of orders 2, 3 and 4 were derived by Runge (1895), Heun (1900) and Kutta (1901). The beautifully simple method due to Kutta, based on Simpson’s rule, is well-known and widely used. By taking the method of analysis used by these pioneers further, a method of order 5 will be constructed, satisfying the 16 condition necessary for this order. Using the same test problem used by Runge and others, the advantage of high order will be illustrated by numerical comparisons. When the comparisons are repeated using an alternative test problem, based on a vector-valued differential equation, the fifth order method now acts as though it is only fourth order. The reason for this discrepancy is that in the modern theory of order, which will be briefly surveyed, there are not 16, but 17, order conditions.
ing to a class of Cahn-Hilliard issues. It is a connecting work from applied mathematics and control areas to industrial area.

**CP-Tu-D-64-2**
**13:50–14:10**
*
**Chaos Synchronization and Hybrid Chaos Synchronization of Identical Hyperchaotic Systems by Control Method**

Prasad, Ram Pravesh

Univ. of Delhi, Delhi

**Abstract:** In this paper, we discuss the chaos synchronization and hybrid chaos synchronization of identical Hyperchaotic Wang systems by active nonlinear control method. The sufficient condition for achieving the stability results are derived by using Lyapunov stability theory. Since the Lyapunov exponents are not required for these calculations, the active control method is very effective for achieving chaos synchronization and hybrid chaos synchronization and numerical simulations shows the effectiveness of the proposed method.

**CP-Tu-D-64-3**
**14:10–14:30**

*The Kalman-Yakubovich-Popov Lemma for Differential-Algebraic Systems*

Voigt, Matthias

Technische Universität Berlin

**Abstract:** The Kalman-Yakubovich-Popov lemma is a popular result that is typically used, e.g., to assess the feasibility of linear-quadratic optimal control problems or to characterize dissipativity of a linear system. We present an extension of this result to differential-algebraic equations by dropping typical restrictions that are made in the available literature. A powerful tool used for the derivation is a new condensed form of the system under feedback equivalence.

**CP-Tu-D-64-4**
**14:30–14:50**

*Constrained Controllability of Neutral Fractional Integro-Differential Systems*

Shannmugam, Divya

Bharathiar Univ., Coimbatore, Tamilnad

**Abstract:** In this paper, we formulate the linear and nonlinear neutral fractional Volterra’s integro-differential system with prescribed control variables and investigate the controllability condition for the steering process which can be accomplished using continuous controls with arbitrary prescribed initial and final values. Such kind of problems involve a number of problems on complex media. For example, the Volterra’s model for population growth of a species within a closed system is characterized by a nonlinear fractional integro-differential equation [1]. Sufficient conditions for the controllability results of fractional dynamical systems are obtained using the contraction mapping principle and the controllability Grammian matrix which defined by the Mittag-Leffler function and the Schauder fixed point theorem.

**CP-Tu-D-64-5**
**14:50–15:10**

*Numerically Efficient Algorithm to Check Controllability and Computing Controllability Indices*

Khare, Swanand

Indian Inst. of Tech. Kharagpur

**Abstract:** In this paper, we propose a numerically efficient algorithm to check whether a given system described by the pair (A,B) is controllable. In order to do so we construct a sequence of structured matrices from the pair (A,B). We prove an equivalent criterion to the controllability of the pair (A,B) in terms of nullity of an appropriate matrix in this sequence. We propose a numerical method involving QR decomposition of this structured matrix to check its rank. We can perform these computations efficiently because of the special structure of this matrix. We show that the computational complexity of this procedure is comparable to the computational complexity of checking controllability using classical controllability matrix approach. We further prove a relation between nullities of structured matrices in the sequence and the controllability indices associated with the pair (A,B). We illustrate the results through numerical examples.

**CP-Tu-D-64-6**
**15:10–15:30**

*Controllability of Nonlinear Neutral Fractional Integro-Differential Systems with Distributed Delays in Control*

Balachandran, Krishnan

Bharathiar Univ.

**Abstract:** Many models in various fields of science and engineering are represented by fractional differential equations. One of the important qualitative properties of a dynamical system is controllability which means that it is possible to steer any initial state to any final state of the system in finite time using an admissible control. In many applications delays are inherent in control and more specifically, models with distributed delays in control occur in the study of agricultural economics and population dynamics. A simplified model for compartmental systems with pipes is represented by neutral Volterra integrodifferential equations which can be remodeled as neutral fractional Volterra integrodifferential equations. In this paper, we establish sufficient conditions for the controllability of nonlinear neutral fractional Volterra integrodifferential systems with distributed delays in control. The results are obtained by using the Mittag-Leffler function and the Schauder fixed point theorem.

**CP-Tu-D-65-5**
**14:50–15:10**

*Globalizing Stabilized SQP by Smooth Primal-dual Exact Penalty Function*

Solodov, Mikhail

IMPA

**Abstract:** An iteration of the stabilized sequential quadratic programming method (sSQP) consists in solving a certain quadratic program in the primal-dual space, regularized in the dual variables. The advantage with respect to the classical sequential quadratic programming (SQP) is that no constraint qualifications are required for fast local convergence (i.e., the problem can be degenerate). In particular, for equality-constrained problems the superlinear rate of convergence is guaranteed under the only assumption that the primal-dual starting point is close enough to a stationary point and a noncritical Lagrange multiplier pair (the latter being weaker than the second-order sufficient optimality condition). However, unlike for SQP designing natural globally convergent algorithms based on the sSQP idea proved quite a challenge and, currently, there are very few proposals in this direction. For equality-constrained problems, we suggest to use for the task line-search for the smooth two-parameter exact penalty function, which is the sum of the Lagrangian with squared penalizations of the violation of the constraints and of the violation of the Lagrangian stationarity with respect to primal variables. Reasonable global convergence properties are established. Moreover, we show that the globalized algorithm preserves the superlinear rate of sSQP under the weak conditions mentioned above. We also present some numerical experience on a set of degenerate test problems. One of the important conclusions is that, when far from the solution, development of some modifications of the sSQP direction/subproblem itself appears to be needed to improve performance.
Prey Predator Algorithm with Adaptive Step Length
Tilahun, Surafel
Univ. of KwaZulu-Natal
Melese, Silleshi
Univ. KwaZulu-Natal

Abstract: Prey predator algorithm is one of the recently developed metaheuristic optimization algorithm which mimics the interaction between a predator and prey. Randomly generated feasible solutions will be assigned as a predator, a best prey and ordinary prey based on their performance in the objective function. The updating is done in such a way that the predator run after the weakest prey, a prey with worst performance, and also will explore the solution space to scare and urge the other solutions to explore the solution space. The best prey will perform a local search only whereas the other prey tend to follow better prey and also run away from the predator. The algorithm parameter includes a step length for local search, another relatively bigger step length for exploration and probability of follow-up which guides if an ordinary prey should follow better solutions or run as far as possible from the predator. The improvement of the performance of the best prey decreases as it approaches a solution due to the step length become larger than the distance between the nearest solution and the best prey itself. Hence in order to come over this problem, in this paper the step length for local search will be made adaptive which will vary through iteration so that the quality of the final solution will be improved compared to a fixed step length for local search, which means with adaptive step length the probability of improvement will be larger when the best solution approaches the nearest optimal solution. A simulation result on selected benchmark problems shows that having adaptive step length improves the quality of the final solutions.

CP-Tu-D-65-6 15:10–15:30
A Case Study on Land Allocation Planning of Seasonal Crops Using Multicriteria Fuzzy Chance Constrained Programming
Biswas, Animesh
Univ. of Kalyani
Modak, Nikikanta
Univ. of kalyani

Abstract: In this article a fuzzy multicriterion chance constrained programming model is developed using fuzzy goal programming for solving land allocation problems of seasonal crops. Optimization of production as well as expenditure for seasonal crops are taken as objectives keeping view in proper utilization of total cultivating land and different farming resources which are expressed in the form of fuzzy numbers and fuzzy random variables. In the solution process, fuzzy probabilistic model is converted into an equivalent multicriteria fuzzy programming model using chance constrained programming in fuzzy environment with the help of α - cut and decomposition theorem. Then, fuzzy goal programming technique is used to achieve the highest degree of the membership goals by minimizing under deviational variables in the decision making environment. The potential use of this methodology is illustrated through a case example of land allocation problem of seasonal crops in a district.

MS-Tu-D-66 13:30–15:30
Recent Advances of Sparse Optimization in Signal Processing
Organizer: Liu, Ya-Feng
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: In recent years, there has been an increasing merger of sparse optimization, signal processing, wireless communications, information theory, machine learning, data mining, and statistics. This minisymposium addresses the interdisciplinary topics of sparse optimization and its various applications to signal processing. The goal of this minisymposium is to give an introduction to recent advances of sparse optimization theory, algorithms, applications, as well as emerging challenges. The speakers shall particularly talk about recent interesting applications of sparse optimization techniques to solve problems arising from signal processing, wireless communications, and information theory.

MS-Tu-D-66-1 13:30–14:00
To Prove or to Disprove: Information Inequalities and Sparse Optimization
Tan, Chee Wei
City Univ. of Hong Kong

Abstract: To prove or disprove an information inequality is a crucial step in the coding theorems of networks. When networks scale up, this is a computational difficulty task. We show how the framework of linear information inequalities by R. Yeung can be used to explicitly construct the shortest proof of an information inequality or the smallest counterexample to disprove it if the inequality is not true in general, and automate these tasks by cloud computing.

MS-Tu-D-66-2 14:00–14:30
Sparse Beamforming for Cloud Radio Access Network

Yu, Wei
Univ. of Toronto

Abstract: We consider a wireless cloud radio access network (C-RAN) in which the base-stations are connected to a central computing cloud with high capacity backhaul links and jointly beamform to the user terminals. We illustrate the role of sparse optimization in the network utility maximization problem over design variables including the transmission powers, beamformers, backhaul capacity allocation, and user scheduling.

EM-Tu-E-01 16:00–18:30
Third Workshop on Hybrid Methodologies for Symbolic-Numeric Computation
Part IV of VIII
For Part 1, see EM-Mo-D-01
For Part 2, see EM-Mo-E-01
For Part 3, see EM-Tu-D-01
For Part 4, see EM-WE-D-01
For Part 5, see EM-WE-E-01
For Part 7, see EM-Th-BC-01
For Part 8, see EM-Th-D-01

Organizer: Giesbrecht, Mark
Univ. of Waterloo
Organizer: Kaltsofen, Erich
North Carolina State Univ.
Organizer: Saley El Din, Mohab
Univ. Pierre & Marie Curie
Organizer: Zhi, Lihong
Acad. of Mathematics & Sys. Sci.

Abstract: Hybrid symbolic-numeric computation methods, which first appeared some twenty years ago, have gained considerable prominence. Algorithms have been developed that improve numeric robustness (e.g., in quadrature or solving ODE systems) using symbolic techniques prior to, or during, a numerical solution. Likewise, traditionally symbolic algorithms have seen speed improvements from adaptation of numeric methods (e.g., lattice reduction methods). There is also an emerging approach of characterizing, locating, and solving "interesting nearby problems", wherein one seeks an important feature (for example a nontrivial factorization or other useful singularities) that in some measure is close to a given problem (one that might have only imprecisely specified data). Many novel techniques have been developed in these complementary areas, but there is a general belief that a deeper understanding and wider approach will foster future progress. The problems we are interested are driven by applications in computational physics (quadrature of singular integrals), dynamics (symplectic integrators), robotics (global solutions of direct and inverse problems near singular manifolds), control theory (stability of models), and the engineering of large-scale continuous and hybrid discrete-continuous dynamical systems. Emphasis will be given to validated and certified outputs via algebraic and exact techniques, error estimation, interval techniques and optimization strategies. Our workshop will follow up on the seminal SIAM-MSRI Workshop on Hybrid Methodologies for Symbolic-Numeric Computation held in November 2010 and the Fields Institute Workshop on Hybrid Methodologies for Symbolic-Numeric Computation, November 16-19, 2011 at the University of Waterloo, Canada. We will provide a forum for researchers on all sides of hybrid symbolic-numeric computation.

EM-Tu-E-01-1 16:00–16:30
Approximate Polynomial Smith Decomposition
Lichtblau, Daniel
Wolfram Research

Abstract: There is considerable literature for effectively computing the Smith
decomposition of a univariate polynomial matrix. This has applications in many areas and, in particular, finds use in computational control theory. The literature has by and large assumed the entries are exact, that is, polynomial coefficients are integer or rational numbers. This is far from the situation encountered in practice. In this talk I describe how to obtain viable results from low precision input.

**EM-Tu-E-01-2** 16:30–17:00

**A Hybrid Approach for the Center-focus Problem**

Hauenstein, Jonathan

Univ. of Notre Dame

Abstract: For systems of differential equations, one often investigates stability. The center-focus problem aims to compute conditions on the parameters to distinguish between a center and a local focus. We developed a hybrid symbolic-numerical approach and used it to obtain center conditions for a three-dimensional system of differential equations, which was previously not possible using traditional, purely symbolic computational techniques.

**EM-Tu-E-01-3** 17:00–17:30

**Connectivity Queries on Space Curves**

Schost, Eric

Western Univ.

Abstract: Given two points in a real algebraic set, the motion planning problem consists in building a continuous path connecting them, if possible. Canny introduced a "roadmap algorithm" that reduces this general question to a problem in dimension one: testing whether two points on a space curve can be connected. This talk focuses on the latter problem. I will describe ongoing work aiming at performing these dimension-one connectivity queries in an efficient manner.

**EM-Tu-E-01-4** 17:30–18:00

**The Nearest Polynomial with Two or More Given Zeros**

Sekigawa, Hiroshi

Tokyo Univ. of Sci.

Abstract: For a given real polynomial \( f \) and two or more given zeros, we consider a problem of describing the distance between \( f \) and the nearest polynomial \( \tilde{f} \) to \( f \) having given zeros. Here, the distance is measured by a norm of the vector of coefficients of \( f - \tilde{f} \).

**EM-Tu-E-01-5** 18:00–18:30

**Certifying and Computing the Simple Zeros of Over-determined Polynomial Systems**

Cheng, Jin-San

Chinese Acad. of Sci.

Abstract: In this talk, I will present a method to certify and compute numerically the simple zeros of an over-determined polynomial system.

**EM-Tu-E-02** 16:00–18:00

**Differential Algebra and Related Topics - Part IV of VIII**

For Part 1, see MS-Mo-D-03
For Part 2, see MS-Mo-E-03
For Part 3, see MS-Tu-D-03
For Part 4, see MS-Tu-E-03
For Part 5, see MS-We-D-03

Organizer: Hu, Xing-Biao

Inst. of Computational Mathematics, Chinese Acad. of Sci. (CAS), China

Organizer: Guo, Li

Rutgers Univ. at Newark, USA

Abstract: This meeting is to offer an opportunity for participants to present original research, to learn of recent progress and new developments on differential algebra and related topics, particularly, the applications of differential algebra to control theory, physics, chemistry, biology and so on.

**EM-Tu-E-02-1** 16:00–16:30

**Rota-Baxter Algebras and Quantum Algebras**

Jian, Run-Qiang

Donggguan Univ. of Tech.

Abstract: In this talk, we will provide some relations between Rota-Baxter algebras and quantum algebras. We will discuss constructions of Rota-Baxter algebras from quantum algebras including quantum quasi-shuffle algebras and quantum groups. We will establish representations of quantum quasi-shuffle algebras from Rota-Baxter algebras as well. As an application, we will give an new approach of multiple q-zeta values from this point of view.

**EM-Tu-E-02-2** 16:30–17:00

**On Integral-differential Algebras**

Gao, Xing

Lanzhou Univ.

Guo, Li

Rutgers Univ. at Newark, USA

Rosenkranz, Markus

Univ. of Kent

Zheng, Shanghua

Lanzhou Univ.

Abstract: In this talk, we introduce integral-differential algebras. By using the method of Grobner-Shirshov bases, we give the constructions of free commutative integro-differential algebras and non-commutative integro-differential algebras.

**EM-Tu-E-02-3** 17:00–17:30

**Rings of Partial Rota-Baxter Operators: An Algebraic Approach to the Linear Substitution Rule**

Rosenkranz, Markus

Univ. of Kent

Gao, Xing

Lanzhou Univ.

Guo, Li

Rutgers Univ. at Newark, USA

Abstract: We set up an algebraic theory of multivariable integration, based on a hierarchy of Rota-Baxter operators and an action of the matrix monoid as linear substitutions. Given a suitable coefficient domain with a bialgebra structure, this allows us to build an operator ring that acts naturally on the given Rota-Baxter hierarchy. We conjecture that the operator relations are noncommutative Groebner basis for the ideal they generate.

**EM-Tu-E-02-4** 17:30–18:00

**Classification of Rota-Baxter Type Operators**

Guo, Li

Rutgers Univ. at Newark, USA

Abstract: A long standing problem of Rota asks for the classification of all algebraic identities that can be satisfied by linear operators on algebras. In a previous work, we consider Rota’s problem for differential type operators. In this talk we discuss Rota’s problem for Rota-Baxter type operators and relate it to rewriting systems and Grobner-Shirshov bases. This is a joint work with Xing Gao, William Sit and Shanghua Zheng.

**MS-Tu-E-03** 16:00–18:00

**Applied Integrable Systems - Part IV of V**

For Part 1, see MS-Mo-D-03
For Part 2, see MS-Mo-E-03
For Part 3, see MS-Tu-D-03
For Part 4, see MS-Tu-E-03
For Part 5, see MS-We-D-03

Organizer: Hu, Xing-Biao

Inst. of Computational Mathematics, Chinese Acad. of Sci. (CAS), China

Organizer: Kajiwara, Kenji

Kyushu Univ.

Organizer: Kakei, Saburo

Rikkyo Univ.

Organizer: Maruno, Kenichi

Waseda Univ.

Abstract: In recent years, there have been major developments in applications of integrable systems. Originally, integrability has been recognized through solitons, which are particle-like nonlinear waves in various physical systems. Thanks to rich mathematical structure of integrable systems, recent applications of integrable systems extend to a wide range of pure/applied mathematics and physical sciences, such as algebraic geometry, combinatorics, probability theory, numerical algorithms, cellular automata, (discrete) differential geometry, computer visualizations, statistical physics, nonlinear physics and so on. The purpose of this minisymposium is to bring together researchers to discuss recent advances on various aspects of applied integrable systems.

**MS-Tu-E-03-1** 16:00–16:30

**Integrability Detectors in Discrete Systems**

Kolkothur Munirathinam, K.M.Tamizhmani

Pondicherry Univ.

Abstract: In this talk, we discuss about two integrability detectors, namely, singularity confinement approach and algebraic entropy method for discrete systems. The power of these methods are demonstrated by deriving discrete Painleve equations and linearizable systems.

**MS-Tu-E-03-2** 16:30–17:00

**Integrability Test in Terms of Co-prime Condition of the Discrete Dynamical Systems**

Masataka, Kaniki

Univ. of Tokyo

Abstract: We propose a so-called "co-prime condition", which can be used as one of the integrability criteria for discrete equations. We re-formulate the famous "singularity confinement test" in an algebraic manner by focusing on the appearance of common factors between the iterates of the given equations. We also give an application of the co-prime condition to obtaining the algebraic entropy of the systems.

**MS-Tu-E-03-3** 17:00–17:30

**Non-singular rational solutions to several nonlinear models**

Hu, Xing-Biao

Inst. of Computational Mathematics, Chinese Acad. of Sci. (CAS), China

Abstract: In the literature, there have been considerable interests in the s-
Study of nonsingular rational solutions for nonlinear models. These nonsingular rational solutions have appeared with different names in a variety of nonlinear systems. In some cases, these nonsingular rational solutions are named as algebraic solitons or algebraic solitary waves. The typical examples are the BO equation and modified KdV equation. For the KdV equation, the corresponding nonsingular rational solutions are called lump solutions. More importantly, these nonsingular rational solutions have played a key role in the study of rogue waves.

In the talk, we will give some other examples of nonlinear models which exhibit nonsingular rational solutions.

**Abstract:**

In this paper, we propose a novel solution to the structural optimization problem that provides minimal deformation of the frame structure under various distributions of force. Such a solution is obtained in two steps. First, we perform an eigen-mode analysis to find the greatest deformation for all normalized distribution of force. Second, we vary the design variables of the frame structure to minimize the deformation.

**MS-Tu-E-05**

16:00–18:00

**Insights from Mathematical Models into Disease Dynamics and Assessment of Control Strategies**

**Organizer:** Rebholz, Leo

Clemson Univ.

**Abstract:**

This mini-symposium will focus on mathematical modeling of human infections caused by various pathogens. Mathematical models represent an important tool in preparation for disease outbreaks and evaluation of control strategies. Talks will consist of mathematical analysis of local and global stability of models based on the ordinary and delay differential equations. Designed models will also be validated by comparison with the surveillance data and abatement strategies will be assessed. Presentations will highlight insights from mathematical models to the disease epidemics and showcase collaborative and interdisciplinary research.

**MS-Tu-E-05-1**

16:00–16:30

**Modeling Dynamics of Mosquito Populations and Assessing Abatement Strategies for West Nile Virus**

**Pawełek, Kasia**

Univ. of South Carolina Beaufort

**Abstract:**

West Nile virus (WNV) is a vector-borne pathogen spread by mosquitoes throughout the continental U.S. and other regions of the world. We designed a mathematical model, based on the system of ODEs, and compared it with surveillance data to obtain more reliable disease outbreak predictions and performed numerical simulations to find optimal control strategies of mosquito population to lower the possibility of WNV transmission.

**MS-Tu-E-05-2**

16:30–17:00

**Modeling and Evaluating Entry-exit Screening Measures on the Spread and Control of Infectious Diseases**

**Liu, Shengqiang**

Harbin Inst. of Tech.

**Abstract:**

A multi-patch epidemic model is formulated to investigate the long-term impact of entry-exit screening measures on the spread of infectious diseases. A threshold dynamics determined by the basic reproduction number is established. As an application, several screening strategies are explored to examine the impacts of screening on the control of the 2009 influenza A (H1N1) Pandemic.

**MS-Tu-E-05-3**

17:00–17:30

**The Impact of Resource and Temperature on Malaria Transmission**

**Hui, Wan**

Nanjing Normal Univ.

**Abstract:**

In this talk, we extend the famous Ross’s model to establish a new model for malaria to incorporate the impact of blood meal resource for mosquitoes and temperature on the transmission of malaria. It is shown that with the new mosquito growth rate, the transmission dynamics of malaria becomes more complex and the Hopf bifurcation may occur which induces sustained oscillations not only in the mosquito population but also in the infected human.

**MS-Tu-E-05-4**

17:30–18:00

**A Within-host Virus Model with Multiple Infected Stages under Time-varying Environments**

**Xia, Wang**

Shaanxi Normal Univ.; Xinyang Normal Univ.

**Liu, Shengqiang**

Harbin Inst. of Tech.

**Abstract:**

In this paper, we propose a within-host virus model with multiple stages for infected cells under time-varying environments, to study how the multiple infected stages affect on the counts of viral load and CD4+ T cells. We establish the sufficient conditions for both permanence and extinction of the system based on two positive constants $\gamma$, $r^*$. Furthermore, numerical simulations are carried out to verify our analytical results.

**MS-Tu-E-06**

16:00–18:00

**Divergence-free elements, grad-div stabilization, and related methods for incompressible flows - Part II of II**

**For Part 1, see MS-Tu-D-06**

**Organizer:** Linke, Alexander

Weierstrass Inst.

**Organizer:** John, Volker

Weierstrass Inst.

**Organizer:** Rebholz, Leo

Clemson Univ.

**Abstract:**

Description: In recent years, great progress has been achieved in
the construction and understanding of divergence-free methods for incom-
pressible flow problems, and in understanding the role of related stabilization
methods for mixed finite elements like the grad-div stabilization. Especially,
a lack of robustness of classical mixed methods with respect to large irrota-
tional forces makes divergence-free methods appear attractive. The idea of
the minisymposium is to gather researchers from around the world, who are
active in this field, in order to discuss new ideas and to reflect on possible
application fields, where divergence-free methods could outperform classical
discretization approaches.

► MS-Tu-E-06-1 16:00–16:30
Stokes Elements Yielding Divergence–free Approximations
Neilan, Michael
Univ. of Pittsburgh
Abstract: We construct conforming finite element spaces for the Stokes and
Navier–Stokes problem in two and three dimensions that yield divergence–
free velocity approximations. The derivation of the finite element pairs is mo-
tivated by a smooth de Rham complex that is well-suited for the Stokes prob-
lem. We discuss the stability and convergence properties of the new elements
and outline the construction of reduced elements that have fewer unknowns.

► MS-Tu-E-06-2 16:30–17:00
Three Dimensional Simplicial Elements for Stokes That Produce Divergence
Free Velocities
Guzman, Johnny
Brown Univ.
Abstract: We define three dimensional stokes elements in three dimensions.
We supplement piecewise polynomial basis functions of the velocity by ratio-
nal functions that are divergence free. This is joint work with Michael Neilan.

► MS-Tu-E-06-3 17:00–17:30
Robust Arbitrary Order Mixed Finite Element Methods for the Incompressible
Stokes Equations
Matthies, Gunar
TU Dresden
Linke, Alexander
Weierstrass Inst.
Tobiska, Lutz
Otto-von-Guericke Univ.
Abstract: We present a novel approach for constructing inf-sup stable mixed
finite element methods of arbitrary order which deliver optimal and pressure-
indepedent velocity error estimates for both conforming and nonconforming velocity
approximations in 2d and 3d. The approach replaces discretely divergence-
free test functions in some operators of the weak formulation by divergence-
free ones. Optimal L2 error estimates for the pressure are given. Several
numerical examples illustrate the results.

► MS-Tu-E-06-4 17:30–18:00
Recent Advances in Isogeometric Divergence-Conforming Discretizations for
Computational Fluid Dynamics
Evans, John
Univ. of Colorado Boulder
Abstract: In this talk, I will discuss several recent advances in isogeometric
divergence-conforming discretizations for computational fluid dynamics. These includes:
(i) divergence-conforming multiscale modeling for incom-
pressible turbulent flow, (ii) divergence-conforming discretizations for fluid-
structure interaction, and (iii) divergence-conforming discretizations for incom-
pressible magnetohydrodynamics. I will discuss the mathematical properties
of the aforementioned technologies with an emphasis on structure preserva-
tion of physical balance laws, and I will present illustrative numerical results.

► MS-Tu-07 16:00–18:00 20A
Sparsity-promoting seismic data analysis - Part I of II
For Part 2, see MS-We-D-07
Organizer: Ma, Jianwei
Harbin Inst. of Tech.
Organizer: Fomel, Sergey
The Univ. of Texas at Austin
Abstract: The objective of this high-level mini-symposia is to bring internation-
al experts in geophysics and applied mathematics together to present their re-
cent research work, to exchange ideas, and to develop new visions for the fu-
ture of the area. The mini-symposia will focus on the sparsity-promoting seis-
cmic data analysis. The invited speakers are all well-known experts from the fields
of exploration geophysics, optimization, harmonic analysis and comput-
ing methods. The mini-symposia will provide an opportunity for participants
both from university and industry to share information and experi-
cences, and a platform for their research collaboration.
We are also submitting the list of speakers (including eight professors from
MIT, Stanford, etc) and titles of their presentations. The mini-symposia could
include two sessions.

► MS-Tu-E-07-1 16:00–16:30
Sparse Decomposition of Seismic Data Using Regularized Non-stationary
Regression
Fomel, Sergey
The Univ. of Texas at Austin
Abstract: Seismic wave propagation in the Earth is strongly affected by fre-
yquency attenuation. In addition, seismic data exhibit variations in local slope,
which can be described using multidimensional non-stationary spectral analy-
sis. I will describe some recent applications of time-frequency decompositions
and local slope decompositions and recently developed time-frequency analy-
sis techniques, involving regularized non-stationary regression. A particularly
sparse representation of multidimensional seismic data can be achieved by
combining slope decompositions with the seislet transform.

► MS-Tu-E-07-2 16:30–17:00
Regularization of the Inverse Scattering Problem Using Shearlet Frames
Kutyniok, Gitta
Technische Universität Berlin
Mehrmann, Volker
TU Berlin
Petersen, Philipp
Technische Universität Berlin
Abstract: In this talk, our focus will be on regularization techniques for
the numerical solution of inverse scattering problems in two space dimensions.
Assuming that the boundary of a scatterer is its most prominent feature, we
exploit as model the class of cartoon-like functions. Since functions in this
class are asymptotically optimally sparsely approximated by shearlet frames,
we consider shearlets as a means for regularization. We will discuss both theo-
retical results and numerical experiments.

► MS-Tu-E-07-3 17:00–17:30
Sparsity Representation of Seismic Data by Asymmetric Chirplet Transform
Ma, Jianwei
Harbin Inst. of Tech.
Abstract: We use the Asymmetric Gaussian Chirplet Model (AGCM) to es-
ablish a dictionary free variant of the Orthogonal Matching Pursuit (OMP),
a Greedy algorithm for sparse approximation of seismic data. The elemen-
t atoms of AGCM, so-called chirplets, display oneside oscillation-attenuation
properties, which make the AGCM very suitable for sparse representation of
absorption decay seismic signals. The model parameters such as envelope
amplitude and arrival-time will be useful to processing and interpretation of
the seismic data.

► MS-Tu-E-07-4 17:30–18:00
Sparse Deconvolution of Seismic Data with A Regularized Norm Ratio
Repetti, Audrey
Univ. of Paris-Est
Pham, Mai Quyen
IFP Energies nouvelles
Duval, Laurent
IFP Energies nouvelles
Chouzenoux, Emilie
Univ. of Paris-Est
Pesquet, Jean-Christophe
Univ. of Paris-Est
Abstract: Sparse blind seismic deconvolution aims at jointly estimating an un-
known sparse signal (reflectivity) and an unknown impulse response (seismic
wavelet). The main difficulty stems from the non-uniqueness of the solution.
They may be regularized by sparsity enforcing norm ratios (Gray, 1978)
which are non convex. In this work, we propose an alternating preconditioned
method, based on forward-backward iterations, to solve this type of problem,
involving a regularized norm ratio, assorted with theoretical convergence re-
sults.

► MS-Tu-E-08 16:00–18:00 20B
Inverse Problems for Medical Imaging - Part II of II
For Part 1, see MS-Tu-D-08
Organizer: Lee, Eunjung
Yonsei Univ.
Organizer: Song, Yizhuang
Yonsei Univ.
Abstract: This minisymposium focuses on imaging methodologies, mathemat-
cal models, and computational algorithms on inverse problems for biomi-
cal applications. The imaging problems in this topic can be formulated as
inverse problems that are intrinsically nonlinear. Experiences over the last
two decades showed that symbiotic interplay among theoretical mathemat-
ics, computational mathematics, and experiments is crucial for understanding
and solving these nonlinear problems in practice. With this minisymposium
we hope to introduce inverse problems related to biomedical applications, to
show how a various methods can solve them, and to present new schemes to
solve these inverse problems.

► MS-Tu-E-08-1 16:00–16:30
Depth Formula in Anomaly Detection Using EIT: Independent on Anomaly
Size and Admittivity Contrast
Lee, Eunjung
Yonsei Univ.
Abstract: X-ray mammography is currently the most common breast cancer
diagnostic imaging technique. Both false-negative and false-positive results
are recorded reasonably frequently; therefore, there is great demand for the
development of supplemental imaging techniques. The electrical impedance
tomography(EIT) is potential supplemental tool for breast cancer detection.
We consider the trans-admittance mammo gram system. A formula for TAM is proposed here that can estimate the depth of an anomaly independent of its size and the admittance contrast.

**Abstract:** Tikhonov regularization is a commonly used technique to solve discrete ill-posed problems, which approximate the given discrete ill-posed problem by a penalized least-squares problem, and the penalization term is defined by a regularization matrix, which may change the quality of the computed solution significantly. Several regularization matrices construction methods were discussed here, and electrical impedance tomography was induced for performance evaluation based on different regularization matrices.

**Abstract:** The convergence of peridynamics inside heterogeneous media in the limit of vanishing nonlocality is analyzed. It is shown that the operator of linear peridynamics diverges when material interfaces are present. A peridynamics material interface model is introduced which generalizes the classical interface model of elasticity. The model consists of a new peridynamics operator along with nonlocal interface conditions. The new peridynamics interface model converges to the classical interface model of linear elasticity.

**Abstract:** The coupling of local and nonlocal continuum models. We formulate the coupling as a control problem where the objective is to minimize the mismatch of the local and nonlocal solutions on the overlap of their domains and the controls are volume constraints and boundary conditions. We consider local and nonlocal linear elasticity models and we provide numerical examples illustrating the accuracy and efficacy of the method.
speed and short-range orientational interaction. This type of collective move-
tion was observed in the collective motion of microtubules running on a glass
plate.

► MS-Tu-E-10-2 16:30–17:00
Chaotic Dynamics in An Integro-differential Reaction-diffusion System in the Presence of 0:1:2 Resonance
Ogawa, Toshiyuki Meiji Univ.
Abstract: The dynamics and bifurcation structure of the normal form in the presence of 0:1:2 resonance are studied. It is proved that connecting orbits exist on the normal form. In fact, by considering the $X_2$ equivariant unfolding of codimension three singularities, sufficient conditions for the existence of heteroclinic cycles in a scaling family of the 0:1:2 normal form are obtained. These results give a reasonable explanation for the behaviors of the solutions to an integro-reaction-diffusion system.

► MS-Tu-E-10-3 17:00–17:30
Spatially Localized Structures in Systems with A Conservation Law
Knobloch, Edgar Univ. of California at Berkeley
Abstract: Systems with a conserved quantity possess a large-scale neutral mode that interacts with pattern-forming instabilities. I will discuss the effects of such a mode on the properties of spatially localized states in two hydrodynamic systems: magnetoconvection and convection in a fluid layer rotating about the vertical. The presence of this mode gives rise to three main effects, which will be explained using (nonlocal) amplitude equations valid in the vicinity of the primary pattern-forming instability.

► MS-Tu-E-10-4 17:30–18:00
Collective Behavior and Localized Bioconvection Patterns of Euglena Suspension Illuminated from Below
Iima, Makoto Hiroshima Univ.
Abstract: Euglena is a phototactic microorganism. Their behavioral response to light causes a spatially localized macroscopic pattern. We discuss the macroscopic patterns based on the hydrodynamic model based on the response functions that has been measured so far. The response behavior of individuals is also characterized by the directional statistics. The connection between the microscopic and macroscopic behavior is discussed.

► MS-Tu-E-11 16:00–18:00
Applied Mathematics Open Online: Julia, Python, Sage, OpenCourseWare, Mobile
Organizer: Strang, Gilbert MIT
Organizer: Grinfeld, Pavel Drexel Univ.
Abstract: The Internet plays a crucial part in modern applied mathematics. New languages can spread quickly. Users learn the system and test it. New code is contributed and the language is extended. The whole effort stays opensource – free to all and open for everyone to join and contribute. This minisymposium will show examples of successful and ongoing growth: Julia, Python, and Sage. At the same time the Internet can teach applied mathematics: the central ideas and the details of specific applications. We all post slides and research papers. It is NOT difficult to prepare and stream video. The experience with ocw.mit.edu indicates a great demand worldwide for education – up to date materials that are free to the student. Those will start at school, here we stay at ICIAM level. Using mobile technology in education is a very important challenge.

► MS-Tu-E-11-1 16:00–16:30
Teaching Online with Video Lectures
Strang, Gilbert
MIT
Abstract: I will share my experience in preparing video lectures for basic mathematics courses. Linear Algebra and also Computational Science came directly from the MIT classroom. Calculus and the new Differential Equations were filmed without students. The videos are uploaded to OpenCourseWare ocw.mit.edu. Using a blackboard can still be more effective than slides (but there is a place for slides). Your voice and movements make a human connection that can change lives.

► MS-Tu-E-11-2 16:30–17:00
Online Learning is A Remarkable Opportunity for Dialog
Grinfeld, Pavel Drexel Univ.
Abstract: I will talk about Lemma, a new online learning platform currently under testing and further development. Lemma attempts to transform the online learning experience into a dialogue between the student and the educator. Computers and tablets offer unique opportunities for capturing student feedback and for facilitating two-way interaction between the student and the educator which, at times, may be even more effective than face to face encounters.

► MS-Tu-E-11-3 17:00–17:30
SageMathCloud and IPython/Jupyter Notebooks for Teaching and Research
LeVeque, Randall
Univ. of Washington
Abstract: SageMathCloud is a cloud platform that allows users to create projects (each a separate linux VM) that can be accessed via a web browser. Bash terminals, IPython/Jupyter notebooks, Sage worksheets, and a WYSIWYG LaTeX editor can all be used from the browser, and worked on collaboratively from different browsers. I will describe recent experiences using this as a platform for teaching, collaborating on research, and sharing code, results and tutorials.

► MS-Tu-E-11-4 17:30–18:00
Julia in the Classroom
Edelman, Alan
MIT
Abstract: This talk will describe the Julia language and describe how it was possible to build an online education homework system entirely out of julia. This is joint work with Shashi Gowda, Tanmay Mohapatra, and Viral Shah.

► MS-Tu-E-12 16:00–18:00
Applied and computational complex analysis II
Organizer: Takashi, Sakajo Kyoto Univ.
Abstract: This session is the part two of minisymposia organized by the international research network initiative, Applied and computational complex analysis (ACCA), between UK and Japan. The first one is organized by Prof. Beatrice Pelloni in the group of ACCA-UK and the second one is done by Prof. Takashi Sakajo in the group of ACCA-JP. We share the same focus with the first symposium and we will invite additional four speakers who apply complex analysis to a wide variety of problems arising in physical and industrial applications. The topics include numerical conformal mapping technique to construct flows in oceans, efficient numerical integrations of oscillatory functions, a new wing design problem. The close cooperation between the two minisymposia by the ACCA networks enhances not only exchanging new ideas on applications of complex analysis, but also fostering future international research collaborations between speakers and participants.

► MS-Tu-E-12-1 16:00–16:30
Moving Frames and Noether’s Conservation Laws
Mansfield, Elizabeth
Univ. of Kent
Abstract: In 2018 is the centenary of Noether’s paper in which conservation laws are calculated from a Lie group symmetry of a variational problem. I will show how rewriting these laws in terms of invariants and a moving frame gives insight into the structure of the solution set. I will show also how the frame can be used to integrate the Euler Lagrange equations.

► MS-Tu-E-12-2 16:30–17:00
Analytical Study of the Dynamics of the Separation Vortices from the Body Using Single Vortex Approximation
Iima, Makoto
Hiroshima Univ.
Abstract: Separation vortices from bodies greatly contribute to lift and moment generation. We study this problem analytically using single vortex approximation, by which a separation vortices structure is approximated by one point vortex alone. Flow around plate or V-shape object in a uniform flow is analyzed. Under this approximation, the system is described by dynamical systems with just four dimensions. Vector field of this system will be used to discuss the effect of the separation vortices.

► MS-Tu-E-12-3 17:00–17:30
Vortices and Polynomials
Clarkson, Peter
Univ. of Kent
Abstract: In this talk I shall discuss special polynomials associated with rational solutions for the Painlevé equations. I shall illustrate how these special polynomials arise in vortex dynamics.

► MS-Tu-E-12-4 17:30–18:00
Contour Surgery in Multiply Connected Domains
Nelson, Rhodri
Kyoto Univ.
Abstract: In this talk we present a new method for computing the motion of vortex patches in multiply connected domains. The method works by first solving for the velocity field owing to an unbounded vortex at appropriate points on the boundaries (as if the boundaries weren’t present). A modified Schwarz-problem is then solved to give a ‘correction’ field so that the no-normal flow boundary condition is satisfied on all boundaries present.
Abstract:
In a wide range of applications, the model reduction techniques pro-
Organizer: Mamonov, Alexander Schlumberger
For Part 2, see MS-We-D-14

16:30–17:00
Rational Approximation of the Function \( z^{-1/2} \) with A Shifted Slit on the Union of A Positive and A Negative Real Line Segment
Druskin, Vladimir
Schlumberger-Doll Research
Guettel, Stefan
The Univ. of Manchester
Knizhnerman, Leonid
Central Geophysical Expedition

Abstract: When constructing absorbing boundary conditions for discretized hyperbolic PDEs, one needs good \([ (m - 1)/m ] \) rational approximations to \( z^{-1/2} \) on the union of a positive and a negative real line segment. These approximants are recalculated into complex end FD subgrids carrying out numerical absorption. We present a theoretically well-grounded algorithm for obtaining “almost best” approximations, our construction exploiting classical Zolotarev’s and Gonchar’s assertions. Our theorems are illustrated with the results of numerical experiments.

Abstract:

17:00–17:30
Surrogate Optimization of Rational Krylov Methods for 3D Transient Electromagnetics Modeling
Guettel, Stefan
The Univ. of Manchester

Abstract: The optimization of pole parameters for rational Krylov methods is an active area of research. We present a new and simple approach to obtaining near-optimal parameters based on a surrogate problem with a diagonal matrix. Considerations from potential theory allows us to choose the eigenvalues of the surrogate such that almost no unwanted spectral deflation occurs in the optimization phase. We demonstrate the applicability of this approach by an example from geophysics.

Abstract:

17:30–18:00
Multi-scale Mimetic Reduced-order Models for Large Wave Problems
Zaslavsky, Mikhail
Schlumberger-Doll Research
Druskin, Vladimir
Schlumberger-Doll Research
Mamonov, Alexander
Schlumberger

Abstract: We have developed a novel approach for discretizing spatial operator in wavefield simulations. We split the reference fine grid model into multiple subdomains. The adjacent subdomains are conjugated using Neumann-to-Dirichlet map. We construct sparse reduced-order model of NtD map for each cell via transformation to Stieltjes continued fraction. This method perfectly fits high performance computing platforms and allows to simulate wavefields in media with unlimited complexity and to achieve spectral accuracy even on regular model-independent

18:00–18:30
A Network Based Inversion Method for the Schroedinger Problem
Guevara Vasquez, Fernando
Univ. of Utah, Mathematics
Mamonov, Alexander
Schlumberger

Abstract: We present a method for reconstructing the Schroedinger potential from Dirichlet to Neumann map measurements at the boundary of a 2D region. Our method relies on the Liouville identity relating the conductivity and Schroedinger equations, and a discrete version relating a resistor network to another resistor network with a discrete Schroedinger potential, i.e. current leaks at the nodes. These leaks are used to reconstruct the continuum Schroedinger potential. Joint with L Borcea and AV Mamonov.

Abstract:

16:00–18:00
Vanishing viscosity limit and incompressible flow - Part I of II

MS-Tu-E-13-1
16:00–16:30
Weak Solutions of the Euler Equations Obtained as Limit of Vanishing Viscosity
Lopes Filho, Milton
Universidade Federal do Rio de Janeiro

Abstract: In this talk we are interested in qualitative properties of weak solutions of the incompressible 2D Euler equations which are limits of vanishing viscosity. We examine the literature on this problem, specially concerning transport of vorticity and conservation of energy.

Abstract:

16:30–17:00
Initial-boundary Layer Associated with the Nonlinear Darcy-Brinkman Model.
Wang, Xiaoming
Florida State Univ.

Abstract: We study the interaction of initial layer and boundary layer in the nonlinear Darcy-Brinkman system at the vanishing Darcy number limit. In particular, we show the existence of a function of corner layer type (so called initial-boundary layer) in the solution of the nonlinear Darcy-Brinkman system. An approximate solution is constructed by the method of multiple scale expansion in space and in time. We establish the optimal convergence rates in various Sobolev norms.

Abstract:

17:00–17:30
Stability of Boundary Layers in Compressible Flows
Wang, Yaguang
Shanghai Jiaotong Univ.

Abstract: In this talk, we shall study the stability of boundary layers in two dimensional non-isentropic compressible flows with non-slip boundary conditions when the viscosity and heat conduction coefficients go to zero, from which we obtain the interaction behavior of viscous layers and thermal layers.

Abstract:

17:30–18:00
Optimal Control of Second Grade Fluids
Cipriano, Fernanda
New Univ. of Lisbon

Abstract: We study optimal control problems of systems describing the flow of incompressible second grade fluids. We prove existence of optimal solutions and derive the corresponding necessary optimality conditions. We also consider the asymptotic behavior of these conditions when the visco parameter \( \alpha \) goes to zero, recovering the necessary optimality conditions for the Navier-Stokes equations.

This is a joint work with Nadir Arada.

Abstract:

16:00–18:30
Optimality in reduced order modeling and inversion - Part I of II
For Part 2, see MS-We-D-14

MS-Tu-E-13-2
16:30–17:00
Multi-dimensional non-isentropic compressible flows with non-slip boundary conditions when the viscosity is very small.

17:30–18:00
A New Inversion Method for NMR Signal Processing. C.E. Yarman, L. Monzo, M. Raynolds, N. Heaton
Yarman, Evren
Schlumberger

Abstract: We present a new, semi-analytic inversion method for NMR log measurements. Our method represents multiwait-time-measurements via short sums of exponentials. The resulting sparse T2-distribution requires fewer T2-relaxation times than present in linearized inversion methods. The T1-relaxation times, and corresponding amplitudes are estimated via convex optimization and a semi-analytic algorithm. We obtain an efficient way to represent the NMR data that can be utilized to estimate petrophysical properties and for compression in logging-while-drilling applications.

For Part 1, see MS-Tu-E-14-1

Abstract: Solving inverse problems by Bayesian inference has become popular because the probabilistic representation of the solution allows for rigorous quantification of its uncertainties. The talk focuses on using sparsity priors and presents several own contributions, including efficient MC/MC methods for posterior sampling, new theoretical insights into the relationship
between MAP and CM estimates and computational results such as the inversion of experimental CT data with TV and Besov priors. Joint work with Martin Burger.

**MS-Tu-E-15-2**
16:30–17:00

**Anomaly Detection in Random Heterogeneous Media**

Simon, Martin
Univ. of Mainz

Abstract: In this talk, we are concerned with the analysis and numerical solution of a stochastic inverse anomaly detection problem in electrical impedance tomography (EIT). More precisely, we study the problem of detecting a parameterized perfectly conducting anomaly in an isotropic, stationary and ergodic conductivity random field whose realizations are rapidly oscillating.

**MS-Tu-E-15-3**
17:00–17:30

**Inverse Scattering Methods for Electrical Impedance Tomography and the Novikov-Veselov Equation**

Siltanen, Samuli
Univ. of Helsinki

Abstract: Electrical Impedance Tomography is an emerging medical imaging method where a body is probed with harmless electrical currents. It leads to a nonlinear and ill-posed inverse problem that can be solved using a nonlinear Fourier transform arising from inverse scattering theory. Furthermore, the same techniques can be used for solving the Novikov-Veselov equation, a (2+1) dimensional generalisation of the KdV equation.

**MS-Tu-E-15-4**
17:30–18:00

**Multilevel Markov Chain - Monte Carlo Method for Bayesian Inversion**

Hoang, Viet Ha
Nanyang Technological Univ.

Abstract: We develop a new Multilevel Markov Chain Monte Carlo sampling strategy for Bayesian Inversion of partial differential equations, with sampling from a multilevel discretization of the posterior and a multilevel discretization of the forward PDE. The method achieves a prescribed level of accuracy with an optimal level of complexity that is equal to that for performing only one step of the standard MCMC procedure. (Joint work with Andrew Stuart (Warwick) and Christoph Schwab (ETH, Zurich)).

**MS-Tu-E-16**
16:00–18:10

**Analysis and Numerics of the Diffusive Peterlin Viscoelastic Model**

Lukacova, Maria
Univ. of Mainz, Inst. of Mathematics

Abstract: We present our recent results on the analysis and numerical simulations of the so-called diffusive Peterlin model for unsteady incompressible polymeric fluids. We prove global in time existence and uniqueness of the so-called diffusive Peterlin model for unsteady incompressible polymeric fluids. We prove global in time existence and uniqueness of a mathematical analysis and numerical results.

**MS-Tu-E-16-1**
16:00–16:30

**On Various Aspects of Behaviour of Polymers**

Gawdzia, Piotr
Univ. of Warsaw

Abstract: Contemporary approaches to the modelling of polymeric fluids have exploited multi-scale descriptions in an essential way. Mathematical models have thus been built by coupling systems describing the motion of the solvent with equations that track the evolution of the microscopic behaviour of the solute in the solution. We wish to explore how the rheological properties of the fluid are affected by the presence of macromolecules.

**MS-Tu-E-16-2**
16:30–17:00

**On Thermodynamically Compatible Models Capable of Describing the Response of Asphalt**

Malek, Josef
Charles Univ. in Prague, Faculty of Mathematics & Physics

Abstract: We develop a thermodynamically compatible model that can be identified as generalisation of the Burgers model and that seems capable of describing the nonlinear response of asphalt binders. We test the efficiency of the model by comparing its predictions against two different sets of torsion experiments. Finally, we solve computationally several time-dependent boundary value problems that have relevance to applications involving asphalt. This is a joint work with K. Tuma and K. R. Rajagopal.

**MS-Tu-E-16-3**
17:00–17:30

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**MS-Tu-E-16-4**
17:30–17:50

**Structural Analysis, Regularization and Integration of Differential-Algebraic Equations**

Steinbrecher, Andreas
TU Berlin

Abstract: In the simulation of dynamical systems usually differential-algebraic equations (DAEs) are used. These in general are of higher index and, therefore, contain hidden constraints which inhibit a numerical treatment or complicate it extremely. Therefore, a regularization or remodeling is required which reduces the index and preserves the set of solutions. In modern simulation environments often regularization approaches based on structural information are used which add hidden constraints and introduce dummy derivatives. Such a regularization often is valid only locally since the choice of the dummy derivatives can vary in time. In this talk we propose a combination of regularization and efficient numerical integration of DAEs. The proposed regularization also uses structural information to construct a regularized overdetermined formulation which (in contrast to the approach above) is globally valid. For the numerical integration we present the software package QUALIDAES which is suited for the direct numerical integration of the proposed regularization.

**Global Existence and Boundedness in the Chemotaxis-fluid Systems with A Tensor-valued Sensitivity**

Wang, Yulan

Xihua Univ.

Abstract: We consider the boundary-value problem in smoothly bounded domain for coupled chemotaxis-fluid systems. Here, one of the novelties is that the chemotactic sensitivity is not a scalar function but rather attains matrix values. We shall establish some new energy-type inequalities or derive a series of a priori estimates to obtain the global existence and boundedness for two chemotaxis-fluid systems with large initial data.

**Asymptotic Profile of A Parabolic-Hyperbolic System with Boundary Effect Arising from Tumor Angiogenesis**

Wang, Zhiyan

Hong Kong Polytechnic Univ.

Abstract: In this talk, we shall discuss a parabolic-hyperbolic system on the half space with boundary effect. The system is derived from a singular chemotaxis model describing the initiation of tumor angiogenesis. We show that the solution of the system subject to appropriate boundary conditions converges to a traveling wave profile as time tends to infinity if the initial data is a small perturbation around the wave.
components, right-hand side or signals show a drastically different activity level, given by very different time scales. Multirate integration scheme aim at exploiting this multirate behavior by integrating the different parts with their respective step sizes, while at the same time preserving the convergence order and stability properties of the underlying schemes. This mini symposium will present recent advances in developing numerical multirate schemes and highlight the efficient use of these scheme in industrial applications.

**Multirate Time-Domain Simulation of Field/Circuit Coupled Pulse-Width-Modulation Controlled Devices**

Guenther, Michael Bergische Universität Wuppertal

Abstract: In this contribution a tailored approach for the simulation of electrical devices with pulse-width-modulated (PWM) supply is proposed. The method is based on decomposing time into fast and slow components similarly to the multitone partial differential approach. To this end, dedicated duty-cycle dependent piecewise polynomial PWM basis functions are introduced. They allow for large switching-frequency-independent time steps and thus significant computational savings. The method is applied to a buck-converter, modeled as a field/circuit coupled system.

**On Construction of Multirate Exponential Integrators**

Tokman, Mayya

Univ. of California, Merced

Abstract: Exponential methods have emerged as a promising alternative to standard implicit integrators for solving large scale stiff systems. Recently a number of classes of exponential integrators including unsplitted, split and hybrid exponential propagation iterative methods of Runge-Kutta-type (EPIRK) have been proposed. In this talk we will explore how the structure of these classes of methods can be exploited to develop exponential multirate integrators.

**Efficiency and Sensitivity Analysis of Observation Networks for Atmospheric Inverse Modelling with Emissions**

Wu, Xueran

Forschungszentrum Juelich/Univ. of Wuppertal

Elbern, Hendrik

Univ. of Cologne/Forschungszentrum Juelich

Jacob, Birgit

Univ. of Wuppertal

Abstract: Different parameters influence the temporal evolution of predictive geophysical models. This renders initial-value-only optimisation by data assimilation methods as insufficient. A quantitative method on validation of measurement configurations to optimize initial values and emissions is introduced. Kalman filter and smoother and their ensemble versions are combined with singular value decomposition to evaluate the potential improvement associated with specific observational networks. Further, their sensitivity to model can be identified by determining the direction of maximum perturbation.

**Combination of Model Order Reduction and Multirate Time Integration**

Bartel, Andreas

Univ. of Wuppertal

Hachtel, Christoph

Univ. of Wuppertal

Guenther, Michael

Bergische Universität Wuppertal

Abstract: Multiphysical problems are often described by coupled problems with largely differing timescales. Frequently, a low dimensional subsystem is active, while the majority of unknowns is latent. Thus applying model order reduction (MOR) to the latent system is a valid idea. Here we address ODEs. Special focus is paid to the design of the coupling interface, which shall enable an efficient computation while combining multirate methods and MOR. Numerical are discussed for a thermal-electric system.

**Generalized Additive Runge-Kutta Methods**

Sandu, Adrian

Virginia Tech

Guenther, Michael

Bergische Universität Wuppertal

Abstract: This presentation discusses a general structure of the additively partitioned Runge-Kutta methods by allowing for different stage values as arguments of different components of the right hand side. An order condition theory is developed for the new family of generalized additive methods, and stability and monotonicity investigations are carried out. This new family, named GARK, introduces additional flexibility when compared to traditional partitioned Runge-Kutta methods.
of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

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**Symposium Session 1: Adaptive Methods for PDEs**

**Title:** Adaptive Methods for a Low Order DG Method

**Authors:** Ryan, Jennifer

**Abstract:** We prove that an adaptive method for a weakly penalized method converges. The penalty parameter only needs to be large enough to guarantee the solution of the linear system arising from the finite element discretization. We consider strategies to keep only directions important for the Krylov subspace. However, this typically requires that we keep all Krylov bases changing linear systems. It has been shown that recycled GMRES usually cannot be used in conjunction with shifted system techniques due to restrictions on the residuals. Recently, a new GMRES method for shifted systems was proposed [S., 2015] eliminating this restriction. In this talk, we discuss combining this new method with subspace recycling, yielding a recycled GMRES method for shifted linear systems.

**Title:** Krylov Recycling Techniques for Hybrid Regularization

**Authors:** De Sturler, Eric

**Abstract:** In hybrid regularization, we build a Krylov subspace and compute approximate solutions by regularizing the linear system projected on the Krylov subspace. However, this typically requires that we keep all Krylov basis vectors. We consider strategies to keep only directions important for the inverse problem solution. This is joint work with Geoffrey Dillon, Julianne Chung, Misha Kilmer, and Katarzyna Swirydowicz.

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**Symposium Session 2: Preconditioning**

**Title:** Constraint Preconditioning for the Coupled Stokes-Darcy System

**Authors:** Ladenheim, Scott

**Abstract:** We propose the use of a constraint (indefinite) preconditioner for the iterative solution of the linear system arising from the finite element discretization of coupled Stokes-Darcy flow. We provide spectral and field-of-value bounds for exact and inexact versions of the preconditioned system which are independent of the underlying mesh size. Numerical experiments in 2D and 3D show the effectiveness of our approach. Joint work with Prince Chidyagwai and Daniel B. Szyld.

**Title:** Splines Suitable for Geometric Modeling and Analysis

**Authors:** Kang, Hongmei

**Abstract:** As the advent of 3D digital acquisition technology, traditional NURBS representations in CAGD face with new challenges. Iso-geometric analysis...
hp-finite element discretization.

**Abstract:** We consider approximation properties of some general finite-element spaces using graded meshes and weighted Sobolev spaces. They are obtained from conformally invariant families of finite elements, leading to higher regularity. We prove that for suitable grading of meshes, one obtains usual optimal approximation results and provide a construction that does not lead to long, “skinny” triangles. Error estimates and quasi-optimal rates of convergence are obtained for finite-element approximations of solutions to strongly-elliptic interface/boundary value problems.

**MS-Tu-E-24-4**

**Analysis and Simulation of Plasma Equilibrium in A Corner Domain**

Labrunie, Simon

Univ. of Lorraine / CNRS / ANR CHROME

Abstract: We present various asymptotic studies on the Boltzmann-Poisson equation, which models the electrostatic equilibrium of a plasma, in a polygon with a reentrant corner. They rely on the properties of non-standard types of solutions: boundary blow-up solutions, or solutions in unbounded sectorial domains. We discuss the numerical implementation of the solution and present several test cases.

**MS-Tu-E-24-5**

**Maximum-norm A Posteriori Error Control for Singularly Perturbed Elliptic Reaction-diffusion Equations**

Demlow, Alan

Texas A&M Univ.

Abstract: In this talk we will present residual-type a posteriori error estimates in the maximum norm for singularly perturbed elliptic reaction-diffusion equations. Our estimates are robust with respect to the singular perturbation parameter and also include estimation of consistency defects due to quadrature errors. This is joint work with N. Kopteva (Limerick, Ireland).

**MS-Tu-E-25-1**

**Analysis of Space-time Computation Technique with Continuous Representation in Time (STC)**

Adler, James

Tufts Univ.

Nistor, Victor

Pennsylvania State Univ. & U. Lorraine

Abstract: We provide experiments that corroborate our theoretical claims for an important applications, and can pose non-trivial computational challenges beyond those typical for source problems. We propose an approach for estimating error in eigenvalue and eigenvector computations for non-self-adjoint operators which makes use of recent work concerning Kato’s Square Root Conjecture, and is robust with respect to multiple or tightly clustered eigenvalues. We provide experiments that corroborate our theoretical claims for an important applications, and can pose non-trivial computational challenges beyond those typical for source problems. We propose an approach for estimating error in eigenvalue and eigenvector computations for non-self-adjoint operators which makes use of recent work concerning Kato’s Square Root Conjecture, and is robust with respect to multiple or tightly clustered eigenvalues. 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in fluid dynamics and is not fully understood. We use a stochastic approach to study the global instability of plane shear flow by solving the stochastic im-
pressible Navier-Stokes equations for a very long time. A critical Reynolds is
determined based on numerical results for the solution transitions between a
localized travelling wave solution and the steady state solution.

**MS-Tu-E-25-2 16:30–17:00**

**Analysis of the Ensemble Kalman Filter for Inverse Problems**

Schirols, Claudia
Univ. of Warwick

Stuart, Andrew
Univ. of Warwick

Abstract: The ideas from the Ensemble Kalman Filter introduced by Evensen in
1994 can be adapted to inverse problems by introducing artificial dynamics.
In this talk, we will discuss an analysis of the EnKF based on the continuous
time scaling limits, which allows to derive estimates on the long-time behavior of
the EnKF and, hence, provides insights into the convergence properties of
the algorithm. Results from various numerical experiments supporting the
theoretical findings will be presented.

**MS-Tu-E-25-3 17:00–17:30**

**Modelling and Simulation of Radio Frequency Applications with Uncertain Parameters**

Pulch, Roland
Univ. of Greifswald

Abstract: In radio frequency applications, signals often represent high-
frequency oscillations, whose amplitude as well as frequency change slowly in
time. Thus a transient simulation of the differential algebraic equations, which
describe the underlying electronic circuit, becomes costly. A multidimensional
signal model allows for decoupling the slow and the fast time scale. Conse-
quently, we obtain a system of multirate partial differential equation-
s (MPDAEs). A local frequency function appears as degrees of freedom in
this model. Due to miniaturisation, the industrial production of the electronic
s (MPDAEs). A local frequency function appears as degrees of freedom in
the model. We solve the random-dependent and robust solvers for large scale least squares problems combining Krylov
space methods and block Krylov space methods. Here we present a
factorization of matrices arising out of solving large scale linear systems by
QR factorization. Two applications will be of interest. The first is the QR
matrix explicitly. In this paper, we propose an effective Jacobian free method
for computing and storing the corresponding Jacobian
matrix, or to compute a pseudoinverse from an incomplete LU factorization
and use it as preconditioner. Numerical experiments on a set of matrices will
be discussed and analyzed. In addition several reordering of the coefficient
matrix are previously applied to the coefficient matrix.

**MS-Tu-E-25-6 17:30–18:00**

**Uncertainty Quantification in Composite Materials Manufacturing**

Tretyakov, Michael
Univ. of Nottingham

Abstract: There are a number of sources of uncertainty which affect manufac-
turing of composite materials. In the talk resin transfer moulding (RTM)
process is considered taking into account random variability of permeability
of dry reinforcement. RTM is described via a moving boundary problem in
random porous media. Results of numerical study of this model will be pre-

**MS-Tu-E-25-5 18:00–18:30**

**Stochastic Variational Inequalities with Polynomial Chaos**

Ghanem, Roger
Univ. of Southern California

Abstract: We will describe the development of stochastic variational inequal-
ities for problems with interfaces, con- tact, and phase transformation that
exhibit variability in material properties. We build on the product space na-
ture of the polynomial chaos decomposition to extend the standard variational
inequality constructions to functional spaces adapted to the stochastic case.
We describe mathematical and computational challenges and demonstrate the
formalism on a wide range of practical problems.

**MS-Tu-E-26 16:00–18:00**

Recent Advances in the Solution of Least Squares Problems 1

Organizer: Hayami, Ken
National Inst. of Informatics

Abstract: Least squares problems appear in many important applications in
science and engineering. Recently, there have been many developments in
the solution of least squares problems of various kinds. Examples are fast
and robust solvers for large scale least squares problems combining Krylov
subspace methods with efficient preconditioners such as stationary inner it-
erations or balanced incomplete factorization. There are also advances in
other kinds of least squares problems, such as nonnegative constrained least
squares problems, nonlinear least squares problems, total least squares
problems and integer least squares problems etc. This mini-symposium will
address on recent advances in such areas.

**MS-Tu-E-26-1 16:00–16:30**

**Application of Inner-iteration Preconditioning to General Least Squares Prob-
lems**

Morikuni, Keiichi
Univ. of Tsukuba

Hayami, Ken
National Inst. of Informatics

Abstract: We apply inner-iteration preconditioning to the left- and right-
preconditioned general minimal residual (GMRES) method (AB- and BA-
GMRES) for solving general least squares problems, whose solutions are the
minimum-norm solutions of standard least squares problems (pseudo-inverse
solutions). We use a two-step procedure, whose first step is to solve a least
squares problem and second step is to solve a linear system of equations.
Numerical experiments show that the proposed method is more efficient than
previous methods.

**MS-Tu-E-26-2 16:30–17:00**

**Preconditioners for Least Squares Problems**

Mas, Jose
Universitat Politècnica de València

Marin, Jose
Universitat Politècnica de València

Hayami, Ken
National Inst. of Informatics

Abstract: New preconditioners for least squares problems based on incom-
plete LU factorizations are presented. Two approaches are considered: com-
puting an incomplete LU factorization of a suitable submatrix of the coefficient
matrix, or to compute a pseudoinverse from an incomplete LU factorization
and use it as preconditioner. Numerical experiments on a set of matrices will
be discussed and analyzed. In addition several reorderings of the coefficient
matrix are previously applied to the coefficient matrix.

**MS-Tu-E-26-3 17:00–17:30**

**Jacobian-Free Three-Level Trust Region Method for Nonlinear Least Squares Problems**

Xu, Wei
Tongji Univ.

Hayami, Ken
National Inst. of Informatics

Zheng, Ning
The Graduate Univ. for Advanced Studies

Abstract: Nonlinear least squares (NLS) problems arise in many applications.
Common solvers require to compute and store the corresponding Jacobian
matrix explicitly. In this paper, we propose an effective Jacobian free method
especially for large NLS problems because of the novel combination of us-
ing automatic differentiation with the preconditioning ideas that do not require
forming the Jacobian matrix. Our method does not rely on the sparsity. Thus,
it can be applied to solve large NLS problems.

**MS-Tu-E-26-4 17:30–18:00**

**Block Gram-Schmidt Algorithms**

Barlow, Jesse
The Pennsylvania State Univ.

Abstract: This talk will discuss some recent advances in block Gram-Schmidt
for QR factorization. Two applications will be of interest. The first is the QR
factorization of matrices arising out of solving large scale linear systems by
Krylov space methods and block Krylov space methods. Here we present a
context for tall-skinny QR factorization in computing these factorizations.
The second is block downdating, the problem of removing several rows from an
already completed QR factorizations.

**MS-Tu-E-27 16:00–18:00**

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Decoupling methods for multi-physics and multi-scale problems - Part I of VIII

For Part 2, see MS-We-D-27

For Part 3, see MS-We-E-27

For Part 4, see MS-Th-BC-27

For Part 5, see MS-Th-SC-27

For Part 6, see MS-Th-E-27

For Part 7, see MS-Fri-D-27

For Part 8, see MS-Fri-E-27

Organizer: He, Xiaoming
Missouri Univ. of Sci. & Tech.
Organizer: Xu, Xuejun
Inst. of Computational Mathematics, AMSS, CAS

Abstract: The inherent multi-physics and multi-scale features of many real
world problems accentuate the importance to develop efficient and stable nu-
erical methods for the relevant PDEs, especially the decoupling method-
s. Although great efforts have been made for solving these problems, many
practical and analytical challenges remain to be solved. This mini-symposium
intends to create a forum for junior and senior researchers from different fields
to discuss recent advances on the decoupling methods for multi-physics and
multi-scale problems with their applications.

**MS-Tu-E-27-1 16:00–16:30**

On A New Robin-type Nonoverlapping Domain Decomposition Preconditioner

Xu, Xuejun
Inst. of Computational Mathematics, AMSS, CAS

Abstract: In this talk, we shall present a new Robin-type nonoverlapping do-
main decomposition preconditioner. The unknown variables to be solved in
this preconditioned algebraic system are the Robin transmission condition on
the interface, which are different from the well-known DD methods like substructuring nonoverlapping DD method and FETI method. By choosing suitable parameter on each subdomain boundary and using the tool of energy estimate, for the second-order elliptic problem, we prove that the condition number of the preconditioned system is \( C(1 + \log(h/H))^2 \), where \( H \) is the characteristic mesh size and \( h \) is the fine mesh size. Numerical results shall be given to illustrate the efficiency of our DD preconditioner. This talk is based on a joint work with Yongxiang Liu.

**MS-Tu-E-27-2** 16:30–17:00
Direct Numerical Simulation of Charged Particles in Complex Flows
Ruede, Ulrich 
FA Univ. Erlangen

**Abstract:** Massive parallelism enables the fully resolved simulation of flows with large ensembles of suspended rigid particles that are represented as individual geometric objects. Our approach uses a Lagrangian approach based on rigid multi body dynamics and an Eulerian description of the flow with the Lattice Boltzmann method. Additionally we model electrostatic forces on the particles using a finite volume discretization for the electric field. All effects are coupled and result in a six-way interaction.

**MS-Tu-E-27-3** 17:00–17:30
Efficient Multi-stage Preconditioners for Highly Heterogeneous Reservoir Simulations on Parallel Distributed Systems
Chen, Zhangxin 
Xi’an Jiaotong Univ. & Univ. of Calgary

**Abstract:** Large-scale reservoir simulation has been a big challenge due to the difficulty of solving linear systems resulted from nonlinear Newton iterations. For black oil simulation, for example, more than 90% of running time is spent on the solution of linear systems. The problem is getting worse when developing parallel reservoir simulators using parallel distributed systems with tens of hundreds of CPUs. Efficient linear solvers and preconditioners are critical to the development of parallel reservoir simulators.

This presentation will address our recent work on developing parallel physics-based preconditioners for highly heterogeneous reservoir simulations. A family of new Constrained Pressure Residual (CPR)-like preconditioners and advanced matrix pre-processing methods are developed, including two new three-stage preconditioners and three four-stage preconditioners. A pressure system is solved by an algebraic multi-grid method, a saturation system is solved by a restricted additive Schwartz method (domain decomposition method), and the entire linear system is also solved by the restricted additive Schwartz method. To overcome a convective issue in reservoir simulation, a parallel potential-based matrix reordering method is employed to stabilize our preconditioners. Matrix decoupling methods, such as the alternative block factorization (ABF) strategy and the quasi-IMPES (implicit pressure explicit saturation) strategy, are also applied. With the restricted additive Schwartz and algebraic multi-grid methods, our preconditioners have good scalability for parallel computers.

Our preconditioners have been applied to oil-water and black oil benchmark simulations. For the SPE 10 project, which is a big challenge for a linear solver because of highly heterogeneous permeability and porosity, our preconditioners with Krylov subspace solvers are stable and efficient. When using 128 CPUs, the number of iterations of our linear solvers is less than 20, and the SPE 10 project is finished in 4.5 minutes. When applying our method to a refined SPE 1 project from black oil simulation with over 80 million of grid cells, the number of iterations of our linear solvers is fewer than 3 using 1,024 CPU cores. Benchmarks with 4,096 CPU cores on IBM Blue Gene/Q are also performed and linear scalability is obtained. Our numerical experiments show that our preconditioners and linear solvers are stable with a large number of CPU cores and are efficient for highly heterogeneous simulations.

**MS-Tu-E-27-4** 17:30–18:00
Strength Failure Models in An Eulerian Context
Grove, John 
Los Alamos National Laboratory

**Abstract:** We will describe an anisotropic failure model for ductile material failure. The model is based on the polar decomposition of the stress tensor. When a stress component exceeds a specified failure tolerance the stress tensor is modified to remove this component in the direction of the corresponding eigenvector. We will discuss the implementation of this method in an Eulerian hydrodynamics code and thermodynamic issues associated with the model.

**MS-Tu-E-28** 16:00–18:30
FLOW, HEAT AND MASS TRANSFER IN FLUID MECHANICS - Part I of II 109
For Part 2, see MS-Wt-D-28

**Organizers:** P A, Dinesh 
M S Ramaiah Inst. of Tech., Bangalore

**Abstract:** The objective of this mini symposium is to develop a mathematical model and to investigate analytically or numerically and systematically the study of flow problems; free, forced and mixed convection heat and mass transfer arises in fluid mechanics. Study of such type of problems in fluid mechanics has received enormous attention of many researchers in industrial applications, scientific and engineering fields. The subject is multidisciplinary and completely encircles the main views of applied mathematics to areas like soil physics, hydrogeology, petroleum industry, filtration of solids from liquids, chemical engineering, biological systems, oil reservoir modelling, food processing, casting and welding, manufacturing processes, the dispersion of pollutants into environment, storage of nuclear waste, power plant stream lines, bio mechanical, polymerization, fluid mechanics, filters, chemical, mechanica,l paper and cloth industry, geophysics, chemistry etc.

The following are the abstracts proposed for the mini symposia:

A numerical solution for the free convective, unsteady, laminar convective heat and mass transfer in a MHD viscoelastic fluid along a semi-infinite vertical plate with Soret and Dufour effects is presented. The Walters-B liquid model is employed to simulate medical creams and other rheological liquid encountered in biotechnology and chemical engineering. This rheological model introduces supplementary terms into the momentum conservation equation. The dimensionless unsteady, coupled, and non-linear partial differential conservation equations for the boundary layer regime are solved by an efficient, accurate and unconditionally stable finite difference scheme of the Crank-Nicolson type.

In this talk, we present the problem of MHD flow of a couple stress fluid to a linearly and quadratically stretching sheet and heat transfer characteristics using variable thermal conductivity is studied in the presence of a non uniform heat source/sink. The thermal conductivity is assumed to vary as a linear function of temperature. The similarity transformation is used to convert the governing partial differential equations of flow and heat transfer into a system of ordinary differential equations.

When a stress component exceeds a specified failure tolerance the stress tensor is modified to remove this component in the direction of the corresponding eigenvector. We will discuss the implementation of this method in an Eulerian hydrodynamics code and thermodynamic issues associated with the model.

**MS-Tu-E-29-1** 17:00–17:30
DOUBLE DIFFUSIVE MIXED CONVECTION IN A COUPLE STRESS FLUIDS WITH VARIABLE FLUID PROPERTIES
Narasappa, Nalinakshi 
Atria Inst. of Tech.

**Abstract:** A numerical approach is made to investigate the double diffusive mixed convection flow of a couple stress fluid over a vertical heated plate. The effect of couple stress parameter and other physical parameters is presented. It is observed that maximum velocities far away from the plate with the increase of couple stress parameter which is due to the rotational field of the velocity generated in couple stress fluid.

**MS-Tu-E-29-2** 16:00–17:00
Numerical Study for Stokes Flow Past A Cylinder in Porous Media
D V, Chandrashekhhar 
Vivekananda Inst. of Tech.

**Abstract:** A numerical study of Brinkman flow is considered for a steady, incompressible, viscous fluid past an impermeable cylinder embedded in a porous medium. By assuming uniform velocity far away from the surface of the cylinder, the similarity transformation method is employed, the resulting ordinary differential equation is solved numerically by using shooting technique. The effects of non-dimensional parameters, on both the tangential and normal components of velocity are investigated and are illustrated graph-
Numerical Analysis of Stochastic Differential Equations - Part II of II

16:00–18:00 VIP2-2

Organizer: Jentzen, Arnulf ETH Zurich

MIN, MISUN Argonne National Laboratory

Abstract: We study a cavity quantum electrodynamics model for the optical response of a metal nano particle system interacting with multi-state multiple quantum dots. We consider the evolution of the quantum-mechanical density operator defined by the statistical ensemble of several quantum states, involving sparse complex density matrix. We explore efficient timestepping and data communication algorithms for large scale Hamiltonian for multiple quantum dots and surface plasmon systems that can be useful in quantum computing.

Superconvergence Properties of Discontinuous Galerkin Methods Based on Upwind-biased Fluxes for Linear Hyperbolic Equations

Frean, Daniel

Univ. of East Anglia

Abstract: Traditionally, superconvergence properties of discontinuous Galerkin (DG) methods have been studied using purely-upwind fluxes. In this talk, we analyze DG methods using upwind-biased fluxes through pointwise spatial discretization error estimates and the smoothness-increasing accuracy-conserving (SIAC) filtered solution. This is done under the assumptions of periodic boundary conditions and a uniform mesh for solving linear hyperbolic equations with smooth solutions. We further illustrate the discussion with numerical experiments. This is joint work with Jennifer Ryan.

Superconvergence of Discontinuous Galerkin Method for Linear Hyperbolic Equations

Yang, Yang

Michigan Technological Univ.

Abstract: We apply the discontinuous Galerkin method to hyperbolic equations in two space dimensions. We prove that, under suitable initial discretization, the scheme is k+2th order accurate at the downwind-biased Radau points, and 2k+1th order superconvergence at the downwind point, where k is the polynomial degree used in the finite element space. Numerical experiments will be given to demonstrate that the rate of convergence is optimal.

High Order Numerical Methods for PDEs - Hybrid Methods - Part I of III

16:00–18:00 305

For Part 2, see MS-We-D-29

For Part 3, see MS-We-E-29

Organizer: Jung, Jae-Hun SUNY at Buffalo

Organizer: Don, Wai Sun Ocean Univ. of China/Brown Univ.

Organizer: Ling, Leevan Hong Kong Baptist Univ.

Organizer: Yoon, Jungho Ewha W. Univ.

Abstract: This session is devoted to the numerical analysis of all kinds of stochastic differential equations (SDEs) and related approximation problems. Among the studied equations, there will be SDEs with irregular coefficients, stochastic partial differential equations (SPDEs) and SDEs with other driving noises than Brownian motion. The goal of this session is to present recent developments in the area of computational SDEs. Particular focus will be given to the interplay of the different topics in this area and to the identification of new research questions.

Mild Stochastic Calculus and Weak Convergence Rates for Stochastic Partial Differential Equations

Jentzen, Arnulf

ETH Zurich

Abstract: In this talk we present a certain class of stochastic processes, which we suggest to call mild Ito processes, and a new - somewhat mild-Ito type formula for such processes. Examples of mild Ito processes are mild solutions of stochastic partial differential equations (SPDEs) and their numerical approximations. We illustrate the use of the mild Ito formula by several applications. More details on this topic can be found at [http://www.sam.math.ethz.ch/sam_projects/jentzen/numerical.php].

First Order System Least Squares Pseudo-spectral Method for Stokes-Darcy Equation

Hessari, Peyman

Ulsan National Inst. of Sci. & Technologu

Abstract: We investigate the first order system least squares pseudo-spectral method for coupled Stokes-Darcy equations. Least squares functional is defined by summing up the $L_2$-norm of residuals of the first order system for coupled Stokes-Darcy equations and that of Beavers-Joseph-Saffman interface conditions. Continuous and discrete homogeneous functionals are shown to be equivalent to appropriate norms. The spectral convergence is derived and numerical experiments are also given.

Adaptive Importance Sampling in Least-squares Monte-Carlo Algorithms for Backward Stochastic Differential Equations

Turkedjiev, Plamen

Ecole Polytechnique

Abstract: We design an importance sampling scheme for backward stochastic differential equations (BSDEs) that minimizes the conditional variance occurring in least-squares Monte-Carlo (LSMC) algorithms. The Radon-Nikodym derivative depends on the solution of BSDE, and therefore it is computed within the Dynamic Programming Equation (DPE). To allow robust error estimates w.r.t. the unknown change of measure, we properly randomize the initial position of the forward process. We introduce novel methods to analyze the error: firstly, we establish norm stability results due to the random initialization; secondly, we develop refined concentration-of-measure techniques to highlight the variance of reduction. Our theoretical results are supported by numerical experiments.
Abstract: In this talk exponential integrator schemes are introduced for the
temporal discretization of semi-linear stochastic wave equations (SWEs) driv-
en by both additive and multiplicative noises. Strong and weak convergence
results of the proposed methods are presented. Both theoretical and nu-
merical results show that the exponential schemes have higher convergence
rate than the backward Euler–Maruyama scheme and the Crank-Nicolson–
Maruyama scheme.

Variance Reduced Monte Carlo Method Path Simulation
Kloeden, Peter
Huzhou Univ. of Sci. & Tech.
Abstract: Classical numerical schemes such as Runge-Kutta schemes can be
used for RODEs but do not achieve their usual high order since the vector field
does not inherit enough smoothness in time from the driving process. It will
be shown how, nevertheless, Taylor expansions of the solutions of RODEs
can be obtained when the stochastic process has Hölder continuous sam-
ples and then used to derive pathwise convergent numerical schemes of
arbitrarily high order.

Variance Reduced Monte Carlo Method Path Simulation
Nagapetyan, Tigran
Weierstrass Inst. for Applied Analysis &
Stochastics
Abstract: In this talk we present a specially designed control variates for es-
imating smooth terminal functionals of discretized paths, arising from SDE
path approximation. Our control variates decrease the variance of the func-
tional down to the order of discretization step in certain power, which allows
us to improve significantly the computational cost / error relation for both Mul-
tilevel and Singlelevel Monte Carlo (SMC) methods. Our results are illustrated
with several numerical examples arising from financial applications.

CVA Calculations in Consistent Models
Baldeaux, Jan
Danske Bank
Abstract: Asset prices are usually modeled via SDEs. Implementing such a
model, different discrete approximations are performed: 1) a forward PDE is
discretised for calibration 2) a backward PDE is discretised to price American
options 3) an MC scheme is discretised to price path-dependent products.
These schemes need not be consistent, i.e. return the same values when
pricing the same product. In this talk we show how to ensure that the three
discretised schemes are consistent.

Simulation of SDEs with Discontinuous Drift
Leobacher, Gunther
Johannes Kepler Univ. Linz
Abstract: We present an algorithm for the numerical treatment of stochas-
tic differential equations (SDEs) with discontinuous drift. This kind of SDEs
appears naturally in stochastic optimal control problems from mathematical
finance. The algorithm is shown to have strong order convergence rate 1/2.
Furthermore, the algorithm is shown, under mild additional assumptions, to
be equivalent to a multidimensional integration problem of a function with
bounded variation, making it useful for QMC. Numerical examples illustrate
the theoretical findings.

Variance Reduction via Simulation of Analytic Conditional Expectations
Reisinger, Christoph
Oxford Univ.
Abstract: We consider financial derivatives in models where the underlying
stock price process has further stochastic parameters, for instance stochastic
volatilities and stochastic interest rates. We demonstrate how the variance of
estimators can be reduced significantly if the expectation with respect to some
of the risk-factors is evaluated semi-analytically. We give a convergence proof
of the approximation scheme and numerical experiments.

Structured-mesh methods for interface problems. Part I of VIII
MS-Tu-E-30-3 17:00–17:30
Exponential Integrator Schemes for Semi-linear Stochastic Wave Equations
Wang, Xiaojie
Central South Univ.
Abstract: In this talk exponential integrator schemes are introduced for the
temporal discretization of semi-linear stochastic wave equations driven
by both additive and multiplicative noises. Strong and weak convergence
results of the proposed methods are presented. Both theoretical and num-
erical results show that the exponential schemes have higher convergence
rate than the backward Euler–Maruyama scheme and the Crank-Nicolson–
Maruyama scheme.

Random Ordinary Differential Equations and Their Numerical Approximation
Kloeden, Peter
Huzhou Univ. of Sci. & Tech.
Abstract: Classical numerical schemes such as Runge-Kutta schemes can be
used for RODEs but do not achieve their usual high order since the vector field
does not inherit enough smoothness in time from the driving process. It will
be shown how, nevertheless, Taylor expansions of the solutions of RODEs
can be obtained when the stochastic process has Hölder continuous sam-
ples and then used to derive pathwise convergent numerical schemes of
arbitrarily high order.
Polishing by SPH

Abstract: This paper summaries recent work by the authors in developing a robust and highly accurate Incompressible Smoothed Particle Hydrodynamics (ISPH) method for general fluid flows. ISPH uses a projection method to enforce incompressibility and a particle redistribution (or shifting) procedure for numerical stability. Internal, free-surface, and two phase flows (Newtonian and non-Newtonian) can be accurately modelled for a wide range of parameters. Industrial applications within offshore/coastal engineering and manufacturing are presented.

Variational Symplectic Algorithm for Kinetic Plasma Simulation

Abstract: In this work, we show how to construct a variational multi-symplectic particle-in-cell (PIC) algorithm with smoothing functions for the Vlasov-Maxwell system. The conservation of discrete symplectic structure make this algorithm specifically suitable for simulating long-term dynamics of plasmas. The algorithm has been implemented in a 6D large scale PIC code, Numerical examples are given to demonstrate the good conservation properties of this algorithm.

Incompressible Smoothed Particle Hydrodynamics

Lind, Steven
Univ. of Manchester

Abstract: This paper summarizes recent work by the authors in developing a robust and highly accurate Incompressible Smoothed Particle Hydrodynamics (ISPH) method for general fluid flows. ISPH uses a projection method to enforce incompressibility and a particle redistribution (or shifting) procedure for numerical stability. Internal, free-surface, and two phase flows (Newtonian and non-Newtonian) can be accurately modelled for a wide range of parameters. Industrial applications within offshore/coastal engineering and manufacturing are presented.
recently offering stable and robust approximation by a low order cost. If \( V = \mathcal{O}_{\alpha}^{m} \), these formats are equivalent to tree tensor networks states and matrix product states (MPS) originally introduced for the treatment of quantum spin systems. Considering the electronic Schrödinger equation, we use an occupation number labeling of Slater determinants, and show that the discrete Fock space becomes isometric to d-fold tensor product of a two-dimensional Hilbert space. We use hierarchical tensor representations, which are equivalent to tree tensor networks, in particular in the form of matrix product states. For the computation of an approximate ground solution this problem can be casted into an optimization problem constrained by the restriction on tensors of prescribed multi-linear ranks \( r \). Dirac Frenkel variational principle developed in a similar fashion as for Multi-Configurational Hartree (-Fock) by observing the differential geometric structure of the novel tensor formats. This provides a variational formulation of the QC (Quantum Chemistry) DMRG (Density Renormalization Group) algorithm We propose a dynamical low rank approximation, corresponding to the Dirac-Frenkel variational principle, for solving a constraint optimization problem. The approach can be applied to ground state calculations as well as to dynamical problems. Convergence of (Riemannian) gradient algorithms can be shown. A simple optimization methods is provided by alternating direction methods, which reveals the DMRG (density matrix renormalization group) algorithm. This approach has been applied by G.C. Chan et al. and O. Legeza et al. to analyze dissociation of diatomic molecules and to transition metal complexes, supporting that the presented approach has a certain potential to treat some strongly correlated electronic systems.

**A Parallel Orbital-Updating Approach for Electronic Structure Calculations**

Xiaoying, Dai
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

**Abstract:** In this talk, we will talk about an orbital iteration based parallel approach for electronic structure calculations. With this new approach, the solution of the single-particle equation is reduced to some solutions of independent linear algebraic systems and a small scale algebraic problem. It is demonstrated by our numerical experiments that this new approach is quite efficient for electronic structure calculations. This presentation is based on some joint works with X. Gong, A. Zhou, and J.Zhu.

**Numerical Algorithms for Stochastic Model and Uncertainty Quantification in High-Dimensional Complex Systems - Part II of II**

For Part I, see MS-Tu-D-35

**Organizer:** Wang, Peng
Beihang Univ.

**Organizer:** Lin, Guang
Purdue Univ.

**Abstract:** Uncertainty persists in most natural and engineering systems, from material discovery to reactive transport in porous media. Quantifying the uncertainty associated with the parameters in complex systems is critical, which can help us to verify our modern simulation codes and assess confidence levels. Our aim is to use accurate computational simulations to predict the behavior of complex systems. For large number of random dimensions, advanced stochastic approximation techniques are necessary to minimize the complexity of mathematical models. This minisymposium will explore recent advances in numerical algorithms and applications for stochastic model, uncertainty quantification, and model reduction in large-scale high-dimensional complex systems.

**Uncertainty Quantification and Parameter Inference for Mesoscopic Modeling**

Huan, Lei
Pacific Northwest Natl Laboratory

Yang, Xiu
Pacific Northwest Natl Laboratory

Bin, Zheng
Pacific Northwest National Laboratory

Karniadakis, George
Brown Univ.

Baker, Nathan
Pacific Northwest Natl Laboratory

**Abstract:** We propose a method to quantify uncertainty for physical systems with high dimensional stochastic space using generalize polynomial chaos expansion. We demonstrate that sparse grid method suffers instability problem for such systems. Alternatively, we re-define a set of variables within active subspace to increase the sparsity of GPC expansion, yielding more accurate surrogate model recovered by compressive sensing method. Our method is demonstrated in soft matter systems, which enables us to identify possible parameter degeneracies.

**STOCHASTIC HOMOGENIZATION OF ELLIPTIC EQUATIONS AND OPTIMAL CONTROL PROBLEMS**

Ming, Ju
Beijing Computational Sci. Research Center

**Abstract:** We consider an optimal control problem governed by elliptic equations with rapidly oscillating random coefficients. Using the stochastic homogenization method in the frame of H-convergence, we derive an optimal problem in which the state equations are associated with the H-limit of the coefficients. Numerical experiments are performed to validate our results.
We consider the optimization of a prescribed eigenvalue of a large matrix.

Abstract: We present a new superlinearly converging algorithm intended for directly approximating the H-infinity norm of large-scale dynamical systems. Under reasonable assumptions, our hybrid expansion-contraction technique guarantees convergence to stationary points of the optimization problem defining the H-infinity norm and in practice, typically converges quadratically to local or global maximizers. Compared to an earlier, idealized algorithm which could sometimes break down, our new method is provably more robust and also significantly faster.

Approximating the Real Structured Stability Radius with Frobenius-bounded Perturbations via Spectral Value Sets

Abstract: We propose a fast method to approximate the real structured stability radius of a linear dynamical system with output feedback when real perturbations bounded with respect to the Frobenius norm are considered. Our work builds on a number of algorithms that have been proposed in recent years for approximating the complex or real pseudospectral radius or the complex stability radius (the reciprocal of the $H_{\infty}$ norm) for large sparse matrices.

Large-Scale Optimization of Eigenvalues

Abstract: We consider the optimization of a prescribed eigenvalue of a large Hermitian matrix valued function, and suggest the orthogonal projection of the matrix valued function onto a small subspace. The subspace is gradually expanded with the additions of eigenvectors at the optimal points of small problems. This subspace projection idea converges quadratically w.r.t. the dimension of the subspace in practice and theory. We conclude with applications to large problems in control theory and structural design.

ROBUST STABILITY FOR HIGHER ORDER IMPLICIT DIFFERENCE EQUATIONS UNDER RESTRICTED PERTURBATIONS

Abstract: In this talk, the robust stability analysis for linear implicit m-th order difference equations is discussed. We allow the leading coefficient coefficient to be singular, i.e., we include the situation that the system does not generate an explicit recursion. A spectral condition for the characterization of asymptotic stability is presented and computable formulas are derived for the real and complex stability radius in the case that the coefficient matrices are subjected to structured perturbations.

Pharmacometrics: Bridging Mathematics to Pharmaceutical Sciences

Organizer: Nekka, Fahima

Organizer: Li, Jun

Organizer: Wu, Xiaotian

Pharmacometrics: the Science of Drug-related Variability and Nonlinearity

Abstract: The search for more efficient therapeutics and concerns about their rational use for target populations and diseases raise important challenges. However drug discovery has achieved a stagnating status, strongly suggesting that the empirical culture of this field is gradually fading to give more ground to alternative quantitative approaches. In this talk, we will discuss the probabilistic pharmacometric framework that we developed to account for drug-related variability and nonlinearity and their therapeutic impact and its added-value.

Fluid structure interaction problems

Abstract: Fluids are the natural environment of almost every organism and fluid structure interaction problems are ubiquitous in many area of biology and geology. As fluid dynamics plays an important role in propulsion and transport, many important fluids and material exhibit nonlinearities and other complex properties. The aim of this mini-symposium is to present examples of such behavior and the techniques use to address these problems.

Note: The number of speakers is five. If this minisymposium is fitted in the conference schedule, the organizer will present the work. If it couldn’t, opportunities will be given to the invited speakers.
Analytical Results on the Role of Flexibility in Flapping Propulsion
Moore, Nick
Florida State Univ.

Abstract: We use small-amplitude asymptotics to model a flexible wing flapping in an inviscid fluid. Remarkably, the model allows for a class of exact solutions that describe the emergent wing kinematics. These solutions allow us to examine how flexibility modifies propulsive performance and in particular the role of resonance.

MS-Tu-E-40-2
16:30–17:00
Fluid Dynamics for Flow &#8211;driven by Nodal Cilia
Zhao, Longhua
Case Western Reserve Univ.

Abstract: Nodal cilia play an important role in the left-right symmetry breaking at the early stage of the mammal embryos. This study is about the flow driven by nodal cilia sweeping out cones above a no-slip plane in low Reynolds number regime. We build a mathematical model to investigate the fluid properties and compared with table-top experimental data. Stereoscopic Lagrangian tracking show quantified agreement with theoretical prediction with our model.

MS-Tu-E-40-3
17:00–17:30
Sensing Flow Directions by A Hydrodynamic Antenna for Swimming Fish
Zhang, Jun
Courant Inst., New York Univ.

Abstract: The lateral line of fish detects hydrodynamic pressure gradients and is thought to be important in swimming behaviors such as rheotaxis and prey tracking. Here, we explore the hypothesis that this sensory system is concentrated at locations where changes in pressure are greatest during motion through water. Our data from our experiments seem to support the notion that the lateral-line of a fish functions like a hydrodynamic antenna. [Collaborators: L. Ristroph and J. Liao]

MS-Tu-E-40-4
17:30–18:00
The Internal Torque Patterns of An Undulatory Swimmer in Resistive Environments
Ding, Yang
Beijing Computational Sci. Research Center

Abstract: Undulatory swimmers such as C. elegans need to overcome the torque generated by resistive forces from environments. We found that the pattern of the torque is also a traveling wave, until it breaks into two traveling waves when the wavelength of the body bending becomes less than half of the body length. Combined with body elasticity, we found that the same torque pattern can generate different wavelengths observed on C. elegans in different environments.

MS-Tu-E-40-5
18:00–18:30
Bodies and Buoyant Jets in Strong Stratification
McLaughlin, Richard
Univ. of North Carolina

Abstract: We present theoretical, computational, and experimental studies of the motion of bodies and buoyant fluids moving through a stratified background density field focusing on the vertical transport. Interesting critical phenomena are observed in which bodies and buoyant fluids may either escape or be trapped as parameters (such as the propagation distance) are varied. An exact solution is derived for the Morton-Taylor-Turner (MTT) closure hierarchy which is proven to be the optimal mixer in this context.

MS-Tu-E-41
16:00–18:10
Numerical Linear Algebra Techniques in Massive Data Analysis
Organizer: Gu, Ming
Univ. of California Berkeley

Abstract: Effective and efficient treatment of massive data sets has become increasingly important in this age of information explosion. Most machine learning and data analysis algorithms for massive data sets require huge amounts of computational time. In this minisymposium, we discuss effective algorithms for analyzing massive data sets by exploiting efficient numerical linear algebra techniques.

This minisymposium is sponsored by the SIAG.

MS-Tu-E-41-1
16:00–16:30
Efficient Algorithms for Solving Kadison-Singer Problems
Gu, Ming
Univ. of California Berkeley

Abstract: The Kadison-Singer Problems are a large class of related problems in a dozen areas of research in pure mathematics, applied mathematics and Engineering. Recent work of Marcus, Spielman and Srivastava shows the existence of the solutions to these problems. In this talk, we present efficient algorithms for solving these problems, including algorithms for computing the Weaver and Feichtinger partitions.

MS-Tu-E-41-2
16:30–17:00
A Dynamic Approach to Sparse Recovery
Yao, Yuan
Peking Univ.

Abstract: We propose a dynamic approach to sparse recovery under noisy linear measurements, which solve a dilemma in statistics discovered by Fan and Li in 2001: LASSO is biased and to remove the bias while keeping sparse recovery, nonconvex regularization is necessary. However, we will show that a simple dynamics, based on gradient flow in dual space, will generate unbiased and sign-consistent solution without boiling to nonconvex optimization.

MS-Tu-E-41-3
17:00–17:30
Fast Randomized Iteration for Matrix Inversion, Eigenproblems, and Exponentiation
Liu, Lek-Heng
Weare, Jonathan
Univ. of Chicago
Univ. of Chicago

Abstract: We introduce randomized iterative algorithms inspired by the diffusion Monte Carlo algorithm for some common tasks in numerical linear algebra. These algorithms work in either linear or constant cost per iteration. Traditional iterative methods in numerical linear algebra were created in part to deal with instances where a matrix (of size $O(n^2)$) is too big to store. Our $O(1)$ iterative methods address instances where even a vector (of size $O(n)$) is too big to store.

CP-Tu-E-41-4
17:30–17:50
Simultaneous Reduction of Large Sparse Matrix Pencils
Sidje, Roger
Univ. of Alabama

Abstract: There are algorithms to simultaneously reduce a pair of symmetric matrices to tridiagonal-tridiagonal form with a congruent transformation, but these algorithms are impractical for large sparse matrices because they successively update the matrices and so destroy their sparsity. We consider pairs that are either symmetric or nonsymmetric in this work. We describe a new Krylov subspace projection method to reduce a symmetric pair to tridiagonal-tridiagonal form with a three-term recurrence that can be interrupted midstream in a Lanczos-like manner. We generalize to reduce a nonsymmetric pair to Hessenberg-Hessenberg form in an Arnoldi-like manner. While the new methods also involve shift-and-invert operations as previous algorithms do, the sparse context means that this step can itself be handled with other specialized methods meant for sparse linear systems. Applications of this work include areas such as the generalized eigenvalue problem where partial simultaneous projection methods can be applied to the matrix pencil.

MS-Tu-E-42
16:00–18:00
Nonlinear waves in systems with dissipation and gain - Part II of II
For Part 1, see MS-Tu-D-42
Organizer: Yan, Zhenya
Chinese Acad. of Sci.
Organizer: Konotop, Vladimir
Univ. of Lisbon

Abstract: In a few recent years there was growing interest in propagation of nonlinear waves in media with gain and losses. These are systems with the parity-time (PT) symmetry, with localized gain or dissipation, with imbalances gain and dissipation but still allowing for linear real spectra, etc. Physically the respective models are relevant to optics, plasmonics, Bose-Einstein condensates, atomic gases, mechanical systems, electric circuits, etc. This Minisymposia aims to joint researches working in the related areas ranging from experimental and theoretical physics to mathematics.

MS-Tu-E-42-1
16:00–16:30
Storage and Retrieval of Optical Solitons in Cold Atomic Gases
Huang, Guoxiang
East China Normal Univ.

Abstract: In recent years, much attention has been paid to the study of slow-light and light memory in various physical systems. In this talk, I shall report our recent research results on the storage and retrieval of slow-light solitons and vortices in cold atomic gases.

MS-Tu-E-42-2
16:30–17:00
Tunable nonlinear parity - time-symmetric defect modes with an atomic cell

Abstract:...
Nonlinear Modes in PT-Symmetric and Asymmetric Complex Potentials
Zeyuuin, Dmitry
Univ. of Lisbon
Abstract: There are several fundamental differences in properties of conservative and dissipative nonlinear systems. One of them is related to the structure of stationary modes. In conservative systems, stationary modes constitute one- (or several-) parametric families, while in the presence of gain and dissipation stationary solutions typically represent isolated fixed points. In the context of the nonlinear Schroedinger equation with an additional external potential, this dichotomy is related to the type of the potential. If the latter is real-valued, then the model is conservative and supports the continuous families. On the other hand, a complex potential involves dissipation and gain and the nonlinear modes appear as isolated points. Recently, this issue attracted special attention in the context of nonlinear extensions of parity-time (PT) symmetric systems. It was established that the PT-symmetric potential, although being complex, still can possess continuous families of localized modes resembling in this way conservative systems.
It our work, we show that there exists another general class of complex asymmetric (generally speaking, non-PT symmetric) potentials of the form \( u\tau(x) \), where \( u(x) \) is a real function, which allows for the existence of one-parametric continuous families of stationary nonlinear modes. Existence of the continuous families in the problem is explained by a "hidden" symmetry, which is expressed in the form of a conserved quantity of the nonlinear dynamical system describing profiles of the nonlinear modes. This remarkable behavior holds for a fairly general choice of functions \( u(x) \). As an illustrative example, we introduce a complex asymmetric double-hump potential and demonstrate that it supports continuous families of nonlinear modes.

CP-Tu-E-42-4
17:30–17:50
Asymptotics for the Defocusing Integrable Discrete Nonlinear Schrödinger Equation
Yamane, Hideshi
Kwansei Gakuin Univ.
Abstract: We study the integrable discretization of the defocusing nonlinear Schrödinger equation, namely the Ablowitz-Ladik model. The asymptotic behavior of the solution is investigated by using the nonlinear steepest descent method of Deift-Zhou. We consider three regions. In the first, where \( 2t \to 2\infty \), \( t \) tends to infinity, the leading part is the sum of two terms which shows the behavior of decaying oscillation. In the second, near \( 2t=\infty \), the leading part is a single term with slower decay and simpler oscillation. In the third, where \( 2t \to 2\infty \) and \( t \) tends to infinity, the solution decays faster than any negative power of \( n \).

MS-Tu-E-43-2
16:30–17:00
An Exact Algorithm for Parallel Machine Scheduling with Conflicts
Leus, Roel
KU Leuven
Kowalcyzk, Daniel
KU Leuven
Abstract: We consider an extension of classic parallel machine scheduling, where an undirected conflict graph is part of the input. Each node in the graph represents a job and an edge implies that its two jobs cannot be scheduled on the same machine. The goal is to find an assignment of the jobs to the machines such that the maximum completion time is minimized. We present an exact algorithm based on branch and price.

MS-Tu-E-43-3
17:00–17:30
MILP Formulations for Order Splitting on a Multi-slot Machine in the Printing Industry
Tautmann, Norbert
Univ. of Bern
Baumann, Philipp
Univ. of California, Berkeley
Forrer, Salome
Univ. of Bern
Abstract: We study the imprinting of customer-specific designs on napkin pouches. Given customer orders are to be split among several slots of printing plates such that the total costs are minimized subject to several constraints. We present two alternative mixed-binary linear programming formulations which eliminate symmetric solutions explicitly or implicitly, respectively, from the search space. The implicit formulation performs significantly better in terms of average integrality gap and number of instances solved to feasibility.

MS-Tu-E-43-4
17:30–18:00
Using Combinatorial Optimization for Large-scale Data Mining
Baumann, Philipp
Univ. of California, Berkeley
Hochbaum, Dorit S.
Univ. of California, Berkeley
Abstract: Combinatorial machine learning algorithms represent the data set in form of a graph. The size of the graph grows quadratically in the size of the data set which poses a challenge in terms of scalability. We address this challenge with a novel method called sparse computation that generates a very sparse graph without losing relevant information. Our empirical results show that sparse computation significantly reduces running times, while having a minimal effect on accuracy.

MS-Tu-E-43-5
18:00–18:30
Flexible Personnel Scheduling Using Branch and Price
Brunner, Jens
Univ. of Augsburg
Abstract: The talk presents a general approach for flexible personnel scheduling which might be applied to flexible shift or days off scheduling. Main objective is to minimize total workforce size subject to demand coverage. When performing scheduling the minimum and maximum number of consecutive periods on as well as off is limited. Furthermore, total number of working periods in the planning horizon is bounded. Computational experiments show the benefits of having flexibility in the scheduling process.

MS-Tu-E-44
16:00–18:00
VIP4-1
Mathematics of Information and Low Dimensional Models - Part I of III
For Part 2, see MS-We-D-44
For Part 3, see MS-We-E-44
Organizer: Bianchard, Jeffrey
Ginnel College
Abstract: This min-symposium considers a variety of ill-posed inverse problems associated with information theory, signal processing, and image processing. By exploiting low dimensional structure, such as in compressed sensing and low rank matrix completion, tractable algorithms permit construction of accurate approximate solutions and low dimensional representations. The mini-symposium will include state-of-the-art work on algorithms, theoretical analysis, and relationships with high dimensional geometry from researchers at all stages of their careers.
Notes to ICIAM Committee: Jared Tanner (Oxford) is a co-organizer of this symposium but does not have a pin. This symposium is sponsored by the SIAM SIAG on Linear Algebra.

MS-Tu-E-44-1
16:00–16:30
Self-calibration and Biconvex Compressive Sensing
Ling, Shuyang
UC Davis
Abstract: Compressive sensing is an ingenious strategy to sample sparse signals. Meanwhile, self-calibration is to equip a hardware device with a smart algorithm that can compensate automatically for the lack of calibration. We show how several self-calibration problems can be treated efficiently as a biconvex compressive sensing problem \( y = D\chi \) with unknown sparse \( x \) and diagonal matrix \( D \). We describe how ‘SparseSolv’ solves this underdetermined system exactly and efficiently via linear programming with theoretic guarantees.
Conjugate Gradient Iterative Hard Thresholding
Blanchard, Jeffrey
Grinnell College

Abstract: Conjugate Gradient Iterative Hard Thresholding is a greedy algorithm for solving the compressed sensing and matrix completion problems combining the advantages of the low per iteration complexity of Normalized Iterative Hard Thresholding and the effectiveness of projection based algorithms such as Hard Thresholding Pursuit and Compressive Sampling Matching Pursuit. This talk will also introduce the compressed sensing and matrix completion problems as examples of low dimensional models.

Recovery of Low Rank Tensors
Holger, Rauhut
Stojanac, Zeljka
RWTH Aachen Univ.

Abstract: We consider extensions of low rank matrix recovery and matrix completion to the recovery of higher order tensors of low rank from incomplete information. While convex optimization and greedy approaches come along with nice theory in the matrix case, one faces several theoretical and numerical difficulties for higher order tensors. We discuss several recent approaches for low rank tensor recovery (with respect to different notions of rank) and present the so-far available results.

Phase Retrieval via Kaczmarz Methods
Wei, Ke
Hong Kong Univ. of Sci. & Tech.

Abstract: We study the Kaczmarz methods for solving a system of quadratic equations, i.e., the generalized phase retrieval problem. The methods extend the Kaczmarz methods for solving systems of linear equations by integrating a phase selection heuristic in each iteration and overall have the same per iteration computational complexity. Empirical performance comparisons establish the computational advantages of the Kaczmarz methods over other state-of-the-art phase retrieval algorithms.

Triangular decomposition of polynomial systems: solvers and applications - Part IV of IV
For Part 1, see MS-Mo-D-45
For Part 2, see MS-Mo-E-45
For Part 3, see MS-Tu-D-45
Organizer: Moreno, Marc
Organizer: Chen, Changbo
The Univ. of Western Ontario
Chinese Acad. of Sci.

Abstract: The Characteristic Set Method of Wen Tsun Wu has freed Ritt’s decomposition from polynomial factorization, opening the door to a variety of discoveries in polynomial system solving. In the past three decades the work of Wu has been extended to more powerful decomposition algorithms and applied to different types of polynomial systems or decompositions: differential systems, difference systems, real parametric systems, primary decompositions, cylindrical algebraic decomposition. Today, triangular decomposition algorithms provide back-engines for computer algebra system front-end solvers, such as Maple’s solve command and have been applied in various areas both in the academia and in the industry.

In this proposed workshop, we hope to gather researchers who have applied and extended the works Joseph Fels Ritt and Wen Tsun Wu. Our goals are, first, to discriminate the techniques and software tools which have been developed by this vibrant community and, second, to stimulate further developments and applications of polynomial system decomposition by means of characteristic sets.

At the International Congress on Mathematical Software (ICMS 2014), a satellite conference of the International Congress on Mathematics, in Seoul (South Korea), a session on the same topics as the proposed one had gathered 9 talks, see http://www.csd.uoo.co.kr/~moreno/ICMS_Triangular_Decomposition_Session.html

About another 30 researchers had expressed interest in participating to this session but were not able to do so at that time the year or in that location. Moreover, three other sessions of ICMS 2014 had talks on this subject of polynomial system decomposition by means of characteristic sets.

In a sum, the proposed workshop for ICIAM 2015 is expected to be well attended and to generate rich interactions. At the same time, the available software such as the RegularChains library (see http://www.regularchains.org) will support software demonstration of the applications of the Characteristic Set Method.

On Computational Formula of Isogenies of Elliptic Curves
Kazuhiro, Yokoyama
Noro, Masayuki
Rikkyo Univ.

Abstract: We consider a computational problem to make an exact formula of isogenies between elliptic curves to examine the effectiveness of several modular methods for computing Groebner bases (triangular sets) and ideal decompositions. This problem is reduced to finding the isolated divisor of a polynomial ideal derived from direct computation of each isogeny, and we report how several modular techniques are efficiently applied with help of mathematical properties of isogenies.
This work presents a shape analysis model using extremal Teichmüller maps (T-Map). Given two corresponding domains with/without labeled landmarks, an extremal T-Map between them can be computed. The extremal T-Map gives rise to a metric called the Teichmüller metric, which can be used to measure shape distance. In this talk, we will describe how the extremal T-Map can be computed and how the Teichmüller metric can be used for shape analysis.

Fshape Spaces : Mathematical Construction and Applications to Computational Anatomy.

Charon, Nicolas
Johns Hopkins Univ.

Abstract: This talk will present the recent mathematical construction of functional shape, which are the combination of a geometrical object (typically a submanifold) with additional functional data supported on it. We will show how the extension of metamorphosis allows to equip fshape spaces with a Riemannian metric which can be complemented by inter-orbit dissimilarity terms based on the idea of varifolds. This leads eventually to a variational formulation of atlas estimation problems in computational anatomy.

Extremes of Flow Quantities in 2D and 3D Turbulence
Takehiro, Shin-ichi
Research Inst. for Mathematical Sci., Kyoto Univ.

Yamada, Michio
Kyoto Univ.

Abstract: Statistical property of extrema of physical variables in fluid phenomena is interesting from both theoretical and practical points of view. The theory of extremum statistics has been established mainly for identical independent random events, where the asymptotic extremum distributions are classified into three groups. In this paper, we summarize difficulties in application of the extremum distributions to fluid phenomena, and then discuss an extremum statistics in two- and three-dimensional fluids.

Instability and Singular Behavior of Surface Tension in Vortex Sheets
Sohn, Sung-Ik
Gangneung-Wonju National Univ.

Abstract: Fluid interfaces with surface tension often exhibits singular behaviors; for example, capillary waves and ripples in the Hele-Shaw flow and water waves. In this talk, we present the unstable motion of vortex sheets with surface tension, mainly on the flow of small surface tension. The linear stability analysis shows dependence of stability on the mode of perturbation and the Weber number. Computational results for the evolution of vortex sheets are presented for various regimes of the Weber number. It is found, for the first time, that for a high Weber number, capillary waves are produced on circular vortex sheets, as well as pinching and self-intersection. The reason of the appearance of capillary waves will be discussed. For an intermediate Weber number, the sheet demonstrates competition between the inertial force and capillary force, while for a low Weber number, it is marginally unstable.

Numerical Exact Solutions Representing Developed Turbulence
Sasaki, Eiichi
Osaka Univ.

Abstract: Fully developed turbulence has universal statistical properties which have attracted many researchers’ interests. We will present numerical invariant solutions which reproduce the statistical properties of turbulence. We will also characterize vortex dynamics in terms of the invariant solutions.

Regularization of Inverse Problems in Imaging Sciences: Theoretical and Numerical Aspects - Part II of II

For Part 1, see MS-Tu-D-48

Organizer: Fadili, Jalal
CNRS & ENSCaen

Organizer: Peyre, Gabriel
CNRS & Universite Paris-Dauphine

Organizer: Zhang, Xiaowen
Shanghai Jiao Tong Univ.

Abstract: Inverse problems have become a central theme in various fields of sciences and engineering such as imaging sciences. This field draws from various mathematical disciplines including linear algebra, differential geometry, harmonic analysis, functional analysis, mathematical physics, numerical analysis, optimization, PDE’s, stochastic and statistical methods. The fields of application encompass medical and astronomical imaging, radar, optics, etc. The goal of the mini-symposium is to present recent theoretical, numerical and applicative advances in these fields. It will focus on ill-posed inverse problems, variational regularization theory, recovery guarantees, and numerical algorithms to solve the corresponding optimization problems.

Methods for Parameter Adaptation in Image Restoration
Grasmair, Markus
NTNU

Abstract: In this talk, we will give a short overview of methods for the local adaptation of regularization parameters in variational methods for image restoration. In particular, we will concentrate on total variation approaches, where the parameter choice is based on a local statistical analysis of the residual.

Parallel-I, A Fully Parallel Algorithm for Combinatorial Compressed Sensing
Tanner, Jared
Univ. of Oxford

Abstract: We consider the problem of solving for the sparsest solution of large underdetermined linear system of equations where the matrix is the adjacency matrix of an expander graph corresponding with at most d neighbours per node. We present a new combinatorial compressed sensing algorithm with provable recovery guarantees, fully parallel with computational runtime less than traditional compressed sensing algorithms, and able to recover sparse signals beyond 11-regularization. This work is joint with Rodrigo Mendoza-Smith.

On Sparse Regularization and Deterministic Sampling in Inverse Problems

MS-Tu-E-48-2 16:30–17:00
Parallel-I, A Fully Parallel Algorithm for Combinatorial Compressed Sensing
Tanner, Jared
Univ. of Oxford

Abstract: We consider the problem of solving for the sparsest solution of large underdetermined linear system of equations where the matrix is the adjacency matrix of an expander graph corresponding with at most d neighbours per node. We present a new combinatorial compressed sensing algorithm with provable recovery guarantees, fully parallel with computational runtime less than traditional compressed sensing algorithms, and able to recover sparse signals beyond 11-regularization. This work is joint with Rodrigo Mendoza-Smith.

On Sparse Regularization and Deterministic Sampling in Inverse Problems
Abstract: Tomography problems typically yield deterministic sampling patterns that are highly structured. Recent developments demonstrate how regularization techniques such as TV and IT work very well with such sampling patterns, however (maybe surprisingly) only on certain structured signals. Given that the sampling patterns are deterministic (as opposed to random), there is no theory explaining this phenomenon. We will discuss how to solve this problem.

On the Meaning of Vertex Couplings in Quantum Graphs
Exner, Pavel
Czech Acad. of Sci.
Abstract: Quantum graphs are a useful model in microelectronics and other areas. In this talk we report a solution [1] to a longstanding open problem showing that any self-adjoint coupling in the graph vertices allowed by probability current conservation can by approximated by a suitable family of scaled Schrödinger operators on a fat graph, in other words, a network of tubes whose widths shrink to zero. [1] P. Exner, O. Post, Commun. Math. Phys. 322 (2013), 207-227

A 2D Nonlinear Algorithm for Monotone Interpolation
Arangida, Francesc
Univ. of Valencia
Abstract: In this talk we present an algorithm for monotonic interpolation to monotone data on a rectangular mesh by piecewise bicubic functions. Carlson and Fritsch develop conditions on the Hermite derivatives that are sufficient for such a function to be monotonic. Here we obtain nonlinear approximations to the first partial and first mixed partial derivatives at the mesh points. We prove that we get a monotone piecewise bicubic interpolant and analyze the order of this nonlinear interpolant. We also present some numerical experiments we compare the results we obtain our algorithm with the obtained using linear techniques.

Subdivision Schemes that are defined by a certain type of piecewise smooth nonlinear rules can be analyzed using the theory of generalized gradients. subdivision schemes or reduced order modeling in scientific computing motivate the study of approaches, in order to discuss the challenges in applications and establish links with ongoing work.

Subdivision Methods for Manifold-Valued Data: Act Locally and Think Global
Subdivision Methods for Manifold-Valued Data: Act Locally and Think Global
Majung, Mauro
Duke Univ.
Abstract: We discuss a geometry-based statistical learning framework for performing model reduction and modeling of stochastic high-dimensional dynamical systems: we construct robust estimators for the number of effective degrees of freedom of the system, global dimension reduction techniques, and fast parallel learning techniques for model reduction, with guarantees on large-time accuracy.

Parallel MD Simulations for Enhanced Conformational Sampling of Biological Systems
Sugita, Yuji
RIKEN
Abstract: Many important chemical and biological phenomena are slow processes on time-scales from microsec to msec or much longer. The limitation of all-atom MD simulations in general purpose computers suggests the importance of enhanced conformational sampling methods. Here, we discuss the practical usages of parallel MD simulation methods developed in our group for overcoming the energy barriers between metastable states in the rugged free-energies landscapes.

Lattice Differential Equation analysis of Schleogl’s second model for particle creation and annihilation
Wang, Chi-Jen
Georgia Inst. of Tech.
Abstract: Schleogl’s stochastic models for autocatalysis on a lattice of dimension d≥2 involves: (i) spontaneous annihilation of particles at lattice sites; and (ii) autocatalytic creation of particles at vacant sites. We analyze the dynamics of interfaces between populated and empty regions via discrete reaction-diffusion equations (dRDE) obtained from approximations to the exact master equations. These dRDE can display artificial propagation failure (APF) absent due to fluctuations. Higher-dimension analysis avoiding APF captures behavior in the stochastic model.
subdivision schemes as a constructive approximation method for such nonlinear data. Like many successful methods, subdivision schemes “act locally but think globally”. On top of being multiscale in nature, they are very effective in handling the nontrivial topologies of manifolds. In this talk we review the applications, algorithms and theory of subdivision methods applied to manifold-valued data.

**MS-Tu-E-51**

**Blood flow and Blood Vessel Systems**

**Organizer:** Hu, Dan Inst. of Natural Sci., Shanghai Jiao Tong Univ.

**Abstract:** The interaction between blood flow and blood vessel systems are important in many life processes and in the pathogenesis of many cardiovascular diseases. Modeling studies of these life processes, such as the blood flow regulation, the blood vessel adaptation, and the blood wave propagation, have provided deep understandings of relevant experimental observations. In this mini-symposium, we will report our recent works on the modeling these important life processes and the application of these models in explaining experimental phenomena. The adaptation of blood vessels in response to the stimulus induced by the wall shear stress of the blood flow is applied successfully in predicting the vessel pruning in embryo zebra fish. The one-dimensional model of blood pulse wave is used in explaining the correlation between pulse phases and diseases, such as the wry pulse and hypertention. The model of arteriole smooth muscle cells based on Ca2+ signaling predicts spontaneous vasomotion and the auto regulation of blood flow in arteries. This mini-symposium will not only provide a platform for us to present the recent discoveries in modeling and experimental studies of the interaction between blood flow and blood vessel systems, but also provide a platform to discuss the future collaborations towards an integrated and deep understanding on the functional mechanism of the cardiovascular systems and the pathogenesis mechanism of a few important cardiovascular diseases.

**MS-Tu-E-51-1**

**Haemodynamics-Driven Developmental Pruning of Brain Vasculature in Zebrafish**

Chen, Qi Max Planck Inst. for Molecular Biomedicine

**Abstract:** The developing vasculature in zebrafish midbrain undergoes extensive vessel pruning, which is driven by changes in blood flow and leads to gradual reduction in the vasculature complexity with development. The occurrence position of vessel pruning could be largely predicted by haemodynamics-based numerical simulation of vasculature refinement. This model, which based on adaptation and optimization of biological transport networks, also indicates low and variable blood flow in pruned segment, which is consistent with experimental observation.

**MS-Tu-E-51-2**

**The Formation of the Pulse Phase in Human Body**

Du, Tao Department of Mathematics & Inst. of Natural Sci., Shanghai Jiao Tong Univ.

**Abstract:** Blood pulse phase is a result of blood pulse wave propagation and reflection in arterial tree, which contains information of our body. This work is to explain the formation of the blood pulse phase based on the wave propagation in single vessel and reflection at bifurcation in arterial tree, and use this result to explain why some abnormal pulse phases appear in human body, such as wry pulse in hypertension and slippery pulse in pregnancy.

**MS-Tu-E-51-3**

**Adaptation and Initiation of Blood Vessel Systems**

Hu, Dan Inst. of Natural Sci., Shanghai Jiao Tong Univ.

**Abstract:** For animals, a visible part of energy is costed on driven the blood flow. An efficient structure of the blood vessel systems is crucial for animals. At the same time, animals are constantly adapting their blood vessel systems to meet the tissue demands for blood flow to supply nutrient and oxygen. In this talk, we show that efficient structure of the vessel systems is achieved with the adaptation and initiation process.

**MS-Tu-E-51-4**

**Modeling Blood Flow in the Kidney**

Layton, Anita Duke Univ.

**Abstract:** To maintain normal kidney function, autoregulatory mechanisms closely regulate renal blood flow. One such autoregulatory mechanism is the myogenic response, wherein a rise in intravascular pressure elicits a reflex constriction that increases vascular resistance. Another mechanism is the tubuloglomerular feedback, which is a negative feedback response that balances glomerular filtration with tubular transport. We use a mathematical model of renal hemodynamics control to investigate the interactions of these mechanisms under physiological and pathophysiological conditions.

**MS-Tu-E-52**

**Stochastic Dynamics in Cellular-Scale Biology - Part II of II**

For Part 1, see MS-Tu-D-52

**Organizer:** Kramer, Peter Rensselaer Polytechnic Inst.

**Abstract:** Many physical processes involving cells and associated entities such as viruses involve inherent irregularities due to thermal fluctuations or other noisy aspects of protein function, arising from the small scales, flexible structures, and/or reliance on diffusive transport of small numbers of biomolecules. The quantitative study of such systems generally relies on stochastic models which integrate the uncertain noisy aspect in a physically, or sometimes phenomenologically, motivated manner. The speakers in this minisymposium will illustrate how stochastic models can be deployed and analyzed to obtain insights on a broad variety of cellular processes.

**MS-Tu-E-52-1**

**Dissipative Particle Dynamics Simulations of Polymer Networks**

Matzavinos, Anastasios Brown Univ.

**Abstract:** In this talk, we present a dissipative particle dynamics approach to simulating the meso-scale dynamics of polymer networks. Our simulations explicitly include mechanical interactions with other meso-scale structures (e.g., lipid membranes) and cytoplasmic flows. We compare the results of our approach to those of Brownian dynamics simulations. We also discuss ongoing work on stochastic homogenization, bridging the gap between the mesoscopic simulations and macroscopic descriptions of bulk mechanical properties.

**MS-Tu-E-52-2**

**Kinetic Theories for Age-structured Populations**

Chou, Tom UCLA

**Abstract:** We derive a new kinetic theory for age-structured populations undergoing a semi-markov birth-death process. A high-dimensional transport equation is derived for the probability density for any number of individual with specified age ranges. Different structural forms required for different processes such as birth-death, branching, and sexual reproduction are highlighted. Our equations form a series analogous to that of the BBGKY hierarchy. We show how low-moment closure leads to the classic deterministic McKendrick equation.

**MS-Tu-E-52-3**

**Spontaneous Neural Activity in the Morris-Lecar Model with Ion Channel Noise**


**Abstract:** Noise induced excitability is studied in types I and II Morris–Lecar neurons. Ion channels open and close randomly, creating current fluctuations that can induce spontaneous firing of action potentials. Both noise sources are assumed to be weak so that spontaneous action potentials occur on a longer timescale than ion channel fluctuations. Asymptotic approximations of the stationary density function and most probable are developed to understand the role of channel noise in spontaneous excitability.

**CP-Tu-E-52-4**

**Solving the Chemical Master Equation by A Krylov-based Finite State Projection and the Stochastic Simulation Algorithm**

Sidje, Roger Univ. of Alabama

**Abstract:** Solving the chemical master equation (CME) allows us to model and simulate the stochastic behavior of biochemical reactions that take place within a biological cell. The mathematical framework is a continuous time Markov chain with a discrete state space that describes the composition of molecules inside the cell. Computing the transient probability distribution of this Markov chain allows us to track the composition over time, and this has important practical applications. However, solving the CME is challenging because the state space is very large or even countably infinite. Truncation and approximation techniques such as the finite state projection and inexact Krylov subspace techniques lead to reduce-sized problems that capture enough of the cell dynamics. But these problems can still be quite large. We show how striking improvements can be further achieved by combining these reduction techniques with the stochastic simulation algorithm (SSA). This work is supported by NSF grant DMS-1320849.

**CP-Tu-E-52-5**

**Exploring the Structural Controllability Properties of the Gene Regulatory Network for Arabidopsis Thaliana Flower Morphogenesis**

Chairez-Veloz, Jose Eduardo Martinez-Garcia, Juan Carlos Alvarez-Buylla, Elena R.

**Abstract:** Exploring the structural controllability properties of the gene regulatory network for Arabidopsis thaliana flower morphogenesis.
We study precommitted strategy of time inconsistent problems, and a Dynamic Approach for Some Time Inconsistent Problems

MS-Tu-E-53 16:00–18:00

Stochastic control perspectives in mathematical finance

Organizer: Ludkovski, Mike UC Santa Barbara
Organizer: Leung, Tim Columbia Univ.
Organizer: Zhu, Chao Univ. of Wisconsin-Milwaukee
Organizer: Song, Qingshuo City Univ. of Hong Kong

Abstract: The stochastic control theory is a field that probability and partial differential equation are intimately intertwined. With the rapid development of the mathematical finance in the last two decades, the stochastic control theory has gained significant interests both from theoretical researchers and practitioners. In particular, many problems driven by financial applications can be formulated into some interesting non-standard control problems, further raise new challenges in this field. This mini-symposium is devoted to the recent advances in the stochastic control theory motivated by the financial applications.

MS-Tu-E-53-1 16:00–16:30

Continuity of the Value Functions of Stochastic Control Problems in A Bound-ed Domain

Zhu, Chao Univ. of Wisconsin-Milwaukee
Song, Qingshuo City Univ. of Hong Kong

Abstract: We determine a weaker sufficient condition than that of Theorem 5.2.1 in Fleming and Soner (2006) for the continuity of the value functions of stochastic exit time control problems.

MS-Tu-E-53-2 16:30–17:00

Stackelberg Game with Regime Switching

Yan, Zhongfeng jinan Univ.

Abstract: This work is devoted to irreversible investment problems in duopoly games with regime switching. The problem is formulated as a stopping time game in presence of Stackelberg leader-follower competition, in which both players determine their respective optimal market entry time. By extending the variational inequality approach, we obtain regime-dependent optimal policies for both players. In addition, numerical examples are reported to demonstrate the properties of the solution.

MS-Tu-E-53-3 17:00–17:30

Consumption in Incomplete Markets

WANG, Gu Univ. of Michigan at Ann Arbor

Abstract: An agent maximizes isoelastic utility from consumption with infinite horizon in an incomplete market, in which state variables are driven by diffusions. We provide (i) a general verification theorem, which links the solution of the HJB equation to the optimal consumption and investment policies; (ii) approximate policies in closed form, which admit an upper bound of utility loss, and become optimal if the market is complete, or utility is logarithmic. Joint work with Paolo Guasoni.

MS-Tu-E-53-4 17:30–18:00

A Dynamic Approach for Some Time Inconsistent Problems

Zhang, Jianfeng Univ. of Southern California

Abstract: We study precommitted strategy of time inconsistent problems, and we note that many such problems in the literature can be transformed into an optimization of a multiple dimensional controlled Backward SDE. We shall introduce a type of “forward utility” so that the problem, which is time inconsistent under the original utility, becomes time consistent under our forward utility. We next characterize our forward utility as a solution to certain McKean-Vlasov type of equations.
Numerical investigation on how the wall shear stress, the streamlines, and viscosity model and provides a comparative study with the numerical results.

We show that the proposed algorithm coupled equations. To overcome the difficulties, we study an inexact Newton-parallel equation, coupled with the non-linear elasticity system. Our solver consists of solving the non-linear system deriving from the discretization of the finite elasticity equations with a Newton-Krylov-BDDC method. 3D parallel tests on a BlueGene/Q cluster show the scalability and quasi-optimality of the proposed method.

Abstract: We present a BDDC solver for the cardiac electro-mechanical coupling, a model describing the electrical excitation of the myocardium and its subsequent contraction. The model is constituted by a parabolic partial differential equation, coupled with the non-linear elasticity system. Our solver consists of solving the non-linear system deriving from the discretization of the finite elasticity equations with a Newton-Krylov-BDDC method. 3D parallel tests on a BlueGene/Q cluster show the scalability and quasi-optimality of the proposed method.

Abstract: We demonstrate the feasibility of high resolution models of bidirectionally coupled cardiac electro-mechanics which resolve cardiac anatomy at a para-cellular resolution. A novel algebraic multigrid method is presented, adapted for non-linear mechanics, which is shown to be strongly scalable up to 8k cores when using a human whole heart four chamber geometry model. A novel algebraic multigrid method is presented, adapted for non-linear mechanics, which is shown to be strongly scalable up to 8k cores when using a human whole heart four chamber geometry model. Benchmark results demonstrate that a single heart beat can be simulated in about 1 hour minutes at full anatomical and biophysical detail.

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Abstract: We develop a locally conservative Eulerian-Lagrangian finite difference model. An Eulerian-Lagrangian WENO Finite Difference Scheme for Advection problems is developed based on the WENO (Weighted Essentially Non-Oscillatory) scheme and the Eulerian-Lagrangian technique. This new scheme is formally high-order accurate in space and time and essentially non-oscillatory. It is free of a CFL (Courant-Friedrichs-Lewy) time step restriction. An analogous analysis with the help of interpolation theory of Hilbert spaces is presented. We consider mixed variational methods for fourth-order boundary value problems. The discretization to the control and optimization problem. We will discuss both approaches and their advantages and disadvantages on the basis of the discretization to the control and optimization problem. We will discuss both approaches and their advantages and disadvantages on the basis of the simulation system UG4. We show that the scheme maintains the designed order accuracy. It is free of a CFL time step stability restriction. We will focus on dealing with the effect of discontinuous parameter in certain industrial and applied mathematics to exchange ideas regarding the developments of robust and efficient numerical schemes that preserve the key physics of these models, and to study the development of fast and efficient linear solution methods.

Abstract: In order to simulate the alkali-surfactant-polymer (ASP) flooding, a computational model is constructed, with governing equations consisting of oil-gas-water mass continuity equation, chemical reaction-diffusion mass conservation equation and chemical equilibrium reaction equation, making it not only have capability to simulate complex physical phenomena, but also suitable to characterize complex reservoir behavior. A sequential solution scheme is designed and find application in the complicate mathematical model. In this talk, we will report some works on designing optimal finite element methods and efficient solvers for multi-phase problems. In particular, we will focus on dealing with the effect of discontinuous parameter in certain industrial and applied mathematics to exchange ideas regarding the developments of robust and efficient numerical schemes that preserve the key physics of these models, and to study the development of fast and efficient linear solution methods.

Abstract: The control and optimization of multi-physics problems requires the construction of reduced models. There are two major approaches, either one starts with a fine grid model and approximates it with a reduced order model that can be handled by control and optimization methods or one readily adapt the discretization to the control and optimization problem. We will discuss both approaches and their advantages and disadvantages on the basis of the simulation system UG4. We show that the scheme maintains the designed order accuracy. It is free of a CFL time step stability restriction. We will focus on dealing with the effect of discontinuous parameter in certain industrial and applied mathematics to exchange ideas regarding the developments of robust and efficient numerical schemes that preserve the key physics of these models, and to study the development of fast and efficient linear solution methods.

Abstract: We develop a locally conservative Eulerian-Lagrangian finite difference scheme with the weighted essentially non-oscillatory property (EL-WENO) in one-space dimension. This method has the advantages of both WENO and Eulerian-Lagrangian schemes. It is formally high-order accurate in space (we present the third and fifth order version) and essentially non-oscillatory. Moreover, it is free of a CFL time step stability restriction and has small time truncation error. A flux correction term is used to make the scheme conservative. A Strang splitting algorithm is presented for higher-dimensional problems. We show formally that it maintains the designed order accuracy. It is also locally mass conservative. Numerical results are provided to illustrate the performance of the scheme and verify its formal accuracy.
both for the stress and displacement. We also proposed an efficient imple-
ment technique for our method to reduce the dimension of the linear system.
most practices, it is implicitly assumed the default probability of the replace-
ment contract is negligible. We go a step further to consider the effect of a
second default and then the full problem and examine the conditions under
which the cost due to more defaults is significant using PDE technique.

Application of G Expectation in the Futures Margin—G-VaR
Yang, Shuzhen
Shandong Univ.
Abstract: In the market, we need to set the futures margin based on the
penetration rate of margin. In the industry, the futures margin is calculated by
H-VaR. The basic idea is that the future is to reproduce the history. When cal-
culating the margin by H-VaR, will with higher penetration rate and cause a
major loss, which is because the tail data quantity is too little. G- expectation
is a kind of nonlinear expectation theory, admit the parameters uncertainty in
the model, including the uncertainty of the mean and volatility. In this study,
by the G-expectation, we use G-VaR to calculate the futures margin.

Optimal Control Model of Wolbachia Transinfection Targeting Vector Popula-
Wu, Jing
Yu, Richard
Univ. of Ottawa
Carleton Univ.
Abstract: Existing optical network planning algorithms do not explicitly mea-
sure the impact of changes of network resources on the design objective.
We propose a measurement based on the Lagrangian relaxation framework,
using the optimized values of Lagrange multipliers as a direct measurement
of resource criticality. Such a quantitative measurement can be naturally ob-
tained along with the optimization process to compute the optimal solution
(or a near-optimal solution) to the static Routing and Wavelength Assignment
(RWA) problems.

Geometric Methods for the Study of Electrical Networks
Durand, Philippe
Cranfield
Maurice, Olivier
Cranfield
Reineix, Alain
Université de Paris
Abstract: The methods developed by Gabriel Kron, for the tensor approach of
networks (TAN), offers a great source of applications for the geometrical and
topological study of electrical networks. The language of tensorial analysis is
well adapted to the description of networks. Tools about discrete combinato-
torial topology are well adapted specifically to the study of graphs., for example,
the Euler characteristic Poincaré, the simplest invariant in topology is connect-
ed to a formula obtained by Kron connecting the nodes of the graphs, edges,
mesh currents and node pairs. Extensions using tools of algebraic topology
are possible in larger dimension. We thus find the node law and the law of
mesh The addition of differential geometry is used to connect discrete data
obtained from circuit and continuous phenomena for example, transmission
problems via antenna.
vector-borne diseases. In this presentation, we propose a mathematical model for Wolbachia transfection targeting the wild population of Aedes aegypti mosquitoes, the principal vector of dengue. The model is formulated in term of optimal control, where the control variable stands for the rate of release of Wolbachia-infected mosquitoes. The purpose of control is to maximize the density of Wolbachia-infected mosquitoes while minimizing the overall number of dengue-infected patient and considering treatment costs. Our approach allows to identify the model parameters (linked to the biological features of Wolbachia) which affect the mosquito’s ability to develop and transmit the virus and which also facilitate the persuasiveness and persistence of Wolbachia infection among mosquito population.

Abstract: We constructed a twin dynamic mathematical model to examine two possible scenarios for the spread of the ebola virus disease (EVD). The first model mimics the initial spread of the disease before a substantial scale-up in public health strategies towards the control of the ebola virus disease was established while the second model takes into account strategies put in place to halt the spread of the disease. We derived EVD parameters from epidemiological data for the current epidemic and propagated uncertainty in epidemiological parameters onto model predictions by using Markov Chain Monte Carlo based sampling methods. We established that if the running reproductive number is unit for large time in the first model then the epidemic will cease even if R0 > 1. Also, using data from Guinea, Sierra Leon, Liberia and Nigeria, we carry out numerical simulation of our models and establish threshold conditions for the eradication of disease.

The Impact of Additional Food as A Part of Prey Harvesting Effort for A Bioeconomic Predator-prey Model
Kumar, Dinesh Chakrabarty, Siddharta
Indian Inst. of Tech. Guwahati Indian Inst. of Tech. Guwahati
Abstract: We consider two bio-economic ratio-dependent predator-prey models for prey harvesting, one without and the other with additional food supply to the predators. We analyze the stability of the equilibrium points and determine the maximum sustainable yield. We then study the problem from the perspective of control theory with the additional food supply as a part of the effort, in addition to the traditional approach of adding a harvesting term. It is shown that the inclusion of additional food into the effort could result in more profitable harvesting even after accounting for the cost of additional food supply.

Estimating Parameters of Biological Models Using Ensemble Kalman Filter
Apri, Mochamad Chaudhary, Sanjay
Industrial & Financial Mathematics Research Division
Abstract: Biological processes are very complex; involving many components with intricate interactions and also influenced by environment. Modelling such processes into mathematical equations often leads to a very large nonlinear differential equation system with many parameters. Some or even all of these parameters might have to be estimated from noisy experimental data. Although some methods are available, the task of estimating parameters remains a challenging task, especially due to the high number of parameter to estimate, noisy data, and limited number of measurable components. In this work, we propose an alternative method to estimate the parameters based on the ensemble Kalman filter. To test the performance, the method is applied to estimate parameters in the heat shock response model. The results show a good agreement.

A Mathematical Model to Diagnose the Level of Diabetes Using Fuzzy Logic System
Kumar, Sanjeev Chaudhary, Sanjay
Dr. B.R. Ambedkar Univ., Agra Dr. B.R. Ambedkar Univ., Agra
Abstract: The diagnosis of disease involves several levels of uncertainty and imprecision and it is inherent to medicine. A single disease may manifest itself quite differently, depending on patient and with different intensities. A single symptom may correspond to different diseases. On the other hand several diseases present in a patient may interact and interfere with usual description of any of diseases. The fuzzy logic has been utilized in several different approaches to modeling the diagnostic process. In this work diagnosis of the level of diabetes is addressed by using fuzzy logic. Here trapezoidal membership function is used for fuzzification process.
Abstract: We propose a new computational technique for large systems of kinetic equations of aggregation and fragmentation processes. In contrast to standard Monte Carlo methods, we solve the grid equations by using the predictor-corrector scheme. Using low-rank approximations of the solution and as well of the coagulation kernel, we tremendously accelerate every time step keeping the same level of accuracy. The complexity is reduced from $O(N^2)$ to $O(N \log N)$, where $N$ is the number of nodes. We prove that our method applies to problems with typical coagulation kernels. The results of simulation are demonstrated on one-dimensional models, however the technique can be generalized to the multidimensional case.

**References:**


In this minisymposium, we will organize several talks covering inverse problems based on partial differential equations which occupy an important position. Different ways to the modeling of inverse problems, among which the inverse imaging process, bring essential difficulties of ill-posedness. There are different possibilities to derive the optimal solutions of MOFCTP and then compared. Finally, a real-life example on MOFCTP is included to illustrate the paper.

**Organizer:** Wang, Haibing
**Southeast Univ.**

**Inverse Problems Based on Partial Differential Equations with Applications**

**16:00–18:30**
**VIP4-3**

- **CP-Tu-E-65-3**
  - **Interior Point Method with the Continued Iteration**
  - Berti, Lilian Ferreira
  - Ghidini, Carla
  - Oliveira, Aurelio
  - UNICAMP
  - FCA - UNICAMP
  - UNICAMP

  **Abstract:** In this work, the continued iteration is presented and incorporated into the predictor corrector interior point method in order to reduce the number of iterations and consequently the computational time necessary to solve large-scale linear programming problems. In the continued iteration a new direction is computed and combined with the predictor corrector one. Computational results show the improvement achieved by the proposed approach.

- **CP-Tu-E-65-4**
  - **Multi-Objective Fixed-Charge Transportation Problem under Random Rough Environment**
  - Roy, Sankar Kumar
  - Vidyasagar Univ.

  **Abstract:** This paper studies the multi-objective fixed-charge transportation problem (MOFCTP) under uncertain environment. Due to globalization of the market, some of the parameters of MOFCTP are treated as rough variables and others are random rough variables. A procedure is shown for converting from uncertain MOFCTP to MOFCTP. Different methods are used to derive the optimal solutions of MOFCTP and then compared. Finally, a real-life example on MOFCTP is included to illustrate the paper.

**17:00–17:20**
**CP-Tu-E-65-5**

- **A FRAMEWORK INTEGRATING BIOGEOGRAPHY-BASED OPTIMIZATION AND SUPPORT VECTOR REGRESSION FOR FREEWAY TRAVEL TIME PREDICTION AND FEATURE SELECTION**
  - Bansal, Prateek
  - The Univ. of Texas at Austin

  **Abstract:** Freeway travel time prediction models have been proposed in literature, but identification of important predictors has not received much attention. Identification of important predictors reduces dimensions of input data, lessens computational load, and provides better understanding of underlying relationship between important predictors and travel time. Moreover, collection of only important predictors can lead to a significant equipment savings in data collection. Therefore, this study proposes a hybrid approach for feature selection (identifying important predictors) along with developing a robust freeway travel time prediction model. A framework integrating biogeography-based optimization (BBO) and support vector regression (SVR) has been developed. It was validated by predicting travel time at 36.1 km long segment of National Taiwan Freeway No. 1. The proposed hybrid approach is able to develop a prediction model with only six predictors, which is found to have accuracy equivalent to a stand-alone SVR prediction model developed with all forty three predictors.

- **CP-Tu-E-65-6**
  - **Feasibility Sampling in Interval Methods for Special Multi-Constrained Global Optimization**
  - Ying, Mengyi
  - Univ. of North Georgia

  **Abstract:** A supplementary feasibility sampling procedure is added to the framework of interval method for finding optimal solutions of global optimization problem over a bounded interval domain subject to multiple linear constraints. Its main feature is the ability to detect infeasibility or actually locate a feasible sample in any working subinterval. Thus it provides tighter upper bounds of the optimal objective function value than the standard methods. Numerical results will be provided to demonstrate its effectiveness.

**17:40–18:00**
**MS-Tu-E-66-1**

- **Determining the Initial Condition or the Right Hand Side in Parabolic Equations from Interior Observations**
  - Dinh-Nho, Hao

  **Abstract:** The problem of identifying the initial condition or the right hand side in parabolic equations with time-dependent coefficients from interior observations is studied. The problem is ill-posed and we numerically analyze its degree of ill-posedness. Then, we propose the conjugate gradient method based on the splitting method for solving the problem numerically. Some numerical results are presented.

**17:00–17:30**
**MS-Tu-E-66-3**

- **Spectral Theory and Inverse Problems for Schroedinger Operators on Perturbed Periodic Lattices**
  - Isozaki, Hiroshi
  - Univ. of Tsukuba

  **Abstract:** We talk about the spectral properties of Schroedinger operators on perturbed lattices. The main topics are the non-existence or the discreteness of embedded eigenvalues, the limiting absorption principle for the resolvent, spectral representations, the S-matrix and the associated inverse problems. Our theory covers the square, triangular, diamond, Kagome lattices, as well as the ladder, the graphite and the subdivision.

**17:30–18:00**
**MS-Tu-E-66-4**

- **The Equivalent Refraction Index for the Acoustic Scattering by Many Small Obstacles: with Error Estimates**
  - Sini, Mourad
  - RICAM

  **Abstract:** Let M be the number of bounded and regular bodies having a maximum radius ‘a’, a_j, located in a bounded domain of R^3. We are concerned with the time harmonic acoustic scattering problem by a very large number M of such small bodies. We derive the limiting scattering problems when a goes to zero and provide explicit error estimates in terms of a. Then, we discuss two applications in engineering materials.

**18:00–18:30**
**MS-Tu-E-66-5**

- **Multiple Parameters Determination in Textile Material Design**
  - Xu, Dinghua
  - Zhejiang Sci-Tech Univ.

  **Abstract:** We give an overall review on the mathematical formulation of textile material design based on clothing heat-moisture comfort, and corresponding results of theoretical analysis and numerical algorithms for direct/inverse problems.

- **SL-Tu-1**
  - **Mathematical aspects of collective dynamics: consensus, the emergence of leaders and social hydrodynamics**
  - Tadmor, Eitan
  - University of Maryland

  **Chair:** Cook, L. Pamela

  **Abstract:**

  - **SL-Tu-1**

  - **19:00–20:00**

  - **Mathematical aspects of collective dynamics: consensus, the emergence of leaders and social hydrodynamics**

  - **Tadmor, Eitan**

  - **University of Maryland**

  **Abstract:**

  - **Inverse Source Problems and Its Numerical Computation**
  - Lu, Shuai
  - School of Mathematical Sci., Fudan Univ.
  - CHENG, JIN
  - Fudan Univ.

  **Abstract:** In this talk, we investigate an interior Helmholtz inverse source problem with multiple frequencies. By implementing sharp uniqueness of the continuation results and exact observability bounds for the wave equation, a nearly Lipschitz increasing stability estimate is explicitly obtained for Cauchy measurements in a non-empty wave-number interval.
Wednesday, August 12, 2015

IL-We-1 8:30–9:30 Ballroom A
Invited Lecture
Chair: Arnold, D. N.
Abstract: Refinement strategies for spline based methods
Buffa, Annalisa
Istituto di Matematica Applicata e Tecnologie Informatiche
Abstract: In the last ten years the use of splines as a tool for the discretisation of partial differential equations has gained interests thanks to the advent of isogeometric analysis (2005, Hughes et al.). In this context, the development of methods capable of local refinement and adaptivity is extremely important as they alleviate the constraints on meshing imposed by the tensor product structure of spline spaces. A few techniques have been proposed in the last years, but somehow their use in adaptivity and the related mathematical understanding are, to a large extend, open research topics. I will present my recent contributions to this field with a special attention to two approaches: T-splines and hierarchical splines.

IL-We-2 8:30–9:30 Ballroom B
Invited Lecture
Chair: Zuazua, Enrique
Abstract: Stabilization of control systems: From the water clocks to the regulation of rivers
Coron, Jean Michel
Université Pierre et Marie Curie
Abstract: A control system is a dynamical system on which one can act by using controls. For these systems a fundamental problem is the stabilization issue: Is it possible to stabilize a given unstable equilibrium by using suitable feedback laws? (Think to the classical experiment of an upturned broomstick on the tip of one’s finger.) On this problem, we present some pioneer devices and works (Ctesibius, Watt, Maxwell, Lyapunov...), some more recent results, and an application to the regulation of the rivers La Sambre and La Meuse in Belgium. A special emphasize is put on positive or negative effects of the nonlinearities.

IL-We-3 8:30–9:30 Ballroom C
Invited Lecture
Chair: Ball, John
Abstract: Weak universality of the KPZ equation
Hairer, Martin
Warwick University
Abstract: The KPZ equation is a popular model of one-dimensional interface propagation. From heuristic consideration, it is expected to be “universal” in the sense that any “weakly asymmetric” or “weakly noisy” microscopic model of interface propagation should converge to it if one sends the asymmetry (resp. noise) to zero and simultaneously looks at the interface at a suitable large scale. In particular, although the equation is not even classically well-posed, any “reasonable” numerical method is expected to converge to it, possibly with limiting parameters different from the “naive” ones. However, the only microscopic models for which this has been proven so far exhibit some very particular structure allow to perform a microscopic equivalent to the Hopf-Cole transform. In this talk, we will see that there exists a rather large class of continuous models of interface propagation for which convergence to KPZ can be proven rigorously. The main tool for both the proof of convergence and the identification of the limit is the recently developed theory of regularity structures, but with an interesting twist.

IL-We-4 10:00–11:00 Ballroom A
Invited Lecture
Chair: Shu, Chi-Wang
Abstract: What’s new in high-dimensional integration? – designing Quasi Monte Carlo for applications
Sloan, Ian
The University of New South Wales
Abstract: This paper, based on an invited talk at ICIAM 2015, describes an approach to high-dimensional integration, developed over the past 15 years, in which the numerical integration rule is a Quasi Monte Carlo rule (i.e. an equal weight rule) especially designed to match a particular problem.

IL-We-5 10:00–11:00 Ballroom B
Invited Lecture
Chair: Görtzschel, Martin
Abstract: Computational Progress in Linear and Mixed Integer Programming
Bixby, Bob
Gurobi Optimization
Abstract: We describe progress in linear and mixed-integer programming (MIP) algorithms and software over the last 25 years. As a result of this progress, modern linear programming (LP) codes are now capable of robustly and efficiently solving instances with multiple millions of variables and constraints. With these LP advances as a foundation, MIP then provides a mathematical framework that enables the representation and solution to provable optimality of a wide range of real-world planning and scheduling models, this in spite of the fact that MIP is NP-hard. Describing the remarkable performance improvements in MIP over the last 25 years and the mathematical underpinnings will central to this talk.

IL-We-6 10:00–11:00 Ballroom C
Invited Lecture
Chair: Xu, Zongben
Abstract: Solution Techniques for the Stokes System: A Priori and A Posteriori Modifications, Resilient Algorithms
Wohlmuth, Barbara
Technische Universität München
Abstract: This article proposes modifications to standard low order finite element approximations of the Stokes system with the goal of improving both the approximation quality and the parallel algebraic solution process. Different from standard finite element techniques, we do not modify or enrich the approximation spaces but modify the operator itself to ensure fundamental physical properties such as mass and energy conservation. Special local a priori correction techniques at reentrant corners lead to an improved representation of the energy in the discrete system and can suppress the global pollution effect. Local mass conservation can be achieved by an a posteriori correction to the finite element flux. This avoids artifacts in coupled multi-physics transport problems. Finally, hardware failures in large supercomputers may lead to a loss of data in solution subdomains. Within parallel multigrid, this can be compensated by the accelerated solution of local subproblems. These resilient algorithms will gain importance on future extreme scale computing systems.

IL-We-7 11:10–12:10 Ballroom A
Invited Lecture
Chair: Xu, Jinchao
Abstract: On Convergence of the Multi-Block Alternating Direction Method of Multipliers
Ye, Yingyu
Stanford University
Abstract: The alternating direction method of multipliers (ADMM), after a long
“silent” period, has recently witnessed a “renaissance” in many application domains, such as signal and image processing, statistics analysis, machine learning, engineering computation, etc. The convergence of ADMM was established 40 years ago when two blocks of variables are alternatively updated. It is computationally beneficial to extend the ADMM directly to the case of a multi-block convex minimization problem. However, whether or not the ADMM is convergent was open until very recently. In this paper, we summarize recent approaches and results in this pursuit. Mainly, we illustrate an example to show that the direct extension of ADMM is not necessarily convergent with three or more blocks. On the positive side, we present the result that, if in each iteration one randomly and independently permutes the updating order of variable blocks followed by the standard Lagrangian multiplier update, then ADMM will converge in expectation when solving certain convex optimization problems.

IL-We-9 11:10–12:10 Ballroom C
Invited Lecture
Chair: Misui, Taketomo
Abstract:
On the interplay between intrinsic and extrinsic instabilities of spatially localized patterns
Nishiura, Yasumasa
Tohoku University
Abstract: Spatially localized dissipative structures are observed in various fields, such as neural signaling, chemical reactions, discharge patterns, granular materials, vegetated landscapes and binary convection. These patterns are much simpler than single living cells, however they seem to inherit several characteristic “living state” features, such as self-replication, self-healing and robustness as a system. Adaptive switching of dynamics can also be observed when these structures collide with each other, or when they encounter environmental changes in the media. These behaviors stem from an interplay between the intrinsic instability of each localized pattern and the strength of external signals. To understand such an interplay, we explore the global geometric interrelation amongst all relevant solution branches of a corresponding system with approximate unfolding parameters. For instance, it has been uncovered that large deformation at strong collision is mapped into the network of unstable patterns called scatterers, and that an organizing center for 1D pulse generators is a double homoclinic orbit of butterfly type. We will illustrate the impact of this approach by presenting its application in relation to the decision making process of amoeboid locomotion and hierarchical structures of ordered patterns arising in reaction diffusion systems and binary fluids.

EM-We-D-01 13:30–15:30 311A
Third Workshop on Hybrid Methodologies for Symbolic-Numeric Computation - Part V of VIII
For Part 1, see EM-Mo-D-01
For Part 2, see EM-Mo-E-01
For Part 3, see EM-Tu-D-01
For Part 4, see EM-Tu-E-01
For Part 6, see EM-We-E-01
For Part 7, see EM-Th-BC-01
For Part 8, see EM-Th-D-01
Organizer: Giesbrecht, Mark
Univ. of Waterloo
Organizer: Kaltofen, Erich
North Carolina State Univ.
Organizer: Sa League
Univ. Pierre & Marie Curie
Organizer: Zhi, Lihong
Acad. of Mathematics & Sys. Sci.
Abstract: Hybrid symbolic-numeric computation methods, which first appeared some twenty years ago, have gained considerable prominence. Algorithms have been developed that improve numeric robustness (e.g., in quadrature or solving ODE systems) using symbolic techniques prior to, or during, a numerical solution. Likewise, traditionally symbolic algorithms have seen speed improvements from adaptation of numeric methods (e.g., lattice reduction methods). There is also an emerging approach of characterizing, locating, and solving “interesting nearby problems”, wherein one seeks an important event (for example a nontrivial factorization or other useful singularities), that in some measure is close to a given problem (one that might have only imprecisely specified data). Many novel techniques have been developed in these complementary areas, but there is a general belief that a deeper understanding and wider approach will foster future progress. The problems we are interested in are driven by applications in computational physics (quadrature of singular integrals), dynamics (symplectic integrators), robotics (global solutions of direct and inverse problems near singular manifolds), control theory (stability of models), and the engineering of large-scale continuous and hybrid discrete-continuous dynamical systems. Emphasis will be given to validated and certified outputs via algebraic and exact techniques, error estimation, interval techniques and optimization strategies.

Our workshop will follow up on the seminal SIAM-MSRI Workshop on Hybrid Methodologies for Symbolic-Numeric Computation held in November 2010 and the Fields Institute Workshop on Hybrid Methodologies for Symbolic-Numeric Computation, November 16-19, 2011 at the University of Waterloo, Canada. We will provide a forum for researchers on all sides of hybrid symbolic-numeric computation.

EM-We-D-01-1 13:30–14:30
A Bounded Degree SOS Hierarchy for Polynomial Optimization
Lasserre, Jean Bernard
LAAS-CNRS
Abstract: We provide a new hierarchy of semidefinite relaxations for polynomial optimization which combines some advantages of the standard LP- and SDP-relaxations: (a) the size of the matrix associated with the semidefinite constraint is the same and fixed in advance, (b) finite convergence occurs at the first step of the hierarchy for an important class of convex problems, and (c) using point evaluations and rank-one matrices make an efficient implementation possible as testified on numerical examples.

EM-We-D-01-2 14:30–15:00
Smaller SDP for SOS Decomposition
Bican, Xia
Peking Univ.
Abstract: Two types of polynomials, convex cover polynomials and split polynomials, are defined. A convex cover polynomial or a split polynomial can be decomposed into several smaller subpolynomials such that the original polynomial is SOS if and only if the sub-polynomials are all SOS. Thus the original SOS decomposition problem can be reduced equivalently to smaller sub-problems.

EM-We-D-01-3 15:00–15:30
Applications of Homogenization in Semidefinite Relaxations of Polynomial Optimization Problems
Guo, Feng
Dalian Univ. of Tech.
Abstract: Recently, polynomial optimization with semidefinite relaxations has been well studied. It applies Positivstellensatz and sums-of-squares technique to relax a polynomial optimization problem to semidefinite programs. Due to the Positivstellensatz, most of the results are only valid for problem with compactness assumption. In this talk, we solve this problem by the technique of homogenization. We apply this method to the problems of minizing rational functions, semi-infinite polynomial programming and semidefinite representations of non-compact semi-algebraic sets.

EM-We-D-02 13:30–15:30 309A
Differential Algebra and Related Topics - Part V of VIII
For Part 1, see EM-Mo-D-02
For Part 2, see EM-Mo-E-02
For Part 3, see EM-Tu-D-02
For Part 4, see EM-Tu-E-02
For Part 6, see EM-We-E-02
For Part 7, see EM-Fri-D-02
For Part 8, see EM-Fri-E-02
Organizer: Feng, Ruyong
Acad. of Mathematics & Sys. Sci.,CAS
Organizer: Guo, Li
Rutgers Univ. at Newark, USA
Organizer: Gao, Xiao-Shan
Acad. of Mathematics & Sys. Sci.,Chinese Acad. of Sci.
Abstract: This meeting is to offer an opportunity for participants to present original research, to learn of research progress and new developments on differential algebra and related topics, particularly, the applications of differential algebra to control theory, physics, chemistry, biology and so on.

EM-We-D-02-1 13:30–14:30
Reductions for Integration, Summation and Creative Telescoping
Li, Ziming
KLMM,AMSS,Chinese Acad. of Sci.
Abstract: We review recent progress in reduction algorithms for integration, summation and creative telescoping. These algorithms allow to determine integrability and summability more efficiently, and help us to separate the computation of telescopes from that of the corresponding certifcatives. Moreover, the properties of the reductions, together with a structure theorem on computable rational functions, enable us to give a criterion on the existence of telescopes for mixed hypergeometric terms.

EM-We-D-02-2 14:30–15:00
Combinatorial Hopf Algebra and the Feedback Loop in Nonlinear Control Theory
Abstract: An integrable self-adaptive moving mesh scheme in 3 dimension.

EM-We-D-02-3 15:00–15:30
Two Applications of Polynomial Systems
Du, Daniel Center for Applied Mathematics, Tianjin Univ.
Hou, Qing-Hu Tianjin Univ.
Wang, Rong-Hua Center for Combinatorics, Nankai Univ.

Abstract: We present two applications of polynomial systems in combinatorics. The first application comes from the problem of counting lattice walks restricted to the non-negative octant. We confirm the conjecture proposed by Bostan, Bousquet-Melou, Kauers and Mezö that states that most 3-dimensional walks associate with a group of an infinity order. The second application is using polynomial system to prove Ramanujan type congruences.

**MS-We-D-03** 13:30–15:30 306A
Applied Integrable Systems - Part V of V
For Part 1, see MS-Mo-D-03
For Part 2, see MS-Mo-E-03
For Part 3, see MS-Tu-D-03
For Part 4, see MS-Tu-E-03

Organizer: Hu, Xing-Biao Inst. of Computational Mathematics, Chinese Acad. Sci. (CAS), China
Organizer: Kajiwara, Kenji Kyushu Univ.
Organizer: Kakei, Saburo Rikkyo Univ.
Organizer: Maruno, Kenichi Waseda Univ.

Abstract: In recent years, there have been major developments in applications of integrable systems. Originally, integrability has been recognized through solitons, which are particle-like nonlinear waves in various physical systems. Thanks to rich mathematical structure of integrable systems, recent applications of integrable systems extend to a wide range of pure/applied mathematics and physical sciences, such as algebraic geometry, combinatorics, probability theory, numerical algorithms, cellular automata, (discrete) differential geometry, computer visualizations, statistical physics, nonlinear physics and so on. The purpose of this minisymposium is to bring together researchers to discuss recent advances on various aspects of applied integrable systems.

**MS-We-D-03-1** 13:30–14:00
Algebraic Solutions of Soliton Equations and Their Applications
Ohya, Yasuhiro Kobe Univ.

Abstract: For some soliton equations, a class of algebraic solutions is constructed by using the direct method. The solutions are expressed in terms of the Gram type determinants. The algebraic structure and some properties of the solutions are discussed.

**MS-We-D-03-2** 14:00–14:30
Darboux Transformations of the Dunkl-shift Operator
Tsuchimoto, Satoshi Kyoto Univ.

Abstract: We will discuss the Darboux transformations of the Dunkl-shift operator containing the shift and the reflection operators. Then we show that this transformation leads to an exceptional orthogonal polynomial system of the Bannai-Ito polynomials.

**MS-We-D-03-3** 14:30–15:00
A Focusing and Defocusing Complex Short Pulse Equation
Feng, Bao-Feng The Univ. of Texas-Pan American

Abstract: In this talk, we are concerned with a focusing and defocusing complex short pulse equation (CSPE). Similar to the NLS equation, the focusing CSPE admits bright soliton solution, while the defocusing CSPE possessing dark soliton solution. Through a reduction from 2D TL hierarchy and Hirota’s bilinear method, multi-soliton solutions of both bright type and dark type are constructed for focusing and defocusing complex short pulse equation, respectively. This is a joint work with Dr. Ohta at Kobe University and Dr. Maruno at Waseda University of Japan.

**MS-We-D-03-4** 15:00–15:30
An Integrable Self-adaptive Moving Mesh Scheme in 3 Dimension

Maruno, Kenichi Waseda Univ.

Abstract: An integrable self-adaptive moving mesh scheme of the local induction approximation equation for a vortex filament is constructed. Various numerical simulations by the self-adaptive moving mesh schemes are shown.
Evolutionary games on complex networks
Organizer: Mu, Yiteng Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: Evolutionary game theory on complex networks has been a hot topic in recent years and gotten lots of interest of scientist from many different fields, like economics, biology, control theory, computer science, etc. By playing games on complex networks, we are able to simulate the interaction among large population with certain social structures. Then the evolution of individual strategy and global equilibrium can help explain the emergence and change of social norms. Additionally, evolutionary games can bring great insight into human behavior, which is the focus of many fields. At the beginning, most related research focused on simulation because of great difficulty on analysis. Kinds of networks with more details have been studied, reflecting different aspects of the story, such as noise, time delay, coevolution of games and networks, etc. In this minisymposia, we will introduce the latest development on the topic, both theoretically and numerically. The reporters are young scientists in this field for many years. Dr. Chunyan Yang is associate professor in Nankai University and her research interests include evolutionary game theory and evolutionary dynamics. Dr. Luolu Luo is associate professor in Wenzhou University, with his research interests including evolutionary game theory and complex networks. Dr. Guanyan Zhu is associate professor in New York University, USA and studies control theory, game theory and applications. Dr. Zhigang Cao is assistant professor in CAS and studies game theory.

Mechanisms to Foster Cooperation in Public Goods Games
Zhang, Chunyan Nankai Univ.
Zengqiang, Chen Nankai Univ.

Abstract: We study the effectiveness of punishing defectors in the evolution of cooperation in rational populations within the threshold public goods game models. We establish two scenarios: defectors will suffer possible punishment whether the game succeeds or not, and defectors will incur punishment only when game fails. A key observation of this work is that given this assumption, punishing free riders can significantly influence the evolution outcomes, and the results are driven by the specific components.

Coexistence of Competing Strategies in Interaction Networks
Zhang, Jianlei Nankai Univ.

Abstract: In this work for two-strategy evolutionary games in structured populations, we follow a different approach, bypassing the requirement for explicit knowledge about the exact payoffs, by encoding the payoffs into the willingness of any player to switch from her current strategy to the competing one. Theoretical computations and numerical simulations show that the evolutionary dynamics are intrinsically regulated by contact relationships specified by the network topologies of the populations.

Equilibrium in Repeated Stackelberg Public Goods Game with Two-leaders-one-follower and One-step-memory
Mu, Yiteng Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: Stackelberg game with hierarchical and information structures has broad background and applications in practice. In this paper the repeated Stackelberg Public Goods game with 2 leaders and 1 follower will be investigated, where the leaders’ strategies are with one-step-memory with respect to the follower’s action. The players act simultaneously at each step. By constructing the state transfer graph for given leaders’ strategy profile, the equilibrium of the game can be solved.

Structure Identification of Uncertain Dynamical Networks
Fu, Xinchu Shanghai Univ.

Abstract: Topological structures and node dynamics of dynamical networks have important influence on their dynamical behaviors. In practical applications, not all of them can be well determined beforehand; therefore this talk investigates the structure identification of an uncertain dynamical network coupled with complex-variable chaotic systems. Based on the Barbalat’s lemma, corresponding network estimators are designed for identifying the unknown or uncertain topological structure and node dynamics. This talk is based on joint work with Zhaoyan Wu.

Analysis of nonsmooth PDE systems with applications to material failure - Part I of II
Organizer: Kees, Dorothee Univ. of Kassel
Organizer: Thomas, Marita Weierstrass Inst. for Applied Analysis & Stochastics (WIAS Berlin)

Abstract: The understanding and modeling of failure processes in solids is a central task in materials sciences. Mathematical models typically result in highly nonlinear, coupled systems of partial differential equations, where additional nonsmooth constraints, as for instance the unidirectionality of evolution processes or the impenetrability of the material, have to be taken into account. This minisymposium intends to discuss recent advances in the mathematical treatment of failure phenomena, and brings together scientists from the fields of modeling, analysis, and numerics. Analytical methods and numerical strategies both for (quasi-)static and rate-dependent, non-smooth failure models will be presented.

On Reconstruction of A Spot Welding Area in An Electric Conductive Body
Itou, Hiromichi Tokyo Univ. of Sci.

Abstract: We consider a mathematical model for nondestructive evaluation of spot-welds between two electric conductive plates. By use of injecting a direct current and measuring the resulted voltage on the accessible side of welded plates, we establish an extraction formula of location of tips of the welds from the single measurement. This is based on joint research with Masaru Ikehata (Hiroshima University, Japan) and Akira Sasamoto (National Institute of Advanced Industrial Science and Technology, Japan).

Phase Field Approximation of Cohesive Fracture Models
Iurlano, Flaviana IAM, Univ. of Bonn
Conti, Sergio IAM, Univ. of Bonn
Focardi, Matteo Univ. of Florence

Abstract: We present an approximation result for Barenblatt’s cohesive fracture energies in the case of antiplane shear. The regularizing functionals are damage energies of Ambrosio–Tortorelli type and the approximation is obtained in the sense of Gamma-convergence. We also discuss how the phase field convergence scheme can be applied to approximate different special fracture models, like Griffith’s model, Dugdale’s model, and models with surface energy density having a power-law growth at small openings.

Analysis of Nonsmooth PDE Systems with Applications to Material Failure – Towards Dynamic Fracture
Thomas, Marita Weierstrass Inst. for Applied Analysis & Stochastics (WIAS Berlin)

Abstract: This talk addresses certain key points arising in the analysis of material failure models. Processes, such as plasticization, damage, delamination, and fracture, are often considered rate-independent and interact with other phenomena such as heat conduction, inertia, and viscous material properties. Mathematically, this leads to nonlinear PDE systems of mixed type also involving non-smooth constraints. A general analytical framework for such systems is discussed and applied to the treatment of models describing dynamic fracture.
revealed in the crust of this area and local earthquake occurrence is thought to be closely related to the crustal heterogeneities. Significant low-velocity anomalies are revealed in the lower crust along the faults, which may reflect fluids in the lower crust. A high-velocity anomaly extended into the upper mantle beneath the hypocenter of the main shock of Landers earthquake is also discovered. The tomographic results indicate the Moho reflection phases are very helpful in improving the spatial resolution of crustal tomographic images.

The Landau-de Gennes model is a variational model for nematic liquid crystals which shares similarities with the Ginzburg-Landau theory. In this talk I will consider minimizers of such energies with different constraints as models of granular media, molecular self-assembly and biological swarm phenomena that is absent for Ginzburg-Landau vortices. This is joint work with Radu Ignat (Toulouse).

Abstract: This focus symposium is on mathematical problems related to Ginzburg-Landau model with application in physics and materials science including but not limited to: superconductivity, superfluidity, liquid crystals, and polymers. The speakers in this minisymposium will describe their recent research, including the development and structure of singular solutions of the Ginzburg-Landau-type problems and the dynamics of vortex motion. This minisymposium is sponsored by the SIAM Activity Group on Mathematical Aspects of Materials Science (SIAG/MS).

Interaction between Neel Walls
Moser, Roger
Univ. of Bath

Abstract: Neel walls are transition layers in thin ferromagnetic films. We study a model with some similarities to Ginzburg-Landau vortices, but with a twist: while we may have a global topological constraint, there is no quantized topological charge for individual singularities. As a consequence, there is an interaction between the core of one Neel wall and the tail of another, a phenomenon that is absent for Ginzburg-Landau vortices. This is joint work with Radu Ignat (Toulouse).

Applications of Phase Tracking in Seismic Imaging
Demanet, Laurent
MIT
Li, Yinyue Elita
Massachusetts Inst. of Tech.

Abstract: Interpretation of seismic shot records in terms of coherent atomic events can be formulated as a hard, nonconvex optimization problem. I will present a method that empirically finds the global minimum of this functional in the case of simple synthetic shot records, even when events cross. I will discuss applications to low-frequency extrapolation and parameter-based FWI. Joint work with Yinyue Elita Li.

Schedules: Wednesday Sessions

MS-We-D-08 13:30–15:30 202B
The Ginzburg-Landau Model and Related Topics - Part I of IV
For Part 2, see MS-We-E-08
For Part 3, see MS-Th-BC-08
For Part 4, see MS-Th-D-08
Organizer: Golovaty, Dmitry
The Univ. of Akron
Organizer: Gori, Tiziana
New Mexico State Univ.

Abstract: The focus of the minisymposium is on mathematical problems related to Ginzburg-Landau model with application in physics and materials science including but not limited to: superconductivity, superfluidity, liquid crystals, and polymers. The speakers in this minisymposium will describe their recent research, including the development and structure of singular solutions of the Ginzburg-Landau-type problems and the dynamics of vortex motion. This minisymposium is sponsored by the SIAM Activity Group on Mathematical Aspects of Materials Science (SIAG/MS).

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A Hybrid Numerical Scheme Based on ONAD Method and Weighted Runge-Kutta Discontinuous Galerkin Method for Wavefield Modeling
He, Xijun
Tsinghua Univ.
Yang, Dinghui
Tsinghua Univ.

Abstract: We develop an effective numerical hybrid scheme based on finite difference method (FDM) and discontinuous Galerkin method (DGM) for seismic wavefield modeling. The FDM we used is a newly-developed and efficient numerical method—the optimal nearly-analytic method, which can effectively suppress the numerical dispersion. The DGM we used is a weighted Runge-Kutta DGM. The scheme combines the advantages of the FDM and DGM. It splits the computational domain into several parts, where the DGM is used to model the complex structures, whereas the FDM is used for regular parts. A transition zone is needed to combine them together. The variables near the transition zone should be carefully treated to keep the accuracy and stability of the hybrid scheme. Numerical tests show that the hybrid scheme is effective, and can save CPU time and storage space.

On the Minimization of Energy Functionals Consisting of Competing Attractive and Repulsive Potentials
Choksi, Rustum
McGill Univ.

Abstract: We consider existence and properties of minimizers for a class of nonlocal functionals consisting of power-law attractive and repulsive potentials of Coulombic type. This is joint work with I. Topaloglu (McMaster University) and, in part, R. Feteau (Simon Fraser University).

Abstract: High resolution seismic tomographic images for the crust of the 1992 Landers earthquake (M 7.3) region in southern California are determined by wave-equation-based traveltime seismic tomography technique using reflected phases from Moho discontinuity (PmP, SmS) as well as first arriving P and S waves. Detailed 3-D P and S wave velocity models and Poisson’s ratio structure of the crust are given in this paper. Strong heterogeneities are revealed in the crust of this area and local earthquake occurrence is thought
Nonlocal problems: modeling, analysis and computation - Part II of III
For Part 1, see MS-Tu-E-09
For Part 3, see MS-We-E-09

Organizer: Lipton, Robert
LSU
Organizer: Du, Qiang
Columbia Univ.
Organizer: Mengesha, Tadele
The Univ. of Tennessee

Abstract: The goal of this minisymposium is to bring together researchers working on problems related to the nonlocal modeling of physical phenomena and their mathematical analysis. The theme is on modeling, analysis and simulation with a focus on nonlocal continuum equations that arise from applications. The session will be multifaceted so as to cover work related nonlocal modeling and computational simulations of models, and analytical and numerical aspects such as well-posedness of nonlocal stationary and evolution equations, regularity of solutions and numerical approximations.

Nonlocal mathematical models arise naturally in many important fields and they are found to be useful where classical (local) models cease to be predictive. Moreover, nonlocal models are suitable for multiscale modeling as they can be effective in capturing the underlying nonsmooth microscale fields. An example is peridynamics, a nonlocal reformulation of the basic equations of motion of continuum mechanics, which is being used to model cracks and discontinuities in materials. Other areas of application include image processing, modeling population aggregation, wave propagation, pattern formation, and porous media flow. In this minisymposium, research works which have produced novel analytical and numerical methods for nonlocal problems will be presented.

▶ MS-We-D-09-1 13:30–14:00
Localization of Nonlocal Gradients and Some Applications in Variational Convergence
Mengesha, Tadele
The Univ. of Tennessee

Abstract: We study weighted directed difference quotients and their localization to classical notions of derivatives in several function spaces. We will characterize vector fields in the space of Sobolev spaces, space of BV functions and space of BD functions in a unified way. As an application, we will use the characterization and localization mechanism to compute Gamma limits of some nonlocal functionals that appear in peridynamics.

▶ MS-We-D-09-2 14:00–14:30
A Fast Numerical Method for Nonlocal Models
Wang, Hong
Univ. of South Carolina

Abstract: Peridynamic/nonlocal diffusion models provide a very effective modeling of phenomena with long range interactions and nonlocal behavior. However, these models involve complex and singular integral operators. Consequently, resulting numerical methods generate dense matrices, and the solution of the direct solvers require $O(N^3)$ computational complexity and $O(N^2)$ memory for a problem of size $N$. This imposes significant computational and memory challenges in realistic applications. We present a fast numerical method for a nonlocal diffusion model by exploiting the structure.

▶ MS-We-D-09-3 14:30–15:00
A Nonlocal Strain Measure for Digital Image Correlation
Lehoucq, Richard
Sandia National Labs

Abstract: We propose a nonlocal strain measure for use with digital image correlation (DIC). Whereas the traditional notion of compatibility (strain as the derivative of the displacement field) is problematic when the displacement field varies substantially either because of measurement noise or material irregularity, the proposed measure remains robust, well-defined and invariant under rigid body motion. Moreover, when the displacement field is smooth, the classical and nonlocal strain are in agreement.

▶ MS-We-D-09-4 15:00–15:30
Local Boundary Conditions in Nonlocal Problems
Celiker, Fatih
Wayne State Univ.

Abstract: We study nonlocal wave equations on bounded domains related to peridynamics. We display a methodology for enforcing boundary conditions (periodic, antiperiodic, Dirichlet, or Neumann) through an integral convolution. We present a numerical study of the approximate solution, study convergence order with respect to the polynomial order of approximation, and observe optimal convergence. We depict solutions for each boundary condition to ascertain the behavior of waves under the nonlocal theory.

Robustness and Fragility of Complex Networks
Organizer: Wu, Jun
National Univ. of Defense Tech.
Organizer: Li, Daqing
Beihang Univ.

Abstract: Networks are everywhere. Examples include the Internet, metabolic networks, electric power grids, supply chains, urban road networks, the world trade web, among many others. In the past few years, the discovery of small-world and scale-free properties has stimulated a great deal of interest in studying the underlying organisng principles of various complex networks. The investigation of complex networks has become an important area of multidisciplinary area involving physics, mathematics, operations research, biology, social sciences, informatics, and other theoretical and applied sciences. The function and performance of complex networks rely on their robustness, i.e., the ability to maintain connectivity when a fraction of their nodes or edges is damaged. For example, modern society is dependent on its critical infrastructure networks: communication, electrical power, rail, and fuel distribution networks. Failure of any of these critical infrastructure networks can bring the ordinary activities of work and recreation to a standstill. Other examples of network robustness arise in nature, such as the food webs robustness to biodiversity loss. Due to its broad applications, the robustness or fragility of complex networks has received growing attention.

This mini-symposium aims to provide a forum for recent developments in the field of network robustness and fragility. Topics of interest include, but are not limited to: robustness of weighted networks; robustness of directed networks; robustness of spatial networks; robustness of Network of Networks; robustness of temporal networks; cascading failure in complex networks; attack and defence in complex networks; optimization of network robustness; application of network robustness.

▶ MS-We-D-10-1 13:30–14:00
Spectral Measure of Structural Robustness in Complex Networks
Wu, Jun
National Univ. of Defense Tech.

Abstract: We introduce the concept of natural connectivity as a measure of structural robustness in complex networks. The natural connectivity has an intuitive physical meaning and a simple mathematical formulation. Physically, it characterizes the redundancy of alternative paths and can also be interpreted as the Helmholtz free energy of a network. Mathematically, the natural connectivity can be derived from the graph spectrum as an average eigenvalue and increases strictly monotonically with the addition of edges.

▶ MS-We-D-10-2 14:00–14:30
Spatial Propagation of Cascading Failures
Li, Daqing
Beihang Univ.

Abstract: Transportation systems, power grids and even financial systems are organized by large amount of components and their intrinsic complex coupling. When these systems are disturbed randomly or maliciously, the local perturbations can propagate through the coupling and ultimately induce global cascading failures and catastrophic consequences. The spatial propagation of cascading failures has become a fundamental question in the study of complex system reliability.

▶ MS-We-D-10-3 14:30–15:00
Cascading Failures in Networks of Networks
Havlin, Shlomo
Bar Ilan Univ.

Abstract: Network science have been focused on the properties of a single isolated network that does not interact or depends on other networks. In reality, many real-networks, such as power grid, protein networks, transportation and communication infrastructures interact and depend on other networks. I will present a framework for studying the vulnerability of networks of independent networks. In interdependent networks, when nodes in one network fail, they cause dependent nodes in other networks to also fail.

▶ MS-We-D-10-4 15:00–15:30
Fragility and Node Importance in Epidemics on Temporal Networks
Holme, Petter
Sungkyunkwan Univ.

Abstract: Infectious disease outbreaks are determined both by the network topology and timing of human contacts. We argue that the temporal component is as important as the topology. We will review some structural factors that influence disease spreading, and how to identify important nodes. We will present a framework for studying the vulnerability of networks of interdependent networks. In interdependent networks, when nodes in one network fail, they cause dependent nodes in other networks to also fail.
Disease spread on dynamics contact networks

Organizer: Su, Yangfeng
Fudan Univ.

Abstract: Epidemic spreading may be affected by the dynamical topological structures. Here we study disease dynamics in populations in which infection occurs along the links of a dynamical contact network. We obtain the formula of the basic reproduction number $R_0$. It is found that it can have a larger impact on the spread of the disease. This model illustrates how dynamics network topology can affect disease dynamics.

Complex contagions through direct and indirect interactions

Organizer: Zhang, Juping
Shanxi Univ.

Abstract: Contagion in structured populations is one of the most interesting topics in the study of complex systems. We model this process with a threshold model in homogeneous and heterogeneous networks. Both direct and indirect influences are considered. It was found that the addition of indirect interactions can speed up spreading process with the high possibility of global cascading. Moreover, the heterogeneities of individual threshold and population structure have dual effects on the contagion process.

Social contagions on complex networks

Organizer: Tang, Ming
Web Sci. Center, Univ. of Electronic Sci. & Tech. of China

Abstract: A key ingredient in social contagions is reinforcement. We first propose a general social contagion model with reinforcement. Then, we develop a unified edge-based compartmental theory to analyze this model. Using a spreading threshold model to understand the memory effect. We find that the memory characteristic markedly affects the dynamics. Strikingly, we uncover a transition phenomenon in which the dependence of the final adoption size on some key parameters.

Analysis of structure preserving algorithms for solving the nonlinear eigenvalue problem.

Organizer: Meerbergen, Karl
KU Leuven

Abstract: The development of linearizations of matrix polynomials that preserve interesting structures that a matrix polynomial might have has been a very active topic of research in the last decade, since they have applications in the development of structure preserving algorithms for computing eigenvalues. Despite this fact, only one linearization is known that preserves, for Hermitian polynomials, the Hermitian structure and the sign characteristic. In this talk, we present a large family of linearizations with these properties.

Vanishing viscosity limit and incompressible flow - Part II of II

Organizer: Lopes Filho, Milton
Universidade Federal do Rio de Janeiro

Abstract: Much of the research on fluid dynamics is concerned with the phenomena of boundary layers and of turbulence. Both of these physical phenomena are associated with flows in the large Reynolds number regime and therefore are directly related with the mathematical study of the vanishing viscosity limit. Vanishing viscosity limits are an active area of research, focusing both on boundary-related issues, motivated by boundary layers, and on bulk flow issues more closely related to turbulence. The purpose of this minisymposium is to showcase current developments along both these lines, primarily focusing on describing the behavior of solutions of the Navier-Stokes and related system when viscosity is very small.

Vanishing viscosity limit and incompressible flow - Part I of II

Organizer: Jiuhua, Quansen
Capital Normal Univ.

Abstract: Many real systems can be properly described by complex networks whose nodes represent individuals or organizations and links denote the interactions among them. One of the original and primary reasons for studying networks is to understand the mechanisms by which diseases and other things (information, computer viruses, rumors) spread over them. The topology structures of complex networks can have dramatic effects on the behavior of epidemic dynamical processes running on top of it, and it has attracted a great deal of interest due to its practical real-world implications is the modeling of epidemic spreading on contact networks. This minisymposia is mainly focused on the research of modeling approaches of infectious disease on complex networks, and how the topology structures of complex networks affect the behaviors of disease spread.

Complex contagion through direct and indirect interactions

Organizer: Tang, Ming
Web Sci. Center, Univ. of Electronic Sci. & Tech. of China

Abstract: Complex contagions through direct and indirect interactions. The model is to show current developments along both these lines, primarily focusing on describing the behavior of solutions of the Navier-Stokes and related system when viscosity is very small.
Approximation of 2D Euler Equations by the Second-Grade Fluid Equations with Dirichlet Boundary Conditions
Zang, Aibin Yichun Univ.
Abstract: We prove three results. First, we establish convergence of the solutions of the second-grade model to those of the Euler equations provided \( \nu = O(\varepsilon^2) \), as \( \varepsilon \to 0 \). Second, we prove equivalence between convergence and vanishing of the energy dissipation in a suitably thin region near the boundary, in the asymptotic regime \( \nu = O(\varepsilon^{\alpha}), \nu/\varepsilon^2 \to \infty \) as \( \alpha \to 0 \). Finally, we obtain an extension of Kato’s classical criterion to the second-grade fluid model.

CONTINUOUS DEPENDENCE ESTIMATE FOR STOCHASTIC BALANCE LAWS DRiven BY LEVY NOISE
Biswas, Imran Tata Inst. of Fundamental Research
Abstract: We are concerned with multidimensional stochastic balance laws driven by Levy processes. Using BV solution framework, we derive explicit continuous dependence estimate on the nonlinearities of the entropy solution. This result is used to show the error estimate for the stochastic vanishing viscosity method. In addition, we establish fractional BV estimate for vanishing viscosity approximations in case the the noise coefficient depends on both the solution and spatial variable.

The Viscosity Method for the Homogenization of Soft Inclusions
Yoo, Minha National Inst. for Mathematical Sci.
Abstract: In this talk, we consider periodic soft inclusions \( \Omega \), with periodicity \( \varepsilon \) such that the solution \( u_\varepsilon \) satisfies semi-linear elliptic equations of non-divergence in \( \Omega_\varepsilon = \Omega \setminus \varepsilon \), with a Neumann data on \( \partial \Omega \). The difficulty lies in the non-divergence structure of the operator where the standard energy method based on the divergence theorem can not be applied. The main object is developing a viscosity method to find the homogenized equation satisfied by the limit of \( u_\varepsilon \), called as \( u_0 \), as \( \varepsilon \) approaches to zero. We introduce the concept of a compatibility condition between the equation and the Neumann condition on the boundary for the existence of uniformly bounded periodic correctors. The concept of second corrector has been developed to show the limit \( u_0 \) is the viscosity solution of a homogenized equation.

Optimality in reduced order modeling and inversion - Part II of II
For Part I, see MS-Tu-E-14
Organizer: Mamonov, Alexander Schlumberger
Organizer: Zaslavsky, Mikhail Schlumberger-Doll Research
Abstract: In a wide range of applications, the model reduction techniques provide a well-established tool for efficient approximation of the transfer functions of large dynamical systems with multiple inputs and outputs. Rather recently the range of applications was extended to reducing the complexity of inverse problems. The optimal choice of the parameters of reduced order models (ROMs) is crucial for the efficiency of the approach. We will consider different ways to parameterize ROMs, for both forward and inverse PDE problems, and discuss optimal sampling of the parameters.

Efficiencies in Global Basis Approximation for Model Order Reduction in Diffuse Optical Tomography
Kilmer, Misha Tufts Univ.
Abstract: We consider the nonlinear inverse problem of reconstructing parametric images of optical properties from diffuse optical tomographic data. Recent work shows MOR techniques have promise in mitigating the computational bottleneck associated with solving for the parameters. In this talk, we give an algorithm for efficiently computing the approximate global basis needed in MOR by utilizing a new interpretation of the transfer function and by capitalizing on Krylov recycling in a novel way.

The Iterative Rational Krylov Algorithm for Bilinear Descriptor Systems
Benner, Peter Max Planck Inst. for Dynamics of Complex Technical Sys.
Abstract: We discuss the extension of the bilinear rational Krylov algorithm (BIRKA) to descriptor systems. Recently, its linear analogue IRKA was extended to linear descriptor systems by Gugercin, Stykel, and Wyatt. We follow the same approach for the extension of BIRKA to bilinear descriptor systems. We also show how this algorithm can be used for model order reduction of nonlinear systems based on (quadratic-)bilinearization. [Joint work with Pawan Goyal and Mian Ilyas Ahmad]
Moreover, we will discuss the existing problems and outline open issues as main challenges in the near future.

**Maximise Viral Spreading Using Percolation-Based Algorithm**

Hu, Yangqing School of Mathematics, Southwest Jiaotong Univ. 
Feng, Ling Inst. of High Performance Computing, A-Star 
Ji, Shenggong School of Mathematics, Southwest Jiaotong Univ. 
Jin, Yuliang Ecole normale superieure

Abstract: Online social networks (OSN) have transformed information spreading from centraлизed broadcasting to autonomous transmission, such that viral spreading becomes increasingly important. Studies have focused on finding efficient computation algorithms to accurately locate the set of most influential individuals. Here we look into the fundamental nature of viral spreading in terms of the super-critical phase in percolation theory, and construct a simple measure to accurately predict spreadability of a node using only local information.

**Lie Symmetries, Solutions and Conservation laws of nonlinear differential equations - Part I of III**

For Part 2, see MS-We-E-16

For Part 3, see MS-Th-BC-16

Organizer: Khaliq, Chaudry Masood North-West Univ., Matfik Campus 
Zheng, Lijun Zhejiang Sci-Tech Univ.

Abstract: This mini-symposium is devoted to all research areas that are related to nonlinear differential equations and their applications in science and engineering. The main focus of this mini-symposium is on the Lie symmetry analysis, conservation laws and their applications to ordinary and partial differential equations. These differential equations could originate from mathematical models of diverse disciplines such as architecture, chemical kinetics, civil engineering, ecology, economics, engineering, fluid mechanics, biology and finance. Other approaches in finding exact solutions to nonlinear differential equations will also be discussed. This includes, but not limited to, asymptotic analysis methodologies, bifurcation theory, inverse scattering transform techniques, the Hirota method, the Adomian decomposition method, and others.

**Multiple Wave Solutions and Conservation Laws of the DKJM Equation via Symbolic Computation**

Adem, Abdullahi Rashid North-West Univ.

Abstract: Exact solutions and conservation laws for the Date-Jimbo-Kashiwara-Miwa equation with the aid of symbolic computation are presented. The exact solutions of the Date-Jimbo-Kashiwara-Miwa equation are constructed by using the multiple exp-function method, which is a generalization of Hirota’s perturbation scheme. The solutions obtained involve generic phase shifts and wave frequencies. Furthermore, infinitely many conservation laws are derived by using the multiplier method.

**Compacton Solutions of Integrable Equations**

Chen, Aiyong Guilin Univ. of Electronic Tech.

Abstract: In this talk, we use dynamical system theory to several types of fully nonlinear wave equations. These equations can be reduced to planar polynomial differential systems by transformation of variables. We treat these polynomial differential systems by phase space analytical technique. The results of our study demonstrate that there exist close connection between nilpotent singular points and compactons. Moreover, we find some new elliptic function compactons instead of well-known trigonometric function compactons by analyzing nilpotent points. Two new compactons induced by singular elliptic are also obtained. We obtain yet kink-compacton and half-compacton solutions for some integrable equations.

**Exact Solutions and Conservation Laws of the (3+1)-Dimension Sinh-Gordon Equation**

Magalakwe, Gabriel North-West Univ.

Abstract: A second order nonlinear wave equation, namely, the (3+1)-dimension sinh-Gordon equation, which appears in a diverse range of physics and engineering such as solid state physics, non-linear optics and stability of fluid motion is studied. Lie symmetry analysis together with the (G'-G) expansion type parabolic-parabolic models is used to obtain travelling wave solutions for the underlying equation. In addition, we derive conservation laws of the (3+1)-dimension sinh-Gordon equation using the direct method.

**Reaction-diffusion-advection systems arising from mathematical biology modeling chemotaxis - Part III of III**

Organizer: Xiang, Tian Renmin Univ. of China

Abstract: As with all living organisms, single cells and bacteria sense and respond to the environment where they live. The primary way these organisms achieve this is through the phenomenon of chemotaxis. Chemotaxis is the oriented movement of cells and organisms along chemical gradients, as a response to gradients of the concentration of chemical substances. It plays a significant role in many biological fields, and chemotaxis models have been successfully applied to the aggregation patterns in bacteria, slime molds, skin pigmentation patterns, angiogenesis in tumor progression and wound healing and many other examples. Therefore, a huge number of works, both theoretical and experimental, have been devoted to exploring and hence understanding the mechanistic basis of chemotaxis.

In 1953, Patlak contributed the first mathematical idea to model chemotaxis. In 1970s, Keller and Segel introduced a classical and important chemotaxis model (a parabolic-parabolic quasi-linear PDE system) to describe the aggregation process of cellular slime mold by chemical attractions. These pioneering works have initiated an intensive mathematical investigation of the (Patlak-)Keller-Segel model and chemotaxis models have become one of the best study models in mathematical biology over the last 40 years.

Despite its simple looking, the Keller-Segel model exhibits the phenomenon of cell aggregation, which is usually modeled by time-dependent solutions blowing up in finite or infinite time. Thus, the issue whether or not the solutions of the proposed chemotaxis models are globally bounded or blow-up becomes the main concern in studying K-S type models. It is a very active research subject; up to now, there are at least 5 beautiful survey papers, Horstmann [1,2], Hillen and Painter [3], Wang [4] and Blanchet [5], where one is provided with a broad survey on the progress of various chemotaxis models as well as with a rich selection of references. The key phenomena are: no blow-up in 1-D, a breakthrough made in Winkler [6]. Chemotaxis phenomenon has been also successfully applied to other equations, for instance, Navier-Stokes equations, see [7] for a glimpse. Thus, in our mini-symposium, our group topics center mainly on reaction-diffusion-advection systems modeling chemotaxis arising from mathematical biology. We bring together active researchers to share and discuss their very recent results on boundedness versus blow-up, critical mass blow-up, global existences, stability and large time behavior so as to understand more insights on the mechanism of chemotaxis. This mini-symposium will definitely stimulate more inspirations.

**Global Existence and Boundedness in A Quasilinear Chemotaxis-Navier-Stokes System with Position Dependent Sensitivity**

Ishida, Sachiko Tokyo Univ. of Sci.

Abstract: This talk will give global existence and global-in-time boundedness in a coupled chemotaxis and Navier-Stokes system with quasilinear diffusion and position dependent sensitivity in 2D domains. Most of studies on
chemotaxis-fluid systems without position dependent sensitivity use an energy estimate to find global solutions. In this research the energy estimate is unnecessary, and it makes the proof easy and the system could have the position sensitivity. Finally we can construct the global bounded weak solutions.

**MS-We-D-17-2**

**Boundedness in A Three-dimensional Chemotaxis-haptotaxis Model**

Cao, Xinru  
Dalian Univ. of Tech.

Abstract: We study the chemotaxis-haptotaxis system on bounded domains with smooth boundary. We show that the chemotaxis dominate the boundedness of solution.

**MS-We-D-17-3**

**Eventual Smoothness and Asymptotics in A Three-dimensional Chemotaxis System with Logistic Source**

Lankeit, Johannes  
Paderborn Univ.

Abstract: We prove existence of weak solutions to the chemotaxis system

\[ u_t = \Delta u - \nabla \cdot (u \nabla v) + \kappa u - \mu u^2 \]

\[ v_t = \Delta v - v + u \]

under homogeneous Neumann boundary conditions in a smooth bounded convex domain \( \Omega \subset \mathbb{R}^3 \), for arbitrary values of \( \mu > 0 \). Additionally, we show that, after some time, these solutions become classical solutions, provided that \( \kappa \) is not too large.

**MS-We-D-17-4**

**Boundedness of Solutions to A Quasilinear Degenerate Keller-Segel System with Subcritical Sensitivity**

Yokota, Tomomi  
Tokyo Univ. of Sci.

Abstract: We study boundedness of weak solutions to a quasilinear degenerate Keller-Segel system with subcritical sensitivity on \( \mathbb{R}^3 \). Global existence of weak solutions to the system was established by Sugiyama-Kunii (2006) and Ishida-Yokota (2012). However, it is still open whether (KS) admits a weak solution that is uniformly-in-time bounded. In this talk we would like to give an answer to this open question.

**MS-We-D-18**

**Nonlinear aggregation-diffusion equations - Part III of III**

13:30–15:00

For Part 1, see **MS-Tu-D-18**

For Part 2, see **MS-Tu-E-18**

Organizer: Huang, Yanghong  
Univ. of Manchester  
Imperial College London

Organizer: Yao, Yao  
Univ. of Wisconsin Madison

Abstract: A large variety of stationary and dynamic patterns are the results of the competition between nonlinear diffusion and aggregation effects, including the well-known Patlak-Keller-Segel system. These systems are typically modelled from the collective behaviour of individuals, as the kinetic and/or continuum description based on mean-field type PDEs. The aim of the mini-symposium is to highlight recent advances on the interplay between the aggregation and the nonlinear diffusion, by developing tools to understand the long time asymptotics, stability of the patterns, related functional inequalities and numerical schemes.

**MS-We-D-18-1**

**Nonlocal Interaction Equations: Phenomena and Structures**

Slepcev, Dejan  
Carnegie Mellon Univ.

Abstract: Nonlocal-interaction equations are a basic model of biological aggregation. We discuss several phenomena: patterns that stable steady states exhibit, rolling traveling swarms in heterogeneous environments, and phase separation (flock / empty space) in systems with a local dispersal mechanism. A new model of aggregation which takes into account that long-range interactions are not additive will also be discussed. Based on joint work with Carrillo, Eisenbeis, Pego, Simon, Topaloglu, and Wu.

**MS-We-D-18-2**

**Derivation of A Modified Keller-Segel Model for E.coli Chemotaxis**

Tang, Min  
shanghai jiao tong Univ.

Abstract: Recently, the biochemical pathways regulating the flagellar motors were uncovered. This knowledge gave rise to a class of kinetic-transport equations, that takes into account an intra-cellular molecular content and which relates the tumbling frequency to this information. Starting from the pathway based kinetic model, we derive the standard Kinetic-transport models that heuristically include tumbling frequencies depending on the pathwise gradient of chemotactic signal and a modified Keller-Segel Model whose coefficients depends on the environmental change.

**CP-We-D-18-3**

**Mixed Convection From An Impermeable Exponentially Stretching Surface**

Patil, Prabhuigouda M.  
Karnatak Univ., Dharwad-580003

Abstract: In this paper we focus on to obtain non-similar solutions numerically for steady two dimensional double diffusive mixed convection boundary layer flows over an impermeable exponentially stretching sheet in an exponentially moving free stream under the influence of chemically reactive species. The nonlinear partial differential equations governing the flow, temperature and species concentration fields are presented in non-dimensional form with the help of suitable non-similar transformations. The resulting final non-dimensional set of coupled nonlinear partial differential equations is solved by using an implicit finite difference scheme in combination with the Newton’s linearization technique. The effects of various non-dimensional physical parameters on velocity, temperature and species concentration fields are discussed. We have also discussed the variations of the skin friction and heat and mass transfer rate parameters. The results reveal that the streamwise co-ordinate significantly influences the flow, thermal and solutal concentration fields which display the importance of non-similar solutions.

**CP-We-D-18-4**

**On the Richards Equation with Hysteresis**

El Behi-Gornostaeva, Elena  
Technical Univ. Munich

Abstract: We study an evolution problem for filtration trough porous media, where we account for hysteresis in the saturation vs. pressure constitutive relation. Mass conservation and Darcy’s law yield a nonlinear diffusion equation, which is coupled with boundary conditions of Neumann and Signorini type. Existence of solutions for the resulting system of PDEs with hysteresis nonlinealities is established, which also applies to the case where the hysteresis operator is of Preisach-type.

**MS-We-D-19**

**Variational Multiscale and Stabilised finite element methods for incompressible flow problems**

13:30–15:30

Organizer: Barrenechea, Gabriel R.  
Univ. of Strathclyde

Abstract: Since their appearance in the mid nineties, Variational Multiscale Methods (VMS) have become a extremely powerful tool to derive new finite element methods in different areas of continuous mechanics. These methods can be applied directly, in a multiscale finite element framework, or can be used as a formal tool to derive perturbed formulations, by either solving the fine scale problems, or model their impact in the macroscale formulation. This latter process has been extensively studied and used as a tool to derive new stabilised finite element formulations. The main focus of this minisymposium is to discuss recent developments in VMS-related approaches for fluid mechanics problems. Talks will range from more theoretical aspects of these sort of methods (and their relationship to stabilisation) to more challenging three-dimensional applications involving turbulent flows. This minisymposium will be organised by myself and Prof. Tomas Chacon-Rebollo, from Universidad de Sevilla, Spain, and University of Bordeaux, France. The reason I am signing this with only my name is because I have not had access to Prof. Chacon’s pin. I hope this doesn’t present a big problem.

**MS-We-D-19-1**

**Old and New Results in Positivity Preserving Schemes for the Convection-diffusion Equation**

Barrenechea, Gabriel R.  
Univ. of Strathclyde

Abstract: In this talk I will review some recent results in nonlinear schemes for the convection-diffusion equation. The common point in all the schemes I present is the fact that they respect the Discrete Maximum Principle. The main part of the talk will be devoted to the Algebraic Flux Correction scheme, for which stability and convergence analyses will be presented. But, I will also present some more recent results on variations and improvements.

**MS-We-D-19-2**

**Spectral Variational Multi-Scale Method for the Two-dimensional Convection-diffusion Problem**

Dia, Ben Mansour  
King Abdullah Univ. of Sci. & Tech.

Chacon Rebollo, Tomas  
Univ. of Sevilla

Abstract: We present an extension of the spectral-VMS method developed in [1] to the two-dimensional convection-diffusion equations as the first step towards a generalization of the method for incompressible flow model. The cited method relies on the computation of the sub-grid contribution which is based on the resolution of eigenvalue problem of a certain normal operator. For the numerical experiments, we consider rectangular elements Q1 so that the contribution of the sub-grid solution is analytically computable.

**MS-We-D-19-3**

14:30–15:00
Finite Element Approximation of A Projection-based VMS Turbulence Model with Wall Laws.
Rubino, Samuele
Univ. of Seville
Chacon Rebollo, Tomas
Univ. of Sevilla
Abstract: We propose a Variational MultiScale (VMS) model improved with wall laws for the simulation of wall-bounded incompressible flows in laminar and turbulent regimes. This is a finite element projection-based VMS model. In view of proposing a viable numerical method, we also consider the combination with stabilized ad-hoc discretizations that perfectly fit into the VMS framework. The numerical analysis and the validation through the simulation of some relevant flow situations justify the interest of our approach.

A New Hybrid Finite Element Scheme for Advection-diffusion-reaction Equation
Araya, Rodolfo
Universidad de Concepcion
Abstract: In this work we will introduce a new hybrid scheme to discretize the advection-diffusion-reaction equation. This new method relaxes the continuity of the primal variable through the action of Lagrange multipliers, while assuring the strong continuity of the normal component of the flux (dual variable). We prove existence and uniqueness of a solution for this method as well as convergence estimates. Also, we propose a face-residual a posteriori error estimator which is used to improve the optimal convergence.

A New Hybrid Finite Element Scheme for the BGK Equation
Organizer: Sun, Jiguang
Michigan Technological Univ.
Organizer: Cakoni, Fioralba
Univ. of Delaware
Organizer: Peters, Stefan
AG inverse problems, Univ. Bremen
Abstract: We characterize interior transmission eigenvalues of penetrable anistropic acoustic scattering objects by a technique known as inside-outside duality. Under certain conditions on the anisotropic material coefficients of the scatterer, the inside-outside duality allows to rigorously characterize interior transmission eigenvalues from multi-frequency far field data. This theoretical characterization moreover allows to derive a simple numerical algorithm for the approximation of interior transmission eigenvalues. It will also be a great chance for these researchers to exchange new ideas and discuss the future development for the transmission eigenvalue problem.

Determining Transmission Eigenvalues of Anisotropic Inhomogeneous Media from Far Field Data
Peters, Stefan
AG inverse problems, Univ. Bremen
Abstract: We characterize interior transmission eigenvalues of penetrable anisotropic acoustic scattering objects by a technique known as inside-outside duality. Under certain conditions on the anisotropic material coefficients of the scatterer, the inside-outside duality allows to rigorously characterize interior transmission eigenvalues from multi-frequency far field data. This theoretical characterization moreover allows to derive a simple numerical algorithm for the approximation of interior transmission eigenvalues.

Some Estimates for Interior Transmission Problems and Their Applications
Qu, Fenglong
Yantai Univ.
Yang, Jiaqing
Xi'an Jiaotong Univ.
Zhang, Bo
Acad. of Mathematics & Sys. Sci., CAS
Abstract: In this talk we will give some estimates for the refractive index of interior transmission problems on the use of interior transmission eigenvalues, the radius of the scattering domain, the first Dirichlet eigenvalue of the negative Laplace operator. Then we prove some uniqueness results for the retractive index based on the estimates for interior transmission problems and some related estimates for the direct scattering problems.

Some Results on Electromagnetic Transmission Eigenvalues
Zeng, Fang
Chongqing Univ.
Sun, Jiguang
Michigan Technological Univ.
Abstract: The electromagnetic interior transmission problem is a boundary value problem, which is neither elliptic nor self-adjoint. In this paper, we show that, in general, there do not exist purely imaginary electromagnetic transmission eigenvalues. For constant index of refraction, we prove that it is uniquely determined by the smallest (real) transmission eigenvalue. Finally, we show that complex transmission eigenvalues must lie in a certain region in the complex plane. The result is verified by examples.

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Minisymposium on discontinuous Galerkin method: recent development and applications - Part II of VIII
For Part 1, see MS-Tu-E-21
For Part 2, see MS-Tu-E-21
For Part 3, see MS-Th-BC-20
For Part 4, see MS-We-D-21
For Part 5, see MS-Th-BC-21
For Part 6, see MS-Th-BC-21
For Part 7, see MS-Th-BC-21
For Part 8, see MS-Fr-D-21
Organizer: Xu, Yan
Univ. of Sci. & Tech. of China
Organizer: Shu, Chi-Wang
Brown Univ.
Abstract: Over the last few years, discontinuous Galerkin (DG) methods have found their way into the main stream of computational sciences and are now being successfully applied in almost all areas of natural sciences and engineering. The aim of this minisymposium is to present the most recent developments in the design and theoretical analysis of DG methods, and to discuss relevant issues related to the practical implementation and applications of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

Fast Solver for the Local Discontinuous Galerkin Discretization of High Order Time-dependent Partial Differential Equations
Xu, Yan
Univ. of Sci. & Tech. of China
Abstract: In this paper, we will develop a fast iterative solver for the system of local discontinuous Galerkin (LDG) spatial discretization and implicit time marching method for high order time-dependent PDEs. Being implicit in time, the severe time step ($\Delta t \propto \Delta x^p$), with the $p$-th order of the PDEs' restriction for explicit methods will be removed. We demonstrate an efficient, practical multigrid (MG) method for solving the equations.

Convergence of Discontinuous Galerkin Schemes for Front Propagation with Obstacles
Cheng, Yingda
Michigan State Univ.
Abstract: We study semi-Lagrangian discontinuous Galerkin (SLDG) and Runge-Kutta discontinuous Galerkin (RKDG) schemes for some front propagation problems in the presence of an obstacle term, modeled by a non-linear Hamilton-Jacobi equation in one space dimension. New convergence results and error bounds are obtained for Lipschitz regular data. These “low regularity” assumptions are the natural ones for the solutions of the studied equations.

High Order Asymptotic Preserving Nodal Discontinuous Galerkin IMEX Schemes for the BGK Equation
Xiong, Tao
Univ. of Houston
Abstract: In the asymptotic limit, the BGK equation in the hyperbolic scaling will lead to the macroscopic models such as Euler and compressible Navier-Stokes equations. We develop high-order asymptotic preserving (AP) schemes based on micro-macro decomposition, which involve nodal discontinuous Galerkin (DG) spatial discretization and globally stiffly accurate implicit-explicit (IMEX) temporal discretization. It is formally demonstrated that the scheme, when the Knudsen number is small, becomes a local DG discretization of the compressible Navier-Stokes equations.
Cooperative Control and Optimization for High-order Multi-agent Systems

Organizer: Chen, Fei  Xiamen Univ.

Abstract: In many biological and engineering applications, the overall system consists of a number of subsystems that are required to work cooperatively to achieve a common goal. Each subsystem is interconnected with a subset of the other subsystems to form a multi-agent network, where local information sharing is essential in achieving certain group-level goals. The proposed session brings expertise in the analysis of multi-agent systems to the audience of the International Congress on Industrial and Applied Mathematics (ICIAM). The session in particular emphasizes high-order dynamics, directed network topologies, gain adaptation, and distributed optimization. The invited articles cover synchronization of multi-agent systems with general linear dynamics, leader-following formation control for nonlinear multi-agent systems with directed topologies, consensus with gain adaptation over a directed graph, and distributed finite-time optimization of second-order multi-agent systems.

Leader-following Formation Control for Nonlinear Multi-agent Systems with Directed Topologies

Lyu, Jing  Beihang Univ.

Abstract: This paper presents two nonsmooth leader-following formation protocols for identical and nonidentical Lipschitz nonlinear multi-agent systems, respectively, with directed communication network topologies. In these protocols, the given directed network topology is only required to contain a spanning tree, while the states of all the agents are available locally within their neighborhoods. The proposed formation protocols are applied to multi-spacecraft systems in deep-space exploration, with numerical simulations demonstrating the effectiveness of the theoretical results.

Synchronization of Multi-agent Systems with General Linear Dynamics

Chen, Michael Z. G.  The Univ. of Hong Kong

Abstract: In this talk, we present new results for general linear multi-agent systems with general linear dynamics. We first present a new condition for the stability of the system. We then present a new approach for the design of decentralized control laws for the system. Finally, we illustrate the use of these new results with an example.

Consensus with Gain Adaptation over A Directed Graph

Mei, Jie  Harbin Inst. of Tech. Shenzhen Graduate School

Abstract: In this paper, we will introduce a gain adaptation strategy, where the gains in the algorithms are varying and updated by using only local information. To analyze the consensus stability, we will establish a connection between a strongly connected directed graph and an undirected graph. We will propose fully distributed algorithms for second-order MAS with heterogeneous varying inertias, second-order MAS with intrinsic Lipschitz nonlinear dynamics, and MAS with general linear dynamics.

Distributed Finite-time Optimization of Second-order Multi-agent Systems

Lin, Peng  UESTC

Abstract: In this paper, a distributed finite-time optimization problem with general differentiable convex objective functions is studied for second-order multi-agent systems. A distributed algorithm is presented in which the interaction gain of each agent can be adaptively adjusted according to the variation of the gradients of the local objective functions. A corresponding condition is then given to guarantee that all agents reach a consensus while minimizing the team performance function in finite time.

Study on social networks

Organizer: Fan, Ying  Beijing Normal Univ.

Abstract: This symposium address the analysis of social networks. Including: 1 How to get Social system data? 2. Using graphs and matrices represent social relations. 3. Basic properties of networks. 4. Some examples: on-line social network, social media networks, scientific citation network 5. Algorithm for networks analysis 6. Centrality and community And so on.

Evolution of Social Media Networks

Li, Menghui  Beijing Inst. of Sci. & Tech. Intelligence

Abstract: By analyzing the growth of empirical social media networks, we found that triadic links plays a dominant role in the evolution of networks. Thus, we propose a simple reaction-diffusion-like coevolving model, in which individuals are activated to create links based on their states, influenced by local dynamics and their own intention. It is shown that the model can reproduce the remarkable properties observed in empirical social media networks.
Numerical Methods for Stochastic PDE and Uncertainty Quantification - Part 4
Organizer: ZHOU, TAO AMSS, the Chinese Acad. of Sci.
For Part 4, see MS-Th-BC-25
For Part 1, see MS-Mo-D-57
Abstract: We consider a novel algorithm for the Monte Carlo solution of least-squares polynomial approximation problems in a collocation framework. A standard Monte Carlo approach would draw samples according to the density of orthogonality. Our proposed algorithm samples with respect to the (weighted) pluripotential equilibrium measure of the parametric domain, and subsequently solves a weighted least-squares problem, with weights given by evaluations of the Christoffel function. We validate the algorithm with theoretical analysis and computational results.

MS-We-D-26 13:30–15:35 110
Recent advances in modeling, analysis, and methodology for interface and free boundary problems and applications - Part III of V
For Part 1, see MS-Mo-D-57
For Part 2, see MS-Mo-E-57
For Part 4, see MS-We-E-26
For Part 5, see MS-Th-BC-25
Organizer: Li, Zhilin North Carolina State Univ.
Organizer: Lai, Ming-Chih National Chiao Tung Univ.
Abstract: In recent years, there is increasing interest in the development and application of advanced computational techniques for interface problems, problem with free boundary and moving interface, fluid-structure interactions driven by applications in physiology, fluid mechanics, material sciences, porous media flow, and biology. There are also many numerical approaches developed in recent years. The aim of this mini-symposium is to bring together scientists in the field to exchange their recent research discoveries and future directions, to stimulate novel ideas, and to nurture collaborations. The focus would be on Cartesian grid method such as the immersed boundary/interface methods, the level set methods, fluid-structure interactions, and applications.

A Christoffel Least Squares Algorithm for Collocation Approximations
Narayan, Akil Univ. of Massachusetts Dartmouth
Jagelman, John Sandia National Laboratories
ZHOU, TAO AMSS, the Chinese Acad. of Sci.
Abstract: We consider a novel method for the Monte Carlo solution of least-squares polynomial approximation problems in a collocation framework. A standard Monte Carlo approach would draw samples according to the density of orthogonality. Our proposed algorithm samples with respect to the (weighted) pluripotential equilibrium measure of the parametric domain, and subsequently solves a weighted least-squares problem, with weights given by evaluations of the Christoffel function. We validate the algorithm with theoretical analysis and computational results.

Simulations of Passive and Active Motion of Blood Elements
Misbah, Chaouqi CNRS & Univ. J. Fourier, Grenoble
Abstract: Blood is primarily composed by RBCs (Red Blood Cells), but contains also other components, like leukocytes. RBCs are transported passively by flow, while leukocytes, besides the passive transport, can also move in an active way, when they fight infections, thanks to an internal machinery. Experiments will be discussed on modeling passive and active motion, and various intricate numerical results are presented.

A Fast Parallel Algorithm for Direct Simulation of Particulate Flows Using Conforming Grids
Minev, Peter Univ. of Alberta
Abstract: This study presents a development of a parallel direction splitting algorithm for flows containing rigid particles. The main novelty of this method is that the grid is fit to the boundaries of the particle and therefore the spatial discretization is very accurate. The equations of motion of each particle are discretized explicitly and the resulting velocity is imposed as boundary condition for the split momentum equations. The pressure is fictitiously extended within the particles.

An Augmented Method for Stokes-Darcy Coupling and Applications
Li, Zhilin North Carolina State Univ.
Abstract: A new finite difference method based on Cartesian meshes is proposed for solving the fluid structure interaction between a fluid flow modeled by the Stokes equations and a porous media modeled by the Darcy’s law. The idea is to introduce several augmented variables along the interface between the fluid flow and the porous media so that the problem can be decoupled as several Poisson equations. The augmented variables should be chosen so that the Beavers-Joseph-Saffman (BJS) and other interface conditions are satisfied. In the discretization, the augmented variables have co-dimension one compared with that of the primitive variables and are solved through the Schur complement system. A nontrivial analytic solution with a circular interface is constructed to check second order convergence of the proposed method. Numerical examples with various interfaces and parameters are also presented. Some simulations show interesting behaviors of the fluid structure interaction between the fluid flow and the porous media. The computational framework can be applied to other multi-phase and multi-physics problems.
The Immersed Interface Method for Flow Around Rigid Objects in 3D
Xu, Sheng Southern Methodist Univ.

Abstract: In this talk, I will present some development of the immersed interface method toward distributed memory parallel computing for flow around complex rigid objects in 3D. I will present how to compute necessary jump conditions for the immersed interface method using triangular mesh representation of complex interfaces, and how to handle communication among processors in parallel computing for moving objects.

MS-We-D-26-5 15:10–15:35
Sharp Interface Methods for Fluid-Solid Interaction
Bhalla, Amreet Pal Singh Univ. of North Carolina - Chapel Hill
Griffith, Boyce Univ. of North Carolina at Chapel Hill

Abstract: Fluid-solid systems are common in scientific and engineering applications. The immersed boundary (IB) method is a general approach to modeling such systems. A difficulty of this IB formulation is that the pressure and viscous stress are generally discontinuous at fluid-solid interfaces. We will describe extensions of the IB method that sharply resolve stress discontinuities at fluid-solid interfaces. These methods can be viewed as extensions of the immersed interface method to non-interfacial (codimension-0) solid bodies.

MS-We-D-27 13:30–15:30 407
Decoupling methods for multi-physics and multi-scale problems - Part II of VIII
For Part 1, see MS-Tu-E-27
For Part 3, see MS-We-E-27
For Part 4, see MS-Th-BC-27
For Part 5, see MS-Th-D-27
For Part 6, see MS-Th-E-27
For Part 7, see MS-Fr-D-27
For Part 8, see MS-Fr-E-27

Organizer: Hu, Xiaoming Missouri Univ. of Sci. & Tech.
Organizer: Xu, Xuejun Inst. of Computational Mathematics, AMSS, CAS

Abstract: The inherent multi-physics and multi-scale features of many real world problems accentuate the importance to develop efficient and stable numerical methods for the relevant PDEs, especially the decoupling methods. Although great efforts have been made for solving these problems, many practical and analytical challenges remain to be solved. This mini-symposium intends to create a forum for junior and senior researchers from different fields to discuss recent advances on the decoupling methods for multi-physics and multi-scale problems with their applications.

MS-We-D-27-1 13:30–14:00
Time-Parallel Methods Based on Waveform Relaxation for Time-dependent Differential Equations
Song, Bo Xi’an Jiaotong Univ.
Jiang, Yao-Lin Xi’an Jiaotong Univ./Jinan University.

Abstract: The parareal algorithm, which permits to solve evolution problems in a time parallel fashion, has created a lot of attention over the past decade. In this talk, we will present a parareal algorithm with the waveform relaxation propagator as the fine propagator for initial-value and time-periodic differential equations. Especially, we will present two new parareal algorithms for time-periodic problems. Several realistic applications are also provided to illustrate the effectiveness of the new strategies.

MS-We-D-27-2 14:00–14:30
A Simple Treatment of the Corner Singularity Using Nonconforming Elements for Cavity Flow
Sheen, Dongwoo Seoul National Univ.

Abstract: In the numerical simulation of cavity flow, one needs to pay attention to deal with the well-known corner singularities. In particular, if conforming finite elements are used, special care should be taken of. In this talk we will introduce a simple treatment of corner singularity using stable cheapest nonconforming elements for cavity flow. Several numerical comparisons show superiority with the proposed method.

MS-We-D-27-3 14:30–15:00
Solving An Inverse Stefan Problem by A Novel Fictitious Domain Method
Huang, Jianguo Shanghai Jiao Tong Univ.

Abstract: A novel fictitious domain method is proposed for solving an inverse Stefan problem, in order to determine a free boundary during the phase transition, by means of measurement data of temperature and heat flux at the left end point of the material. Theoretical analysis and numerical simulation are provided to show the computational performance of the method. This is a joint work with Huashan Sheng and Wan Tang from Shanghai Jiao Tong University.

MS-We-D-28 13:30–15:30
FLOW, HEAT AND MASS TRANSFER IN FLUID MECHANICS - Part II of II
For Part 1, see MS-Tu-E-28

Organizer: P A, Dinesh M S Ramaiah Inst. of Tech., Bangalore

Abstract: The objective of this mini-symposium is to develop a mathematical model and to investigate analytically or numerically and systematically the study of flow problems; free, forced and mixed convection heat and mass transfer arises in fluid mechanics. Study of such type of problems in fluid mechanics has received enormous attention of many researchers in industrial applications, scientific and engineering fields. The subject is multidisciplinary and completely encircles the main views of applied mathematics to areas like soil physics, hydrogeology, petroleum industry, filtration of solids from liquids, chemical engineering, biological systems, oil reservoir modelling, food processing, casting and welding, manufacturing processes, the dispersion of pollutants into environment, storage of nuclear waste, power plant stream lines, bio mechanical, polymerization, fluid mechanics, filters, chemical, mechanical, paper and cloth industry, geophysics, chemistry etc.

The following are the abstracts proposed for the mini symposia:

A numerical solution for the free convective, unsteady, laminar convective heat and mass transfer in a MHD viscoelastic fluid along a semi-infinite vertical plate with Soret and Dufour effects is presented. The Walters-B liquid model is employed to simulate medical creams and other rheological media encountered in biotechnology and chemical engineering. This rheological model introduces supplementary terms into the momentum conservation equation. The dimensionless unsteady, coupled, and non-linear partial differential conservation equations for the boundary layer regime are solved by an efficient, accurate and unconditionally stable finite difference scheme of the Crank-Nicolson type.

The aim of this study is to present chemical reaction and thermohydrodynamic effects on MHD mixed convective incompressible flow, viscous and electrically conducting fluid over a radiate isothermal inclined plate embedded in a porous medium in the presence of heat source/sink. We analyzed the effects of thermal radiation, viscous dissipation and magnetic field on boundary layer flow of a nanofluid past a nonlinear permeable stretching/shrinking sheet. In this problem the flow of a viscoelastic fluid due to a linearly and quadratically stretching sheet and heat transfer characteristics using variable thermal conductivity is studied in the presence of a non uniform heat source/sink. The thermal conductivity is assumed to vary as a liner function of temperature. The similarity transformation is used to convert the governing partial differential equations of flow and heat transfer into a ordinary differential equations. Shooting method is used to obtain the numerical solution for the resulting boundary value problem. The effects of Chandrashekar Number, Prandt Number, Non-Uniform heat source/sink parameters and Variable Thermal Conductivity parameter on the dynamics are shown graphically in several plots. In this paper, a multi grid analysis of the effect of surface roughness in hydrodynamic lubrication of a porous journal bearing with a heterogeneous slip/no-slip surface is studied. In the traditional lubrication theory, it has been assumed that all the bearing surfaces are smooth but it is unrealistic study for the bearing with small film thickness. This study reports a numerical investigation of the convective flow and heat transfer in a square porous cavity with partially active thermal walls. Five different heating and cooling zones are considered along the vertical walls.
Prasad, Ramakrishna  
JNTUH

Abstract: For Heterogeneous catalysts, their catalytic activity and selectivity are dependent on chemical composition, microstructure and reaction conditions. Hence it is worth doing research over the composition of the catalyst and the reaction conditions that will enhance its performance. In this paper a computational intelligence approach based on adaptive social behavior optimization (ASBO) for catalyst composition optimization to enhance the resulting yield or to achieve the maximal objective is proposed.

► MS-We-D-29-3  
14:30–15:00  
Radiation and Magnetfield Effects on Boundary Layer Flow of a Dissipative Nanofluid Past A Nonlinearly Permeable Stretching/shrinking Sheet  
Naramgari, Sandeep  
VIT Univ.

Abstract: We analyzed the effects of thermal radiation, viscous dissipation and magnetic field on boundary layer flow of a nanofluid past a nonlinearly permeable stretching/shrinking sheet. The governing equations are solved numerically by using Shooting Technique. Effects of Thermal Radiation parameter, Magneticfield parameter, Viscous Dissipation parameter, Brownian motion parameter, Suction parameter, Thermodiffusivity parameter and the stretching/shrinking sheet parameter on velocity, temperature, concentration, skin friction, local Nusselt and Sherwood numbers are thoroughly investigated and presented through graphs and tables.

► MS-We-D-29-4  
15:00–15:30  
FINITE DIFFERENCE ANALYSIS OF UNSTEADY MHD FREE CONVECTION IN A WALTER `S B VISCOELASTIC FLOW PAST A SEMI-INFINITE VERTICAL PLATE  
Bangalore, Ruchi Kumar  
VIT Univ.

Abstract: A numerical solution for the free convective, unsteady laminar convective heat and mass transfer in a MHD viscoelastic fluid along a semi-infinite vertical plate with Soret and Dufour effects is presented. The Walters-B liquid model is employed to simulate medical creams and other rheological liquids encountered in biotechnology and chemical engineering. The dimensionless unsteady, coupled, and non-linear partial differential equations are solved by an efficient and unconditionally stable finite difference scheme of the Crank-Nicolson type.

MS-We-D-29  
13:30–15:30  
High Order Numerical Methods for PDEs - Hybrid Methods - Part II of III  
For Part 1, see MS-Tu-E-29  
For Part 2, see MS-We-E-29

Organizer: Jung, Jae-Hun  
SUNY at Buffalo
Organizer: Don, Wai Sun  
Ocean Univ. of China/Brown Univ.
Organizer: Ling, Leesun  
Hong Kong Baptist Univ.
Organizer: Yoon, Jungho  
Ewha W. Univ.

Abstract: In this mini-symposium, we gather together researchers in the areas of high order numerical approximation methods for PDEs and Images and their applications. The mini-symposium will present recent progress in high-order methods including ENO/WENO methods, spectral methods, discontinuous Galerkin methods, and radial basis function methods. Particularly we are interested in the recent development of the hybrid methods that combine the different high order methods in a single frame. The proposed mini-symposium will gain a significant attention since it will provide a valuable opportunity for researchers from different areas to investigate the idea of hybridization of their methods.

► MS-We-D-29-1  
13:30–14:00  
Single Domain Hybrid Fourier Continuation Method and WENO Finite Difference Scheme for Conservation Laws  
Li, Peng  
Beijing Inst. of Tech.
Gao, Zhen  
Ocean Univ. of China
Don, Wai Sun  
Ocean Univ. of China/Brown Univ.
Xie, Shusen  
Ocean Univ. of China

Abstract: We introduce a hybrid FC method and WENO finite difference scheme, together with the high order multi-resolution algorithm in solving hyperbolic conservation laws in a single domain framework, as opposed to a multi-domain framework. The Hybrid scheme conjugates an efficient shock-capturing WENO-Z nonlinear scheme in discontinuous stencils with an essentially non-dissipative and non-dissipative linear FC method in smooth stencil s. Extensive examples regarding the efficiency and accuracy of the Hybrid scheme will be shown.

► MS-We-D-29-2  
14:00–14:30  
Investigation of Hybrid Fourier-Continuation Method and WENO Finite Difference Scheme for Complicated Flow Structures  
Li, Peng  
Beijing Inst. of Tech.
Gao, Zhen  
Ocean Univ. of China
Don, Wai Sun  
Ocean Univ. of China/Brown Univ.

Abstract: We investigate a hybrid Fourier-Continuation method and fifth order WENO finite difference scheme in the simulation of complex flows containing both discontinuous and complex small scale structures. The Hybrid scheme is used to keep the discontinuities captured by the WENO-Z scheme in an essentially non-oscillatory manner while the smooth parts are highly resolved by an linear, essentially non-dissipative and non-disspersive Fourier Continuation method which can also speedup the computation of the overall scheme.
Optimal Control of Surface PDEs

Hinze, Michael
Universität Hamburg

Abstract: We consider optimal control of surface PDEs with special emphasis on tailored discretization of the underlying optimal control problem. We numerically analyze the errors stemming from the discretization of the surface and of the finite element discretization of the surface PDE. We present numerical examples which support our numerical findings.

Error Estimates and Superconvergence of Mixed Finite Element Methods for Bilinear Optimal Control Problems

Chen, Yanping
South China Normal University

Abstract: In this work, we investigate error estimates and superconvergence of the bilinear elliptic optimal control problems by Raviart-Thomas mixed finite element methods. The control variable enters the state equation as a coefficient. The state and the co-state variables are approximated by Raviart-Thomas mixed finite element spaces and the control variable is approximated by piecewise linear or constant functions. We obtain a priori and a posteriori error estimates for the control variable and coupled state variable. Finally, we obtain the superconvergence property between average $L^2$ projection and the approximation of the control variable, the convergence order is $h^2$.

Integration, Approximation and Discrepancy - Part I of III

For Part 2, see MS-We-E-31
For Part 3, see MS-Th-BC-31

Organizer: Ullrich, Mario
Johannes Kepler Univ.

Organizer: Gnewuch, Michael
Christian-Albrechts-Universität zu Kiel

Abstract: Numerical methods for high dimensional integration and approximation play a crucial role in a number of applications. This session brings together experts from the areas of integration, approximation, discrepancy theory, information-based complexity, potential theory, and partial differential equations (PDE) to discuss numerical methods for these types of problems. In this context, well distributed point sets are important. The generation of good point sets for various problems as well as bounds for their discrepancy and integration error will be covered in the minisymposium. Particular emphasis is given to the dependence of the results on the dimension. Approximation of functions is intimately related with the integration problem and the proposed minisymposium should stimulate the exchange between both communities.

A Universal Cubature Formula for Functions with Mixed Smoothness

Ullrich, Mario
Johannes Kepler Univ.

Abstract: We prove upper bounds on the order of convergence of Frolov’s cubature formula for numerical integration in function spaces of dominating mixed smoothness on the unit cube. More precisely, we study worst-case integration errors for Besov and Triebel-Lizorkin spaces, and our results treat the whole range of admissible parameters. In particular, we study the effect of small smoothness. (Joint work with Tino Ullrich, HCM Bonn)

Probabilistic Discrepancy Bounds for Latin Hypercube Samples

Gnewuch, Michael
Christian-Albrechts-Universität zu Kiel

Abstract: The best known upper bound for the minimal star discrepancy of a point set in the d-dimensional unit cube with explicit dependence on the dimension and on the number of points is based on a probabilistic discrepancy bound for random i.i.d. points that are uniformly distributed. We were able to improve the constant in this upper bound and to generalize the probabilistic discrepancy bound to certain sets of random points that include Latin hypercube samples.

Optimality of Taylor Algorithm for Solving IVPs with Presence of Noise

Morkisz, Pawel
AGH Univ. of Sci. & Tech., Krakow

Abstract: Initial value problems are widely studied in case of $\mathbb{R}^2$ right-hand side function. Our aim is to generalize these results for problems when the information we may gain about the function is perturbed by some deterministic noise. It turns out that Taylor algorithm is optimal also in this case.

Structured-mesh methods for interface problems. - Part II of VIII

For Part 1, see MS-Tu-E-32
For Part 3, see MS-We-E-32
For Part 4, see MS-Th-BC-32
For Part 5, see MS-Th-D-32
For Part 6, see MS-Th-E-32
For Part 7, see MS-Fr-D-32
For Part 8, see MS-Fr-E-32

Organizer: Chen, Huanzhen
College of Mathematical Sci., Shandong Normal Univ.

Organizer: He, Xiaoming
Missouri Univ. of Sci. & Tech.

Organizer: KWAK, Do Young
Korea Advanced Inst. of Sci. & Tech.

Organizer: Zhang, Xu
Purdue Univ.

Abstract: In many real world applications it is more convenient or efficient to utilize structured meshes for solving different types of interface problems. Since the structured meshes may not fit the non-trivial interfaces, special methods need to be developed to deal with the difficulties arising from the interface problems in order to solve them on these meshes. Therefore, great efforts have been made for solving interface problems and tracing the moving interfaces based on structured meshes in the past decades. This mini-symposium intends to create a forum for researchers from different fields to discuss recent advances on the structured-mesh numerical methods for interface problems and their applications.

A Flux Preserving Immersed Finite Element Method for Elliptic PDEs

Jeon, Youngmok
Aju Univ.

Abstract: An immersed finite element method based on the flux continuity on intercell boundaries is introduced. To overcome non-symmetry of the stiffness system we introduce a modification based on the Riesz representation and a local postprocessing to recover local fluxes. This approach yields a P1 immersed nonconforming finite element method with a slightly different source term. An optimal rate of convergence in the energy norm is obtained and numerical examples are provided.

Multiscale Model of Blood Cell-Vessel Wall Interaction in Blood Flow

Xu, Zhiyue
Univ. of Notre Dame

Abstract: I will present a new 3D multiscale model to simulate receptor-mediated adhesion of deformable platelets at the site of vascular injury under different shear rates of blood flow. The model couples submodels at three biological scales crucial for the early clot formation: hybrid cell membrane submodel to represent physiological elastic properties of a platelet, stochastic receptor-ligand binding submodel to describe cell adhesion kinetics and blood flow submodel. A new FSI method is also introduced.

An Immersed Finite Volume Element Method for 2D-PDEs with Discontinuous Coefficients and Nonhomogeneous Jump Conditions

Zhang, Zhiyue
Nanjing Normal Univ.

Abstract: An immersed finite volume element method is developed to solve the 2D-elliptic interface problem with variable coefficients and nonhomogeneous jump conditions. Using the source removal technique, an equivalent elliptic interface problem with homogeneous jump conditions is obtained. The nodal basis functions are constructed to satisfy the homogeneous jump conditions near the interface and the usual finite element nodal basis functions
are applied away from the interface. Numerical experiments demonstrate the convergence rates $O(h^2)$ in some norms.

**MS-We-D-33** Mathematical Modelling, Analysis and Computation for Bose-Einstein condensation - Part I of III

For Part 2, see MS-We-D-33-2

For Part 3, see MS-Th-BC-33

Organizer: Wang, Hanquan

Yunnan Univ. of Finance & Economics

**Abstract:** Recently, modeling and simulation of Bose-Einstein condensates (BEC) at zero temperature are one of most interesting research topics in physics as well as applied mathematics. At such low temperature, different kinds of BEC can be modeled by the famous Gross-Pitaevskii equation (GPE) or coupled GPEs or nonlocal GPE(s). How to analyze and solve the GPE(s) for understanding the physics of BEC is interested by mathematicians and physicists. In this minisymposium, we aim to discuss the mathematical properties of these nonlinear Schrödinger type models, find solutions to these models both analytically and numerically, do numerical analysis for efficiency numerical methods, and show their applications into simulation of BEC and related physics. This minisymposium can be helpful to design efficient numerical methods for nonlinear Schrödinger type equation. It can be also helpful for applied mathematician to share their latest research work with physicists who are working on research of BEC and related physics.

**MS-We-D-33-1** 13:30–14:00

**Gross-Pitaevskii Equations in Modeling Bose-Einstein Condensates and Their Numerical Computations**

Hanquan, Wang

Yunnan Univ. of Finance & Economics

**Abstract:** At zero temperature, BEC can be modeled by the famous Gross-Pitaevskii equation (GPE) or coupled GPEs or nonlocal GPE. In this talk, firstly, we answer the mathematical properties of models and their applications. Secondly we propose efficient numerical methods for solving these GPEs. Finally we employ these efficient numerical methods and investigate both the ground state and dynamics of various kinds of BEC at zero temperature.

**MS-We-D-33-2** 14:00–14:30

**Numerical Study of Quantized Vortex Dynamics and Interaction in Superfluidity and Superconductivity**

Tang, Qinglin

INRIA - Univ. of Lorraine

**Abstract:** The appearance of quantized vortices is regarded as the key signature of superfluidity and superconductivity, and their phenomenological properties have been well captured by the Ginzburg-Landau-Schrodinger (GLSE) equation and the Gross-Pitaevskii equation (GPE). In this talk, we will propose accurate and efficient numerical methods for simulating GLSE and GPE. Then we apply them to study various issues about the quantized vortex phenomena based on GLSE and GPE.

**MS-We-D-33-3** 14:30–15:00

**Accurate and Efficient Computation of Some Nonlocal Potentials Based on Gaussian-sum Approximation**

Zhang, Yong

Wolfgang Pauli Inst.

**Abstract:** We introduce an accurate and efficient method for the evaluation of a class of free space nonlocal potentials, such as the free space Coulomb and Poisson potential in 2D/3D and dipolar potential in 2D/3D. Starting from the convolution formulation, for smooth and fast decaying densities, we make a full use of the Fourier pseudospectral (plane wave) approximation of the density and a separable Gaussian sums approximation of the kernel.

**MS-We-D-33-4** 15:00–15:30

**Mathematical Models and Numerical Simulations for Solid-state Dewetting Problems**

Jiang, Wei

Wuhan Univ.

**Abstract:** The solid-state dewetting problem of thin films is a hot research topic which is attracting increasing attention from a lot of scientists. In the talk, I will discuss several mathematical models which are used to simulate the solid-state dewetting problems, such as the phase field model and sharp-interface model.

**MS-We-D-34** 13:30–15:30

Mathematics and Algorithms in Quantum Chemistry - Part III of III

For Part 1, see MS-Tu-D-34

For Part 2, see MS-Tu-E-34

Organizer: Melgaard, Michael

Univ. of Sussex

Organizer: Shao, Shihong

Peking Univ.

**Abstract:** Ab initio models of electronic structures has had an immense impact in the physics and chemistry communities, as well as the materials science community, due to the capacity for carrying out realistic computations. The mathematical formulation and the efficient numerical simulation of such models is a notoriously difficult problem for several reasons, e.g., high dimensional configurations spaces, multi-particle interactions, multiple scales, nonlinear effects, and/or degeneracies of eigenspaces. Further developments in this area require the integration of physical modeling, mathematical analysis, and algorithm development in order to obtain reliable computational tools. The mini-symposium aims to bring together quantum chemists, applied and computational mathematicians, physicists and materials scientists all of whom are working in quantum chemistry to exchange ideas and to share their recent progress on the frontiers of theory and numerical methods as well as applications in material science. The mini-symposium will particularly focus on three topics: Time-dependent problems and excited states; Wave function methods; Relativistic effects.

**MS-We-D-34-1** 13:30–14:00

**Critical Point Theory and Variational Methods with Applications to Electronic Structure Models Within Quantum Chemistry**

Melgaard, Michael

Univ. of Sussex

**Abstract:** We report on a series of rigorous results on the existence of ground states and excited states for various weakly coupled, semilinear nonlinear elliptic PDEs arising in electronic structure models of molecular systems in quantum chemistry.

For variational methods, we give results for Hartree-Fock type models taking into account relativistic effects and magnetic fields by using the Lions-Fang-Ghoussoub critical point approach to multiple solutions on a noncompact Riemannian manifold.

Within Density Functional Theory (DFT), we give rigorous results on the open-shell, spin-polarized Kohn-Sham models for non-relativistic and quasi-relativistic $N$-electron Coulomb systems, that is, systems where the kinetic energy of the electrons is given by either the non-relativistic operator $-\Delta_{\text{NR}}$ or the quasi-relativistic operator (nonlocal, pseudodifferential operator of order one) $\sqrt{-\Delta_{\text{NR}} + \alpha^2} - \alpha^{-2}$; here $\alpha$ is Sommerfeld’s fine structure constant. For standard and extended Kohn-Sham models in the local density approximation, we prove existence of a ground state (or minimizer) provided that the total charge $N_{\text{tot}}$ of $N$ nuclei is greater than $N - 1$. For the quasi-relativistic setting we also need that $N_{\text{tot}}$ is smaller than a critical charge $N_{\text{crit}} = C - \gamma N_{\text{tot}}^{-3/2}$.

This is joint work with C. Aragez (University of Iceland, Iceland), E. Chiumiento (IAM CONICET, Argentina) and M. Enstedt (Uppsala University, Sweden).

**MS-We-D-34-2** 14:00–14:30

**Nonadiabatic Couplings Within Time-dependent Density Functional Theory**

Li, Zhendong

princeton Univ.

**Abstract:** Time-dependent density functional theory (TD-DFT) has emerged as a powerful tool for investigating electronic excitations of molecular systems. In this talk, I will show how the problem of calculating nonadiabatic couplings within TD-DFT is solved by extending the standard response theory to include nuclear derivatives.

**MS-We-D-34-3** 14:30–15:00

**Electron Correlation in A Relativistic Framework**

SAUER, Trond

CNRS/Laboratoire de Chimie et Physique Quantiques

**Abstract:** The proper and efficient inclusion of electron correlation is a major challenge in molecular quantum chemistry. In 1958 L.R. & A. 1964: 8246: win defined the correlation energy as the difference between the exact eigenvalue of the electronic Hamiltonian and the Hartree-Fock energy. In relativistic theory a severe complication arises since the electronic Hamiltonian has no bound solutions. In the present contribution we shall explore the proper definition of correlation energy in a relativistic framework.

**MS-We-D-34-4** 15:00–15:30

**Relativistic Scales for Absolute Nuclear Magnetic Shielding Constant**

Xia, Yulong

College of Chemistry & Molecular Engineering, Peking Univ.

**Abstract:** The relativistic expression for nuclear magnetic shielding (NMS) constant and nuclear spin-rotation (NSR) constant are studied base on the relativistic body-fixed frame molecular Hamiltonian. Because of the closely connection of two properties (NMS and NSR constants), a relativistic scale for absolute nuclear magnetic shielding is proposed.
Monte Carlo Methods for Solving Partial Differential Equations - Part I of II
Organizer: Cal, Wein
Florida State Univ. CS Dept Uni. of North Carolina at Charlotte
Abstract: Monte Carlo Methods (MCMs) have been used extensively in di-
verse computational applications in the sciences, engineering, and finance. This is due to their natural parallelism, data parsimony and locality, and their capability to tackle high dimension problems that are otherwise intractable. In this mini-symposium, we will present several talks that study the use of M-
CMs to solve partial differential equations (PDEs). These include using the Feynman-Kac formula to develop MCMs for PDEs, using polynomial chaos for solving stochastic PDEs, Monte Carlo linear solvers that arise from PDEs, algorithmic issues of the walk-on-sphere method, fault tolerance in multilevel MCMs, stability analysis of MCMs for mixed type PDEs, estimation of diffu-
sion process sensitivities, as well as the application of MCMs in capacitance calculation of microchip ICs and multi-asset finance options.

Low Variance Estimation of Diffusion Process Sensitivities
Gobet, Emmanuel
Ecole Polytechnique
Abstract: We design a Monte-Carlo method to compute efficiently the sensi-
tivities of diffusion processes in a general framework with low variance esti-
mates. Numerical experiments confirm the performance of the method, com-
parison tests with usual Malliavin calculus representations or Finite Differe-
tence based approaches are given. Joint work with Gang LIU (Ecole Poly-
technique).

Sabelfeld, Karl
Inst. of computational mathematics & mathematical geophysics, Russian Acad. of Sci.
Abstract: In this presentation we deal with stochastic boundary value problems for nonlinear partial integro-differential equations. Our goal is to present recent Monte Carlo ideas, stochastic models and algorithms for solving differ-
ent practically interesting problems: (1) simulation of annihilation of spatially
separate electrons and holes in a disordered semiconductor, governed by
nonlinear Smoluchowski equations with random initial distribution density, (2)
recovering the particle nanosize distribution from diffusion battery measure-
ments, (3) retrieving the step structure of the epitaxial. Comparative simulation-

Determining Optimal Multilevel Monte Carlo Parameters with Application to Fault Tolerance
Arbenz, Peter
ETH Zurich
Abstract: In the multilevel Monte Carlo (MLMC) method numerous paramete-
ers have to be determined. Their choice is crucial for the work and error of
the method. We propose to determine the number of samples per level, the
finest and coarsest level by solving an integer optimization problem. Faults
influence the MLMC levels to a different extent. We present a fault-tolerant
MLMC method that adapts to experienced failures without a priori knowledge
of the failure distribution.

Application Monte Carlo Method for Evaluation the Price of Multi-Asset Rainbow Options
Rasulov, Abdujabar
Univ. of World Economy & Diplomacy
Abstract: In multidimensional case one of useful features Monte Carlo
method allows the solution of boundary value problems to be found at just
one point. This property be useful in problems of option pricing, where the
value of an option is required only at the time of striking. In this work we
consider European multi-asset options which described by the system of s-
tochastic differential equations and construct Monte Carlo algorithms for the
solution.

Mori-Zwanzig formulation and applications - Part II of II
For Part 1, see MS-Tu-E-36
Organizer: Stinis, Panos
Pacific Northwest National Laboratory
Organizer: E, Weinan
Peking Univ. & Princeton Univ.
Abstract: The Mori-Zwanzig formalism allows reducing the number of vari-
ables in large systems of coupled equations. For differential equations, the
reduced equations model the effect of the unresolvable variables, leading to a
Markovian, memory and fluctuating terms. This formalism can be a starting
point for multiscale and meso-scale modeling, based on first principles cal-
culations. We will investigate recent mathematical developments as well as
applications to materials, fluid mechanics, soft matter, biology and uncertainty
quantification.

Coarsening of Particle Systems
Levermore, C. David
Univ. of Maryland
Abstract: We present a framework for constructing the dynamics for a coars-
ened system of simulated particles. We build an approximate solution to
Liouville equation for the original system from the solution of an equation for
the phase-space density of the coarsened system. We do this with a Markov
approximation in a Mori-Zwanzig formalism based on a reference density. We
then identify the evolution equation for the reduced phase-space density as
the forward Kolmogorov equation.

An Application of the Mori-Zwanzig Formulation to the Stochastic Burgers Equation
Venturi, Daniele
Brown Univ.
Abstract: By using the Mori-Zwanzig formulation, we derive exact reduced-
order equations for the one- and two-point probability density function of the
solution to the stochastic Burgers equation. We study random flows gener-
ated by random initial conditions and random additive noise, yielding multiple
interacting shock waves at random space-time locations. The new equations are
solved numerically by using discontinuous Galerkin methods.

Mori-Zwanzig Atomistic to Continuum Coupling
Aristoff, David
Colorado State Univ.
Abstract: We discuss possible approaches to using the Mori-Zwanzig ap-
proach within an atomistic-to-continuum framework.

Bipartite Consensus over Coopetition Networks
Hu, Jiangping
Univ. of Electronic Sci. & Tech. of China
Abstract: Multagent systems are integrations of information and control sys-
tems with physical processes and interacting with the environment, and have
attracted a great deal of attention in the control community. In the past
decade, extensive studies have been conducted for the so-called complex
systems, multi-agent systems, networked systems, etc. The minisymposium
aims to present some recent developments in control and analysis of multi-
agent systems, including 1) modeling and analysis of collective dynamics on
cooperation networks; 2) distributed average tracking control of multi-agent
systems; 3) event-triggered control and connectivity preservation; 4) high or-
der consensus control.

Bipartite Consensus over Cooperation Networks
Hu, Jiangping
Univ. of Electronic Sci. & Tech. of China
Abstract: Cooperation and competition are two typical interactional
ships in natural and engineering networked systems, which are called coopera-
tion networks. Some interesting collective behaviors can emerge through
local interactions over such networks with various kinds of structural balance
conditions. In this talk, we will give an overview of our recent results on the re-
lation between collective dynamics and the structural balance and some
bipartite control strategies as well.
s of agents are required to track the average of multiple time-varying reference signals in a distributed way, the so-called distributed average tracking (DAT) problem. In this talk, we will give an overview of our recent research progress on DAT of multi-agent systems. Theoretical results on DAT for general reference signals and DAT for agents with second-order dynamics and Euler-Lagrange dynamics will be presented.

**MS-We-D-37-3**
14:30–15:00

**Event-triggered Connectivity Control of Multi-Agent Systems**
Fan, Yuan
Anhui Univ.

**Abstract:** In this work we consider the rendezvous problem of multi-agent systems with event-triggered control schemes. Each agent has only a limited communication range and connectivity-preserving rendezvous controllers with bounded inputs have been developed. It is shown that with some very mild assumptions, existing communication links will be preserved and the group rendezvous can be achieved under the proposed controllers.

**MS-We-D-37-4**
15:00–15:30

**Consensus Control of Multi-Agent Systems with Switching Directed Topologies**
Wen, Guanghui
Southeast Univ.

**Abstract:** Recently, consensus control of multi-agent systems has received much attention from various scientific research communities ranging from applied mathematics to control theory. To guarantee consensus in a network, individuals need to share information with their neighbors. However, the underlying communication topology may be time-varying, due to limitations of the range of the communication. The main contributions of the talk are: (1) we characterize the uniform exponential stability of a matrix-valued cooperative systems.

**Analysis and design of hybrid dynamical systems**

**MS-We-D-38-1**
13:30–14:00

**Spectral Abscissas of Sets of Matrices: Definition, Estimation, and Applications**
Sun, Zhendong
AMSS, Chinese Acad. of Sci.

**Abstract:** For a set of real square matrices, we introduce the concept of spectral abscess, which is an indirect extension of the spectral abscess of a matrix. We prove that the abscess is exactly the largest common (induced matrix) measure of the matrix set under all possible vector norms. As an application, we discuss the connection between the spectral abscess and the worst-case performance of a wide class dynamical systems with piecewise linear structures.

**Formal Design of Distributed Cooperative Systems**
Lin, Hai
Univ. of Notre Dame

**Abstract:** A common challenge in our future engineered system design, such as power grids, intelligent transportation networks and flexible-manufacturing systems, is how to make a large number of distributed systems work together as power grids, intelligent transportation networks and flexible-manufacturing systems. This is reached using the dissipativity property. Two special forms of dissipativity, passivity and L2-gain, are addressed. This dissipativity theory for switched systems is an extension of the standard dissipativity theory for non-switched systems.

**MS-We-D-39**
13:30–15:30

**Optimization techniques in target tracking and multi-sensor information fusion**
Organizer: Shen, Xiaojing
Sichuan Univ.

**Abstract:** Target tracking and multi-sensor information fusion have benefited from a surge of research in recent years, due in part to intense research in optimization theory and the connections made between the three fields. In this minisymposium, we present some progress in target tracking and multi-sensor information fusion including 1) minimized Euclidean error data association and tracking; 2) target tracking with constrained target motion; 3) robust optimization techniques in hypothesis testing problems; 4) decentralized detection/estimation fusion in multi-sensor networks. The new algorithms developed in this talk lead to improvement over standard approaches in target tracking and sensor network applications.

**MS-We-D-39-1**
13:30–14:00

**Constrained Target Motion Analysis, Modeling and Tracking**
Duan, Zhansheng
Xi’an Jiaotong Univ.

**Abstract:** Unconstrained target motion, e.g., air target, has been extensively studied. However, the motion of many targets are constrained by some tracks, e.g., ground target motion on road network. Comparatively, the study of constrained target motion is very scarce. In this talk, we will introduce our most recent work on the analysis of the difference between constrained target motion and unconstrained one, how to model constrained target motion and the tracking algorithms for constrained motion targets.

**MS-We-D-39-2**
14:00–14:30

**Robust Hypothesis Testing without A Symmetry Assumption of Nominal Densities under A Relative Entropy Tolerance**
Song, Enbin
Sichuan Univ.

**Abstract:** We consider the open problem about a binary minimax test, where the nominal likelihood ratio is a monotone nondecreasing function and the actual probability densities of the observations are located in neighborhood characterized by placing a bound on the relative entropy between actual and nominal densities. Without the restrictive symmetry assumption on two nominal conditional probability densities under the two hypotheses, the robust hypothesis testing problem is reduced to solving a nonlinear system involving two.

**Majorization Minimization Techniques for Sparse Signal Recovery**
Fang, Jun
Univ. of Electronic Sci. & Tech. of China

**Abstract:** In this talk, we study the problem of recovering a high-dimensional sparse signal from low-dimensional measurements. This problem has found many applications in array signal processing, MRI imaging, data mining, etc. The sparse signal recovery problem can be cast into an optimization problem which minimizes a certain sparsity-promoting functional subject to a data-fitting constraint. Some effective sparsity-promoting functions are discontinuous and non-convex. We will show how to use majorization-minimization techniques to solve these problems.

**MS-We-D-40**
13:30–15:30

**Analysis and Synthesis with Incomplete Information and Its Applications**
Organizer: Shen, Bo
Donghua Univ.

**Abstract:** Recently, new challenging issues have emerged in the networked environment that may affect the performance of the whole systems, for example, network-induced time delay, data missing and quantization effect, etc.. These phenomena have made it difficult to analyze and synthesize functional information from real-world networked systems under the framework of traditional control theory. Therefore, to meet the application requirements,
new analysis/synthesis paradigms are needed which must necessarily depart from classical analysis/control strategies. The minisymposium aims to bring together the latest approaches to understanding, estimating and controlling systems with incomplete information and present their applications in fault diagnosis and sensor networks.

**MS-We-D-40-1** 13:30–14:00  
**Fault Estimation with Incomplete Information: Krein-Space Approaches**  
Shen, Bo  
Donghua Univ.  
Abstract: Fault estimation of time-varying systems serves as an important research topic owing to its significance for engineering reliability. In this presentation, some recent results are introduced. The system under consideration is subject to delayed measurements, missing measurements, uncertainties, and so on. For the time-varying nature, the Krein space approach is used to solve the fault estimation problems. Moreover, a fault detection scheme with an integrated online performance evaluation is proposed.

**MS-We-D-40-2** 14:00–14:30  
**Probability-Dependent Gain-Scheduled Control and Filtering for Systems with Randomly Occurring Incomplete Information**  
Wei, Guoliang  
University of Shanghai for Sci. & Tech.  
Abstract: This talk presents an overview of the recent developments on the gain-scheduled control and filtering problems for the parameter-varying systems. First of all, we recall several important algorithms suitable for gain-scheduling method. Secondly, various important system models are reviewed. In particular, our recent work based on the probability-dependent gain-scheduling methods are reviewed. Furthermore, some latest progress in this area is discussed. Finally, conclusions are drawn and several potential future research directions are outlined.

**MS-We-D-40-3** 14:30–15:00  
**Distributed Filtering for Sensor Networks—A Brief Introduction**  
Dong, Hongli  
Northeast Petroleum Univ.  
Abstract: The last few decades have witnessed constant research interests on various aspects of sensor networks. In particular, the distributed filtering or estimation for sensor networks has been an ongoing research issue that attracts increasing attention from researchers in the area. In this minisymposium, we will give a brief introduction about sensor networks, and then report our recent work on distributed filtering over sensor networks.

**MS-We-D-40-4** 15:00–15:30  
**Recursive Approach to Filtering with Network-Induced Phenomena**  
Jun, Hu  
Harbin Univ. of Sci. & Tech.  
Abstract: In this talk, we will deal with the recursive filtering problems for time-varying nonlinear stochastic systems with network-induced phenomena. The network-induced phenomena under consideration mainly include missing measurements, fadings, measurements, signal quantization, probabilistic sensor delays, and sensor saturations. With respect to these network-induced phenomena, the recursive filters are designed for time-varying nonlinear stochastic systems. Both the theoretical research and engineering applications will be discussed, and a series of recently published results will be reported.

**MS-We-D-41** 13:30–15:30  
**Systematic Rationalization of Industrial Alarm Systems**  
Organizer: Wang, Jiaodong  
Peking Univ.  
Abstract: Alarm systems play a vital role for safe operation and high efficiency of modern large-scale industrial systems. This Minisymposium provides an overview of new quantitative methods for analysis and design of industrial alarm systems as an emerging research area. The Minisymposium targets academic researchers and industrial practitioners involved in alarm management. Four topics will be presented, namely, (1) Introduction to Industrial Alarm Systems, (2) Representation, Analysis and Visualization of Alarm Data, (3) Optimal Alarm Design for Univariate and Multivariate Alarm Systems, and (4) Root Cause Analysis and Alarm Flood Management. Industrial case studies will be provided to illustrate the effectiveness of developed techniques for advanced alarm systems.

**MS-We-D-41-1** 13:30–14:00  
**Optimal Alarm Design**  
Wang, Jiaodong  
Peking Univ.  
Abstract: Introduction to process data; Alarm design trade-offs: how to minimize false and missed alarms; ROC curves; Filtering, deadbands, delay-timers; Optimal design framework; Dealing with the tradeoff between latency/delays and accuracy. Alarm processing and trip point design in an univariate framework with examples. Advantages of alarm design in a multivariate framework in terms of fewer false and missed alarms. Industrials case studies to illustrate alarm design procedures for univariate and multivariate processes.

**MS-We-D-41-2** 14:00–14:30  
**Alarm Data: Representation, Analysis and Visualization**  
Chen, Tongwen  
Univ. of Alberta  
Abstract: Introduction to alarm data; Graphical representation; High density alarm plots; Alarm correlation color map; Parallel coordinate plots; Run-length distributions; Merged plots of process and alarm data. Detection of chattering and oscillating alarms.

**MS-We-D-41-3** 14:30–15:00  
**Quantitative Analysis and Design of Alarm Systems**  
Shah, Sirish L.  
Univ. of Alberta  
Abstract: Alarm systems and process monitoring; Historical incidents; False alarm and nuisance alarms; Alarm standards; Alarm systems life cycle; Alarm rationalization; Current status of alarm systems; How to deal with information resources (alarm data, process data, connectivity information).

**MS-We-D-41-4** 15:00–15:30  
**Connectivity Information: Root Cause Analysis and Alarm Flood Management**  
Yang, Fan  
Tsinghua Univ.  
Abstract: Introduction to process connectivity information; Representation of connectivity information; Signed directed graphs; Ontological models, Process modeling and alarm design; Root cause determination of process faults using causality analysis; Root cause determination of plant-wide oscillations; Introduction to alarm floods; Analysis of alarm flood patterns.

**MS-We-D-42** 13:30–15:30  
**Cooperative Control and Multi-Agent Systems IV**  
Organizer: TCCT Technical Committee on Control Theory, CAA  
Abstract: Recent advances in sensing, communication and computation technologies have enabled a group of agents, such as robots, to communicate or sense their relative information and to perform tasks in a collaborative fashion. The past few years witnessed rapidly-growing research in cooperative control and MAS, including: 1) asynchronous time and event hybrid-driven consensus; 2) event-based consensus; 3) event-triggered consensus; 4) multiple UAVs coordinated control.

**MS-We-D-42-1** 13:30–14:00  
**Asynchronous Time and Event Hybrid-Driven Consensus in Multi-Agent Systems**  
Xiao, Feng  
Harbin Inst. of Tech.  
Abstract: Several consensus protocols for asynchronous multi-agent systems are presented in the framework of time and event hybrid-driven control. In these protocols, event-triggerring conditions could be checked periodically or aperiodically. We study their effectiveness in solving consensus problems and show their robustness against time delays.

**MS-We-D-42-2** 14:00–14:30  
**Event-based Consensus of Multi-agent Systems with General Linear Models**  
ZHU, WEI  
Chongqing Univ. of Posts & Telecommunications  
Abstract: In this talk, our recent progress on event-based consensus of multi-agent systems with/without time-delays will be discussed. For each agent, the controller updates are event-based and only triggered at its own event time. It is shown that the continuous communication between neighboring agents can be avoided and the Zeno-behavior of triggering time sequence is excluded.

**MS-We-D-42-3** 14:30–15:00  
**Event-Triggered Consensus for General Linear Multi-Agent System**  
Lu, Pingli  
Beijing Inst. of Tech.  
Yang, Daping  
Beijing Inst. of Tech.  
Liu, Xiangdong  
Beijing Inst. of Tech.  
Abstract: We study the event-triggered consensus problem for multi-agent systems with general linear dynamics under a general directed graph. We propose a decentralized event-triggered consensus controller (ETCC) for each agent to achieve consensus, without requiring continuous communication among agents. We prove that under the proposed ETCC there is no Zeno
behavior exhibited. To relax the requirement of continuous monitoring of each agent’s own state, we further propose a self-triggered consensus controller (STCC).

**MS-We-D-42-4**

Swarm Intelligence Approach to Multiple UAVs Coordinated Control

Duan, Haibin
Beihang Univ. (BUAA)

Abstract: Swarm intelligence is the attempts to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insect colonies and other animal societies. Multiple unmanned aerial vehicles (UAVs) can accomplish various types of complicated missions. In this talk, our new progresses in swarm intelligence will be introduced. Meanwhile, our recent researches on swarm intelligence based coordinated control for UAVs will also be discussed. Furthermore, the challenging areas in this field will be presented.

**MS-We-D-43**

SPDEs/SEDs, Queues, and Optimization with Applications

Organizer: Dai, Wanyang
Nanjing Univ.

Abstract: We will address the theory, numerical methods, and applications of stochastic partial differential equations (SPDEs), queueing systems, and optimizations. The SPDEs cover both forward and backward forms with possible reflection over boundaries and include their degenerate form of stochastic differential equations (SDEs). The queueing systems are broadly viewed ones, including those widely appeared in communication networks, quantum mechanics, cloud computing, service and management systems, etc. The optimizations mainly cover stochastic processes based optimizations and optimal controls/differential games. In particular, we will address the interactions among these SPDEs/SEDs, queueing systems, and optimization methods, for examples, to establish performance models, or to design dynamical control policies/algorithms and prove their optimality through diffusion approximations and asymptotic optimization/optimal control regimes.

**MS-We-D-43-1**

A Unified B-SPDE with Levy Jumps: Well-Posedness, Algorithm with Numerics, and Applications

Dai, Wanyang
Nanjing Univ.

Abstract: We study the well-posedness of adapted strong solution and design an algorithm with numerics for a unified backward stochastic partial differential equation (B-SPDE) with Levy jumps. We also study the applications of our unified B-SPDE in several areas: optimal control and stochastic differential game problems with general number of players, jumps, and possible skew reflections; reflecting diffusion processes associated with queueing networks for cloud computing, service, and communication systems; statistical physics and quantum mechanics.

**MS-We-D-43-2**

Fractional Time Stochastic Partial Differential Equations

Chen, Zhen-Qing
Univ. of Washington

Abstract: In this talk, we introduce a class of stochastic partial differential equations (SPDEs) with fractional time-derivatives, and study the $L^p$-theory of the equations. This class of SPDEs can be used to describe random effects on transport of particles in medium with thermal memory or particles subject to sticking and trapping. Based on joint work with K.-H. Kim and P. Kim.

**MS-We-D-43-3**

Stationarity and Interchange of Limits in Heavy Traffic Analysis

Ye, Hongqing
Hong Kong Polytechnic Univ.

Abstract: We develop a streamlined and systematic approach to validate the diffusion limit as an approximation to the stationary performance of stochastic processing networks. We first demonstrate that the stability of a deterministic dynamic complementarity problem is sufficient for both the diffusion limit and pre-limit networks to have stationary distributions, and given an additional and mild condition, also justifies the so-called interchange of limits. (Joint work with David D. Yao of Columbia University)

**MS-We-D-43-4**

Hydrodynamic Limits of Large-scale Stochastic Systems

Ramanan, Kavita
Brown Univ.

Abstract: We establish mean-field limits for a class of large-scale stochastic networks with load balancing in the presence of general service distributions. We introduce a state representation in terms of interacting measure-valued processes, derive a propagation of chaos result, and obtain PDE approximations to the dynamics that shed insight on the performance of these networks. We also discuss how our mathematical framework can also be used to study models of grain growth arising in materials.
The aim of this mini-symposium is to bring researchers from the mathematical sciences together with scientists from engineering, biology, and computer science, to study problems arising from modelling and analysis of complex dynamical systems on networks using mathematical methods. The scope of this mini-symposium is twofold. The theoretical part includes but not be limited by the following: modelling of complex systems by networks, dynamics of complex networked systems; delays in complex networks; the application part includes but not be limited by the following: cybersecurity on networks; intelligent computation on networks; biological networks. The specific issues that will be discussed in detail at the minisymposium are: whether and how the emerging important problems arising in real-world complex systems can be answered by the present results in network science; whether and how these questions lead to new issues and arise in network science. In view of the broad range of backgrounds of the audience, we are specifically inviting speakers who will present the state-of-the-art of the scope of complex networked dynamical systems, and furthermore aim to bridge the gaps between the different scientific communities represented at the conference.

- **Complexity and Network Sciences Supporting the Emerging Science of Cyber Security: Challenges and Exciting Research Opportunities**
  
  Xu, Shouhui  
  Université de Texas à San Antonio  
  
  Abstract: We see the dawn of Science of Cyber Security, which is the holy-grail challenge that computer/information/network/cybersecurity researches have confronted with. In this talk, I will present the novel framework of Cybersecurity Dynamics, which is a promising candidate to serve as the foundation for Science of Cyber Security. I will discuss a unique set of inherent technical barriers, which I hope will serve as a call to action to the Complexity and Network Sciences communities.

- **utilization of data in complex networked systems by data assimilation**
  
  Lu, Wenlian  
  Fudan Universiteit  
  
  Abstract: How to utilize "big" data in modelling complex systems by complex networks is a challenge in both network science and data science. Data assimilation may be a promising method to solve this problem due to the occurrence of "big data" and powerful computers. In this talk, I will introduce the basic ideas and techniques of data assimilation. By the neuronal network example, I discuss the prospective of application of data assimilation in complex networks.

- **Generalized Halanay Inequalities with Applications to Dynamical Networks with Time Delays**
  
  Liu, Bo  
  Xidian University  
  
  Abstract: In this report, we will provide a series of generalization of the classical Halanay inequality under more general conditions, we will also demonstrate how these generalizations can be used to the analysis of dynamical behaviors of networks with time delays.

- **Time Delays and Spatio-temporal Patterns on Networks**
  
  Atay, Fatihcan M.  
  Max Planck Inst. for Mathematics in the Sci.  
  
  Abstract: We will study dynamical patterns on networks arising from coupling delays. The motivation comes from recent interest in chimera states, which were originally observed in ring configurations under symmetric coupling conditions. We shall present a systematic method for searching for nontrivial patterns in networks based on symmetry analysis and bifurcation theory. We will give several examples of novel dynamics and their stability analysis. Particular emphasis will be devoted to patterns combining synchrony and stationary states.

- **Inverse Problems for Image Reconstruction and Processing - Part I of IV**
  
  Organizer: Wei, Suhua  
  Inst. of Applied Physics & Computational Mathematics  
  
  Abstract: Inverse problems arise in various fields of science. In imaging, for example, the goal is to recover the image that produced a given measurement. This problem is ill-posed in the sense that small errors in the measurements can lead to large errors in the reconstructed image. The aim of this session is to discuss recent developments in the theory and methods for solving inverse problems in imaging.

- **A Fast Combined Algorithm for Blind Image Restoration**
  
  Shi, Yuying  
  North China Electric Power Univ.  
  
  Abstract: The blind image restoration problem is not an easy problem to solve for its complexity and difficulty. In this paper, we propose a new algorithm to simultaneously recover the blurring kernel and the original image, which combines split Bregman technique, fast Fourier transform and spectral decomposition technology to accelerate the computation of blind image restoration problem. Numerical results demonstrate that the proposed algorithm is efficient and robust.

- **Combining Models is An Open Problem**
  
  Nikolova, Mila  
  CMLA, CNRS - ENS Cachan  
  
  Abstract: Many imaging tasks amount to solve inverse problems. They are typically solved by minimizing an objective that accounts for the models of the recording device and the sought-after image. The common approach is to take a weighted combination: however it appears that the solution deviates from both models. Our talk focuses on the ways how these models can be used jointly so that all available information is used more efficiently.

- **Total Variation Regularisation as A Discrete Gradient Flow**
  
  Schöll, Carola-Bibiane  
  Univ. of Cambridge  
  
  Abstract: In this talk, we discuss the application of discrete gradient approaches for the solution of total variation regularised problems. We will show that the discrete gradient approach offers guaranteed energy decrease in every step, and could be particularly interesting for large-scale data as its computation may reduce to the solution of a sequence of 1D problems. This is joint work with Volker Grimm, Robert MacLachlan, David McLaren, and Reinout Quispe.

- **Preconditioned Alternating Direction Method of Multipliers for Non-Smooth Regularised Problem**
  
  SUN, HONGPENG  
  Short Term Visiting Scholar of IAPCM  
  
  Abstract: ADMM is a popular first order method. However, it suffers from solving linear subproblems in various applications. We give a preconditoned ADMM method by writing ADMM as a new kind of proximal point method, and prove the weak convergence in infinite dimensional space. Various efficient preconditioners could be used in preconditoned ADMM and any finite preconditoned iterations could guarantee the convergence of the solutions. This talk is based on joint work with Prof. Kristian Bredies.

- **Recent progress in modeling and simulation of multiphase thin-film type problems**
  
  Organizer: Peschka, Dirk  
  Weierstrass Inst.  
  Organizer: Wang, Li  
  Univ. of California Los Angeles (UCLA)  
  
  Abstract: Thin-film type equations have important applications, e.g. in coating flows, food processing, solar cells. Recently research has focussed on the inclusion of more challenging physics of multiphase systems. This minisymposium features corresponding research including additional surfactant transport, suspension flows, flows over liquid substrates. Another major issue is the thermodynamically consistent formulation of such models. Problems are presented from an applied perspective and their modeling, numerics and analysis are discussed. Identifying common mathematical problems inherent to systems of thin-film type problems and successful solution strategies will support industrial applications and the fundamental understanding of such problems.

- **Droplets on Liquids and Their Long Way into Equilibrium**
  
  MS-We-D-47-1  
  13:30–14:00
  
  Abstract: Many imaging tasks amount to solve inverse problems. They are typically solved by minimizing an objective that accounts for the models of the recording device and the sought-after image. The common approach is to take a weighted combination: however it appears that the solution deviates from both models. Our talk focuses on the ways how these models can be used jointly so that all available information is used more efficiently.
Abstract: The dynamics of a complex network is generally very complicated due to the self-dynamics of the node and their interactions. Many existing conditions for reaching certain desirable dynamics in a complex network require global information of the network, for example the spectrum of its Laplacian matrix. A challenging problem is how the network structure affects the network dynamics in a distributed way especially for directed networks, which is still unclear today. In this talk, we will investigate the impact of the network structure for synchronization on an undirected complex network, a second-order multi-agent system with undirected topology, and a general directed complex network. We will also develop a scheme to change the weights in a local manner to achieve a desired behavior. In particular, network synchronization is investigated, for which some distributed adaptive laws are designed on the coupling weights for reaching synchronization.

Organizer: Liu, Zhixin

AMSS, Chinese Acad. of Sci.

Abstract: In the investigation of multi-agent systems (MAS), a central issue is to understand how local interactions between agents lead to collective behavior of the system. We introduced a random framework and some mathematical tools such as multi-array martingale theorem and estimation of spectral gap of random geometric graphs, to study the synchronization of a basic class of MAS with large population. Meanwhile, I present some quantitative results on how we intervene in MAS such that the system exhibits the expected behavior.

Organizer: Liu, Zhixin

AMS, Chinese Acad. of Sci.

Abstract: Game theory is a study of strategic decision making. Specifically, it is "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers". Hierarchical theory is a new and promising area of general systems theory. This theory deals basically with the decomposition of a system into subsystems forming a hierarchical structure and is, therefore, on method of dealing with complexity. The minisymposium aim to present the highest standard researches in game theory and hierarchical systems study, including 1) study of multi-player pursuit evasion game with one superior evader; 2) team problem research of mean field models with Markov jump parameters and coupled tracking-type indices; 3) analysis of inverse Stackelberg public goods games with multiple leaders, followers, or levels; 4) the design of approximate simulation-based hierarchical control on nonlinear systems.

Organizer: TCCT Technical Committee on Control Theory, CAA

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Organizer: Liu, Zhixin

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Abstract: In the investigation of multi-agent systems (MAS), a central issue is to understand how local interactions between agents lead to collective behavior of the system. We introduced a random framework and some mathematical tools such as multi-array martingale theorem and estimation of spectral gap of random geometric graphs, to study the synchronization of a basic class of MAS with large population. Meanwhile, I present some quantitative results on how we intervene in MAS such that the system exhibits the expected behavior.

Organizer: MS-We-D-48-3

14:30–15:00

Design Distributed Consensus Protocols for Linear Multi-Agent Systems

Li, Zhongkui

Peking Univ.

Abstract: Consensus control of multi-agent systems has received compelling attention. Due to the large size of agents, the spatial distribution of actuators, limited sensing or communication capability, consensus protocols of multi-agent systems should be distributed, depending on local information of neighboring agents. The purpose of this talk is to present our recent results on designing distributed adaptive consensus protocols for linear multi-agent systems, which can be constructed and implemented in a fully distributed fashion.

Organizer: MS-We-D-48-4

15:00–15:30

Analysis and Intervention of Multi-Agent Systems with Large Population

Liu, Zhixin

AMSS, Chinese Acad. of Sci.

Abstract: In the investigation of multi-agent systems (MAS), a central issue is to understand how local interactions between agents lead to collective behavior of the system. We introduced a random framework and some mathematical tools such as multi-array martingale theorem and estimation of spectral gap of random geometric graphs, to study the synchronization of a basic class of MAS with large population. Meanwhile, I present some quantitative results on how we intervene in MAS such that the system exhibits the expected behavior.

Organizer: MS-We-D-49

13:30–15:30

Game Theory and Hierarchical Systems

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Multi-player Pursuit Evasion Game with One Superior Evader

Peng, Zhihong

Beijing Inst. of Tech.

Abstract: This paper discusses a multi-player pursuit evasion game with one superior evader, who moves faster than the pursuers. Through theoretical analysis, we find an analytical expression of non-escape angle of the evader and the minimum number of the pursuers required. We provide the strategies for the pursuers (evader) to maintain and shrink (destroy) the encirclement and the minimum number of the pursuers required. We provide the strategies for the pursuers (evader) to maintain and shrink (destroy) the encirclement corresponding to three different movement patterns of the evader. Finally, we verify the correctness of the theories proposed in this paper.

Organizer: MS-We-D-49-2

14:00–14:30

Team Decision Problem for Markov Jump Mean Field Models

Wang, Bingshan

Shandong Univ.

Abstract: This talk is on the team problem of mean field models with Markov jump parameters and coupled tracking-type indices. Due to random parameters, the population aggregate effect is a stochastic process dependent on Markov jump parameters instead of a deterministic function. We achieve control synthesis by the parametric approach and the state space augmentation. By constructing stochastic Lyapunov functions, we show that the closed-loop
Abstract: In this presentation we will formalize the inverse Stackelberg Public Goods game in discrete and continuous case with multiple leaders, followers, or levels. We will investigate the equilibrium and outcome of such games and compare them with the case in Nash equilibrium. Related important and interesting questions such as incentive controllability and fairness will also be studied.

Hierarchical Control Design of Nonlinear Systems Based on Approximate Simulation
Tang, Yutao
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: Hierarchical control for nonlinear systems is discussed using approximate simulation relation in this paper. An approximate bound is obtained under a modified approximate simulation function at first. The abstraction and interface construction problem is solved for a class of nonlinear systems, especially those in the lower triangular form.

Synchronization of A Class of Small-World Networks via Drivingly Coupled Scheme
Zhu, Henghui
Chinese Acad. of Sci.

Abstract: Synchronization is a ubiquitous phenomenon in nature. This paper aims at further investigates the synchronization of a class of small-world networks via drivingly coupled scheme. In detail, based on the Master Stability Method, we further discuss the distributions of eigenvalues $\lambda_2$ and $\lambda_n$ of coupling matrices for realizing the synchronization of small-world networks via a drivingly coupled scheme. It indicates that the distributions of eigenvalues $\lambda_2$ and $\lambda_n$ are largely different.

Collective dynamics of online social systems - Part I of II
Organizer: Jianguo, Liu
Univ. of Shanghai for Sci. & Tech.

Abstract: Billions of online user’s behavior data provide valuable opportunity to analyze the collective behavior patterns of online users, interest migration patterns, measuring online user reputation, designing personalized recommendation algorithms, online link prediction, as well as other new challenges. This Minisymposia will introduce the pioneer progresses of online user behavior analysis scientists from China, including the statistics properties of online user behavior, online information dissemination, interest measurements, and personalized recommendation algorithms, which would help researchers catch up the current situation of this research direction.

Epidemic Dynamics on Information-driven Adaptive Networks
Zhang, Zi-Ke
Alibaba Research Center for Complexity Sci., Hangzhou Normal Univ.

Abstract: In this work, we propose an information-driven adaptive network. For the information-driven adaptive process, the susceptibles individuals who have realized the existence of the disease would break the links to their infect ed neighbors to prevent the epidemic from further spreading. Concentrating on the infected density distribution, we find four types of dynamical phenomena. In addition, we present a new local bifurcation diagram to illustrate the evolution among these dynamical behaviors.
prefer turbo warrants with low prices, high volatilities, and high skewness. Our analysis highlights the importance of investor behavior in pricing of turbo warrants.

14:00–14:30
Pricing Path-dependent Options with Regime Switching
Song, Yingda
Univ. of Sci. & Tech. of China
Cai, Ning
Hong Kong Univ. of Sci. & Tech.

Abstract: We propose a general approach to pricing path-dependent options such as barrier options and lookback options under regime-switching models, where different regimes may follow different processes. Numerical results indicate that our method is accurate and efficient. This is joint work with Ning Cai and Steven Kou.

14:30–15:00
Analytical Pricing of Asian Options under A Class of Option Pricing Models
Cai, Ning
Hong Kong Univ. of Sci. & Tech.

Abstract: A unified framework is proposed for pricing both continuously and discretely monitored Asian options under Markov processes. Numerical experiments show that our pricing method performs well under a wide range of popular Markov process models, including the CIR model, the CEV model, the Merton’s jump diffusion model, the double-exponential jump diffusion model, the variance gamma model, and the CGMY model.

13:30–15:30 212A
Analytical Pricing Methods for Path-Dependent Options

Organizer: Stettner, Lukasz Inst. of Mathematics Polish Acad. of Sci.

The aim of this symposium is to present various important aspects in mathematics of finance. The session shall consist of four lectures devoted to summarize the most recent developments and ideas in the field, with a special emphasis given to the theoretical and observational results obtained within the last few years.

13:30–14:00
Neural Network for Constrained Nonsmooth Optimization Using Tikhonov Regularization
Qin, Sitian
Harbin Inst. of Tech. at Weihai

Abstract: This paper presents a one-layer neural network to solve nonsmooth convex optimization problems based on the Tikhonov regularization method. It is proved that for any initial point, the state of the proposed neural network is globally convergent to the unique optimal solution of the related strongly convex optimization problems. Compared with the existing neural networks, the proposed neural network has lower model complexity and does not need penalty parameters.

14:00–14:30
Neural Network for Solving Constrained Convex Optimization Problems with Global Attractivity
Bian, Wei
Harbin Inst. of Tech.

Abstract: In this paper, we propose a neural network modeled by a differential inclusion to solve a class of nonsmooth convex optimization problems. By the regularization item, without any estimation on the exact penalty parameters, the solution of proposed network is convergent to the optimal solution set of optimization problem. Moreover, when the feasible region satisfies another condition, the solution of proposed network converges to the feasible region in finite time and it is global attractive.

14:30–15:00
Recurrent Convolutional Neural Network for Object Recognition
Hu, Xiaolin
Tsinghua Univ.

Abstract: Inspired by the biological neural networks in the brain where recurrent connections are abundant, we propose a recurrent CNN (RCNN) for object recognition. The idea is to incorporate recurrent connections in the convolution layers of CNN, which results in a dynamic system. With fewer trainable parameters, RCNN outperforms the state-of-the-art models on four popular object recognition datasets.

15:00–15:30
Real Time Model Predictive Control Based on Neurodynamics
Yan, Zheng
Huawei Technologies

Abstract: Model predictive control (MPC) requires real time solutions to, generally nonconvex, constrained optimization problems to obtain optimal control signals. Numerical optimization may not be competent for MPC applications due to the stringent requirements on time and optimality. Neurodynamics optimization based on recurrent neural networks emerges as a promising approach to real time optimization. In this talk, MPC problems are first formulated as sequential dynamic optimization problems, then neurodynamic approaches will be designed and customized.

13:30–15:30 311B
Analytical Pricing Methods for Path-Dependent Options

Organizer: Łukkowski, Mike UC Santa Barbara
Organizer: Leung, Tim Columbia Univ.
Organizer: Cai, Ning Hong Kong Univ. of Sci. & Tech.

Abstract: This minisymposium will explore new developments related to valuation of complex financial contracts, especially those with path-dependent features, such as Asian and Callable contracts.

13:30–14:00
Investor Behavior and Valuation of Turbo Warrant
Yang, Xuewei
Nanjing Univ.

Abstract: We examine how investors evaluate turbo warrant, which are essentially barrier options. Investors treat turbo warrant like lotteries in that they prefer turbo warrant with low prices, high volatilities, and high skewness. Our investment behavior proceeds accordingly.
zon with general utility function and general transaction costs. It is the price on market without transaction costs such that optimal value of the functional is the same as on the market with proportional transaction costs. To construct shadow price we introduce so called weak shadow price, which is the price depending on our financial position. Result is based on joint paper with T. Rogala.

**MS-We-D-54-3**  
14:30–15:00  
**Arbitrage Pricing of Multi-Person Game Contingent Claims**  
Rudkowski, Marek  
Univ. of Sydney  
Abstract: A novel class of multi-player competitive stochastic game in discrete-time with an affine specification of redistribution of payoffs at exercise is introduced. We identify conditions under which the optimal equilibria and the value for the game exist. We introduce a class of financial contracts involving several parties by extending the concept of the two-person game option due to Kiefer (2000). We provide conditions under which a multi-person game contingent claim admits an arbitrage price.

**MS-We-D-54-4**  
15:00–15:30  
**Dynamic Conic Finance via Backward Stochastic Difference Equations**  
Bielecki, Tomasz  
Illinois Inst. of Tech.  
Abstract: We present an arbitrage free framework for modeling bid and ask prices of dividend paying securities in discrete time using theory of dynamic acceptability indices given in terms of solutions of backward stochastic difference. We introduce pricing operators that are defined in terms of dynamic acceptability indices. We define bid and ask prices for underlying securities and then for derivatives in this market. We discuss related hedging issues in terms of control problems for g-expectations.

**MS-We-D-55**  
13:30–14:00  
**Fluid-structure interaction problems in biological and physical systems**  
Organizer: Lim, Sookkyung  
Univ. of Cincinnati  
Abstract: The interplay between fluid and elastic structures plays an important role in many biological and physical systems. This Mini-symposium will highlight recent developments in modeling, simulation, and methods for a wide range of fluid-structure interaction problems. The problems include flexibly-channel flow, DNA transport, sperm motility, and efficient methods of elastic rod dynamics.

**MS-We-D-55-1**  
13:30–14:00  
**Modeling Sperm Motility Using A Kirchhoff Rod Model**  
Olson, Sarah  
WPI  
Abstract: Sperm flagella have been observed to propagate different waves of bending, depending on the fluid environment. In this talk, we will discuss modeling aspects of the relevant fluid environment and chemical concentrations, relating emergent waveforms and interactions to current experiments. The acceptability flagellum is represented as a Kirchhoff rod and a regularized Stokes formulation will be used to solve for the local fluid flow. Results will be shown to describe emergent waveforms and swimming speeds.

**MS-We-D-55-2**  
14:00–14:30  
**Electro-hydrodynamic Effect on DNA Dynamics During Transport**  
Lim, Sookkyung  
Univ. of Cincinnati  
Abstract: We present computer simulations of DNA dynamics under electric field by using a stochastic version of the generalized immerced boundary method. Our simulations show that DNA molecule in a fluid in the presence of counterions and electric field has a tendency to undergo compression, and the amount of compression depends on the ionic strength and the electric field intensity. This is a joint work with David Swigon (University of Pittsburgh, USA) and Yongsam Kim (Chung-Ang University, Korea).

**MS-We-D-55-3**  
14:30–15:00  
**Self-excited Oscillations of Flexible-channel Flow with Fixed Upstream Flux**  
Xu, Feng  
The Univ. of Manchester  
Abstract: To understand onset of self-excited oscillations in a collapsible-tube flow driven by fixed upstream flux, we consider flow in a finite-length planar channel, where a segment of one wall is replaced by a tensioned membrane. We demonstrate how oscillations are driven by divergent instabilities when the membrane has similar length to the rigid segment of channel downstream of the membrane or a 1:1 resonant interaction when the downstream segment is much longer than the membrane.

**CP-We-D-55-4**  
15:00–15:20  
**Non Homogeneous Boundary Value Problems for the Stationary Navier-Stokes Equations in 2-d Symmetric Semi-infinite Outlet**  
Chipot, Michel  
Univ. of Zurich  
Abstract: We would like to present existence results for the stationary non homogeneous Navier-Stokes problem in symmetric domains having a semi-infinite outlet. We assume for this Leray problem the so called general outflow condition. (Joint work with K. Kalukayte, K. Pleciks and W. Xue)

**MS-We-D-56-1**  
13:30–14:00  
**Spectral Method for Substantial Fractional Differential Equations**  
Huang, Can  
Xiamen Univ.  
Zhimin, Zhang  
Beijing Computational Sci. Research Center, & Wayne State Univ.  
Abstract: A non-polynomial spectral Petrov-Galerkin method and associated collocation method for substantial FDEs are proposed, analyzed, and tested. We extend the generalized Laguerre polynomials to form our basis. Our PG method results in a diagonal and well-conditioned linear systems for model equations. In the meantime, we construct explicit fractional collocation matrices for them. Moreover, the proposed method allows us to adjust a parameter in basis selection according to different given data to maximize the convergence rate.

**MS-We-D-56-2**  
14:00–14:30  
**Moving Finite Element Methods for A System of Semi-linear Fractional Diffusion Equations**  
Ma, Jingtao  
Southwestern Univ. of Finance & Economics  
Abstract: We will present moving mesh finite element methods for a system of semi-linear fractional diffusion equations. The system of fractional diffusion equations may arise in competitive predator-prey models by replacing the second-order derivative in the spatial variables with a fractional derivative of order less than two. Moving finite element methods are developed to solve the system of fractional diffusion equations and the convergence rates of the methods are proved.

**MS-We-D-56-3**  
14:30–15:00  
**Optimal Error Estimates of Spectral Galerkin and Collocation Methods for Fractional Differential Equations**  
Zhang, Zhongqiang  
Worcester Polytechnic Inst.  
Karniadakis, George  
Brown Univ.  
Zeng, Fanhai  
Brown Univ.  
Abstract: We present optimal error estimates for spectral Galerkin method- and spectral collocation methods for linear fractional differential equations with initial value or boundary values on a finite interval. We also develop La- guerre spectral Petrov-Galerkin methods and collocation methods for fraction- al equations on the half line. Numerical results confirm the error estimates.

**MS-We-D-56-4**  
15:00–15:30  
**Modeling, Applications, Numerical Methods, and Mathematical Analysis of Fractional Partial Differential Equations II – Part II of IV**  
For Part 1, see MS-Tu-E-56  
For Part 3, see MS-We-E-56  
For Part 4, see MS-Th-BC-56  
Organizer: Karniadakis, George  
Brown Univ.  
Organizer: Wang, Hong  
Univ. of South Carolina  
Abstract: Fractional Partial Differential Equations (FPDEs) are emerging as a new powerful tool for modeling many difficult complex systems, i.e., systems with overlapping microscopic and macroscopic scales or systems with long-range time memory and long-range spatial interactions. They offer a new way of accessing the mesoscale using the continuum formulation and hence extending the continuum description for multiscale modeling of viscoelastic materials, control of autonomous vehicles, transitional and turbulent flows, wave propagation in porous media, electric transmission lines, and speech signals. FPDEs raise modeling, computational, mathematical, and numeri- cal difficulties that have not been encountered in the context of integer-order partial differential equations. The aim of this minisymposium is to cover the recent development in mathematical and numerical analysis, computational algorithms, and applications in the context of FPDEs and related nonlocal problems.
Fractional Partial Differential Equations II—Fast Laplace Transform for Fractional Diffusion Equations
SUN, Hai-wei
Univ. of Macau

Abstract: The Laplace transform with hyperbolic contour is exploited to solve space-fractional diffusion equations. By making use of the Toetplitzlike structure of spatial discretized matrices and the relevant properties, the regions that the spectra of resulting matrices lie in are derived. Suitable parameters in the hyperbolic contour are selected based on these regions to solve the fractional diffusion equations. Numerical experiments are provided to demonstrate the efficiency of our contour integral methods.

MS-We-D-57 13:30–15:30 402A
Advances in Numerical Methods for Porous Media Flow - Part III of IV
For Part 1, see MS-Tu-D-57
For Part 2, see MS-Tu-E-57
For Part 4, see MS-We-E-57
Organizer: Wang, Hong
Univ. of South Carolina
Organizer: Sun, Shuyu
King Abdullah Univ. of Sci. & Tech.
Organizer: Rui, Hongxing
Department of Mathematics, Shandong Univ.
Abstract: Porous media flow has wide applications in many areas, including environmental, energy, biological and engineering applications. They lead to strongly coupled transport processes also with nonlinear chemical reactions, which are computationally challenging, for it demands high accuracy and local mass conservation. Porous media manifest dramatically different at different spatial and temporal scales. Heterogeneity, anisotropy, and discontinuity of medium properties require special treatment. The aim of this minisymposium is to bring together researchers in the aforementioned field to highlight the current developments, to exchange the latest research ideas, and to promote further collaborations in the community.

▶ MS-We-D-57-1 13:30–14:00
Iterative Methods for Multiphysics Including Flow and Geomechanics in Fractured Porous Media
Kumar, Kundan
Uni of Bergen
Wheeler, Mary F
UT-Austin
Abstract: Fractures play an important role in determining the flow profile and at the same time are vulnerable regions for the mechanical deformations. We consider an iterative scheme for solving coupled mechanics and flow problems in a fractured poroelastic medium. For the flow problem, we use newly developed multipoint flux mixed method discretization techniques and comment on the extensions to multiphase flows.

▶ MS-We-D-57-2 14:00–14:30
Numerical Methods for Darcy-Forchheimer Flow in Porous Media
Rui, Hongxing
Department of Mathematics, Shandong Univ.
Abstract: Darcy Forchheimer model is a kind of nonlinear model to describe flow which can not be modelled by Darcy’s law in porous media. In this talk we will present some cell-centered finite difference methods based on the lowest order mixed elements to non-Darcy (Darcy-Forchheimer) flow problems. We will present the approximate schemes, existence and uniqueness analysis, error estimate and numerical examples.

▶ MS-We-D-57-3 14:30–15:00
TWO-PHASE FLUID SIMULATION USING A DIFFUSE INTERFACE MODEL WITH PENG–ROBINSON EQUATION OF STATE
Qiao, Zhonghua
The Hong Kong Polytechnic Univ.
Sun, Shuyu
King Abdullah Univ. of Sci. & Tech.
Abstract: Two-phase fluid systems are simulated using a diffuse interface model with the Peng – Robinson equation of state (EOS), a widely used realistic EOS for hydrocarbon fluid in the petroleum industry. Some energy stable numerical schemes are developed to solve the resulting partial differential equation. Our proposed algorithms are able to solve successfully the spatially heterogeneous two-phase systems with the Peng – Robinson EOS in multiple spatial dimensions, the first time in the literature.

▶ MS-We-D-57-4 15:00–15:30
From Coupling Stokes-Cahn-Hillard Equations to Darcy’s Law for Two-phase Fluid Flow in Porous Medium by Volume Averaging
Chen, Jie
Xi’an Jiaotong University
Sun, Shuyu
King Abdullah Univ. of Sci. & Tech.
Wang, Xiaoping
Hong Kong Univ. of Sci. & Tech.
Abstract: A technique of local volume averaging is applied to a two-phase fluid mixture system and general equations are obtained which depict mass and momentum transport in porous media. Starting from coupling Stokes-Cahn-Hillard equations for incompressible two-phase fluid flow, the averaging is performed without significantly idealizing either the porous medium or the fluid mechanical relations. The resulting equations are generalized Darcy’s law for two-phase flow with medium parameters resulted from the averaging procedure.

MS-We-D-58 13:30–16:00 401
Numerical Methods for Multi-physics Problems - Part II of III
For Part 1, see MS-Tu-E-58
For Part 3, see MS-We-E-58
Organizer: Bazilevs, Yuri
Univ. of California, San Diego
Organizer: Xu, Jinchao
PKU, and The Pennsylvania State Univ.
Organizer: Zhang, Shuo
Inst. of Computational Mathematics, Chinese Acad. of Sci.
Abstract: Most systems targeted by mathematical modeling in modern science and engineering are multi-physical and multi-scale. These models involve complex coupled nonlinear systems of PDEs built from different physical processes at different scales. Developing robust, efficient, and practical numerical algorithms that can tackle these complex models is one central task of modern computational sciences and also a challenging one. This minisymposium will gather together experts from around the world in the related fields in industrial and applied mathematics to exchange ideas regarding the development of robust and efficient numerical schemes that preserve the key physics of these models, and to study the development of fast and efficient linear and nonlinear solvers that are scalable and optimal.

▶ MS-We-D-58-1 13:30–14:00
Comparison of Turbulence Modeling Approaches in the Context of Fluid-structure Interaction
Schafer, Michael
TU Darmstadt
Abstract: Fluid-structure interaction phenomena play an important role in many technical applications. In most cases the involved fluid flows are turbulent. We present investigations concerning the influence of the turbulence modeling on the prediction quality of fluid-structure interaction simulations. The comparative study involves RANS, LES, hybrid DNS-RANS, and hybrid LES-RANS approaches as well as experimental results. Aspects of numerical efficiency and accuracy are discussed for representative test cases.

▶ MS-We-D-58-2 14:00–14:30
Parallel Adaptive Mesh Refinement and Coarsening: Algorithms and Implementation
Zhang, Lin-bo
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Abstract: The newest vertex bisection scheme for conforming triangular meshes has been successfully used in many adaptive finite element computations. But due to the complexity of the algorithms, its scalable parallel implementations are still very few. In this talk we will present parallel local mesh refinement and coarsening algorithms and their implementations in the parallel adaptive finite element toolbox PHG (http://lsec.cc.ac.cn/phg/index_en.html), and show timing results of these algorithms in adaptive finite element computations.

▶ MS-We-D-58-3 14:30–15:00
Space-time Trace FEM for Incompressible Flows with Moving Interfaces
Reusken, Arnold
IGPM, RWTH Aachen Univ.
Abstract: We consider a sharp interface model for a flow problem with two different immiscible incompressible newtonian phases (fluid-fluid or fluid-gas). This fluid dynamics model may be coupled with a model for mass transport between the phases and a model for transport of surfactants on the interface. In recent years so-called trace finite element techniques have been developed for this type of multi-physics problems. In this presentation we treat space-time variants of this trace FEM technique.

▶ MS-We-D-58-4 15:00–15:30
Quantifying the Influence of Conformational Uncertainty in Biomolecular Solution
Huan, Lei
Pacific Northwest Natl Laboratory
Yang, Xiu
Pacific Northwest Natl Laboratory
Bin, Zheng
Pacific Northwest National Laboratory
Lin, Guang
Purdue Univ.
Baker, Nathan
Pacific Northwest Natl Laboratory
Abstract: Biomolecules exhibit conformation fluctuations near equilibrium states, inducing uncertainty in various biological properties. We have developed a general method to quantify this uncertainty using a generalized polynomial chaos expansion on collective variables identified using the active subspace method. The method is demonstrated on solvation properties and shown to yield a more accurate response surface than standard sparse grid collocation methods. Our framework is generalizable and can be used to
investigate uncertainty in numerous biomolecular properties.

**MS-We-D-58-5**  
15:30–16:00  
**High Order Extended Finite Element Methods for Interface Problems**  
Wang, Fei  
Pennsylvania State Univ.  
Xu, Jinchao  
PKU, and The Pennsylvania State Univ.  
Zhang, Shuo  
Inst. of Computational Mathematics, Chinese Acad. of Sci.  
Xiao, Yuanming  
Nanjing Univ.

Abstract: For subdomain coupled multi-physics problems, the most difficult part is dealing with an interface, which separates two phases of matter. The extended finite element method (XFEM) has shown its potential in a variety of applications that involve non-smooth solutions near interface. We consider a high order XFEM with DG schemes to solve an elliptic interface problem. We show the optimal convergence rate for any order XFE space if the solution satisfies certain regularity in each sub-domain.

**MS-We-D-59**  
13:30–15:30  
**Modeling, Simulation and Analysis of Interface and Defect Problems in Solids**  
For Part I, see MS-Tu-D-59  
For Part II, see MS-Tu-E-59

Organizer: Yang, Xiang  
Hong Kong Univ. of Sci. & Tech.

Abstract: Interfaces or defects in crystalline materials, such as vacancies, dislocations, cracks, grain boundaries, and surfaces, play important roles in the mechanical, electronic, and plastic properties of these materials. The complexity of modeling microstructures of these defects and their evolution at various length and time scales presents new challenges for mathematical modeling and analysis. Multiphysics models are required to accurately describe the complicated interactions among various defects involved in the equilibrium and dynamics processes. The speakers in this minisymposium will discuss recent advances in the modeling approaches and new findings obtained in analysis and simulations.

**MS-We-D-59-1**  
13:30–14:00  
**Efficient Sum-of-exponentials Approximations for the Heat Kernel and Their Applications**  
Jiang, Shidong  
New Jersey Inst. of Tech.

Abstract: In this talk, we show that efficient separated sum-of-exponentials approximations can be constructed for the heat kernel in any dimension. The number of exponentials in the approximation depends only logarithmically on the total number of time steps. When combined with integral equation method to solve the boundary value problems of the heat equation in complex geometries, the resulting algorithms are nearly optimal in computational complexity. The algorithms can also be parallelized in a straightforward manner.

**MS-We-D-59-2**  
14:00–14:30  
**Construction and Analysis of Atomistic/Continuum Coupling Method**  
Zhang, Lei  
Shanghai Jiao Tong Univ.

Abstract: We discuss the construction of quasi-optimal energy based atomistic/continuum (A/C) coupling methods for crystalline solids with defects, based on tools from numerical analysis. For general multi-body interaction on the 2D triangular lattice (and potentially for 3D lattices), we show that ghost force removal (patch test consistent) A/C methods can be constructed for arbitrary interface geometries. Further improvement can be achieved by using blending method and if a good ‘predictor’ is available.

**MS-We-D-59-3**  
14:30–15:00  
**Dislocation Climb Formulation for Discrete Dislocation Dynamics**  
Srolovitz, David J  
Univ. of Pennsylvania

Abstract: We derive Green’s function formulation for the climb of curved dislocations and multiple dislocations in three-dimensions. In this new formulation, the dislocation climb velocity is determined from the Peach-Koehler force on dislocations through vacancy diffusion in a non-local manner. We also present a numerical discretization method of this Green’s function formulation appropriate for implementation in discrete dislocation dynamics simulations.

**MS-We-D-59-4**  
15:00–15:30  
**Efficient Algorithms for Transition State Calculations**  
Gao, Weiguo  
Fudan Univ.

Abstract: Transition states (or index-1 saddle points) are fundamental to understanding the reaction dynamics qualitatively. We introduce a locally optimal search direction finding algorithm and an iterative minimizing method for the translation which improve the rotational step by a factor and the translational step a quantitative scale. Numerical experiments demonstrate the efficiency of our proposed algorithms. This is joint work with Jing Leng, Zhi-Pan Liu, Cheng Shang and Xiang Zhou.

**IM-We-D-60**  
13:30–15:30  
**Industrial Mathematics Around the World - Part V of VIII Activities on Industrial-Mathematics in East Asia and the West Pacific Region (besides China)**

For Part 1, see IM-Mo-D-60  
For Part 2, see IM-Mo-E-60  
For Part 3, see IM-Tu-D-60  
For Part 4, see IM-Tu-E-60  
For Part 5, see IM-We-E-60  
For Part 7, see IM-Th-BC-60  
For Part 8, see IM-Th-D-60

Organizer: Cat, Zhijie  
Fudan Univ.

Organizer: Chen, Gui-Qiang G.  
Univ. of Oxford

Organizer: Huang, Huaxiong  
York Univ.

Organizer: LU, Liqiang  
Fudan Univ.

Organizer: Ockendon, Hilary  
Univ. of Oxford

Organizer: Ockendon, John  
Univ. of Oxford

Organizer: Peng, Shige  
Shandong Univ.

Organizer: Tan, Yongji  
Fudan Univ.

Organizer: Wake, Graeme  
Massey Univ.,

Organizer: Zhu, Yichao  
The Hong Kong Univ. of Sci. & Tech.

Organizer: CHENG, JIN  
Fudan Univ.

Abstract: The aim of this section is to boost the use of mathematics as an industrial resource in China and around the world. It will highlight (i) the global experience in industrial mathematics and (ii) the new mathematical ideas that these activities have created as well as the exploitation of existing technologies to new applications. Participants will come from both academia and industry and, for this purpose, the section is proposed to consist of eight minisymposia. Four of them will overview the identification and solution of industrially-driven mathematical problems and the mechanisms that have evolved to deal with them in different regions: China, other Asia-Pacific countries, Europe and North America. Three of the remaining minisymposia will focus on the problems coming from different sectors: financial industry, petroleum industry and industrial areas in which wave propagation is important. The last minisymposium will involve an open discussion on how the global mathematics community can best respond to the increasing demand from industry for applied and computational mathematics; the agenda will include both the mechanisms for academic / industrial collaboration and the areas where it will be most fruitful.

**IM-We-D-60-1**  
13:30–14:00  
**Mathematics-for-Industry and Industry-for-Mathematics**  
Wakayama, Masato  
Kyushu Univ.

Abstract: The concept of Mathematics-for-Industry highlights the fact that, in order to find solutions to problems raised by real-life problems, one must look for possible solutions in the wild forest of available mathematical knowledge. Sometimes, the relevant mathematics is already there, waiting to be harvested. More often, know mathematics must be adapted and viewed from a new perspective, like sculpturing a figure from a block of wood. Occasionally, and very importantly, the inverse process arises where the application...
Numerical simulation of radiative transfer equation is important algorithm. Signature matrix method with the block fixed point iteration and its complexity the shortest augmenting path algorithm for finding maximum value transverse and efficient algorithm for computing the large scale DAEs system. We exploit ear and high index. To make use of its sparsity, this paper provides a simple In general, the feature of DAEs is a sparse large scale system of fully nonlinear and high index. To make use of its sparsity, this paper provides a simple and efficient algorithm for computing the large scale DAEs system. We exploit the shortest augmenting path algorithm for finding maximum value transversal as well as block triangular forms (BT). We also present the extended signature matrix method with the block fixed point iteration and its complexity results. Furthermore, a range of nontrivial problems are demonstrated by our algorithm.

Numerical Method for Euler Equations with Boundary Conditions Monnuanprang, Peiangprob Phranakon Rajabhat Univ.

Abstract: In this paper present numerical methods for the solution of the Euler equations of an ideal incompressible fluid flow through a bounded domain with inlet, outlet and impermeable parts of the boundary. The plots of flow structure and isolars under some geometries and flow conditions are included. The code can be used to predict flows for three different kinds of boundary conditions on inlet and outlet parts of a channel.

Efficient Algorithm for Computing Large Scale Systems of Differential Algebraic Equations Qin, Xiaolin Chengdu Inst. of Computer Applications, Chinese Acad. of Sci.

Abstract: In many mathematical models of physical phenomena and engineering fields, such as electrical circuits or mechanical multibody systems, while solve the differential algebraic equations (DAEs) systems naturally. In general, the feature of DAEs is a sparse large scale system of fully nonlinear and high index. To make use of its sparsity, this paper provides a simple and efficient algorithm for computing the large scale DAEs system. We exploit the shortest augmenting path algorithm for finding maximum value transversal as well as block triangular forms (BT). We also present the extended signature matrix method with the block fixed point iteration and its complexity results. Furthermore, a range of nontrivial problems are demonstrated by our algorithm.

Numerical Study on the Difference Schemes for Radiative Transfer Hang, Xudeng Inst. of applied physics & computational mathematics

Abstract: Numerical simulation of radiative transfer equation is important while difficult. In this paper, we study the behaviors of difference schemes for the discrete ordinates equations of radiative transfer. The performances are compared for the diamond scheme, the step scheme, corner balance schemes and two new schemes. Numerical experiments show different precision and stability behavior. The two new difference schemes show good precision and are more stable than the diamond schemes and the corner balance schemes. We also study the discretization of the material energy equation in the radiative transfer equations. Two discretization methods are studied, one is to discretize the energy equations on the cell and the other is to discretize on the sub cells. We propose a way to discretize the equation on the cells which is as precise as the one on sub cells.

A Monotone Finite Volume Scheme Preserving Fully Positivity for Diffusion Equation Sheng, Zhiqiang Inst. of Applied Physics & Computational Mathematics

Abstract: An entropy stable central solver developed recently, named MOVERS (Method of Optimal Viscosity for Enhanced Resolution of Shocks) of Jaisankar and Rao (J Comput Phys 2009:228:770-798), is designed to capture steady discontinuities exactly by enforcing Rankine-Hugoniot condition directly in the discretization process. This scheme is low dissipative and free of Riemann solvers. However, MOVERS requires entropy fix to avoid non-smoothness at the expansion regions. Here, the entropy conservation equation is used as a guideline to fix the optimal amount of numerical dissipation for smooth regions of the flow and dissipation from MOVERS is used at the discontinuities. This hybrid scheme uses limiters to switch over from smooth regions to large gradients of the flow. The resulting new scheme is entropy-stable, free of shock instabilities, captures steady discontinuities exactly and yet avoids the usage of entropy fix.
Abstract: In this article, trapped mode frequencies, which are embedded in a continuous spectrum, are computed for a pair of horizontal circular cylinders, each of infinite extent along the y-axis are placed in either layer of a two-layer fluid of infinite depth bounded above by a thin ice-cover. A fifth-order boundary condition arising at the ice-cover makes the problem more complex but interesting. Using multipole expansion, an infinite system of homogeneous linear equations is obtained with complex-valued coefficients. For a fixed geometrical configuration and density ratio, the existence of trapped modes is examined by numerically computing the natural frequencies for which the truncated complex determinant vanishes. When the cylinders are placed in lower layer, the variation of these modes is investigated by varying the depth of upper layer and also the submergence depth. The effect of the variation of ice parameters on the existence of trapped modes is also looked into.

**CP-We-D-62-3**
14:10–14:30
Sloshing in An Annular Vertical Circular Cylindrical Container in Presence of A Rigid Baffle Inside Fluid Domain

Choudhary, Neelam  
Bora, Sarwop Nandan  
Indian Inst. of Tech. Guwahati

Abstract: If an annular baffle is attached to the outer cylinder wall in the annular region of a circular cylinder, filled with an ideal liquid, at some depth, the natural frequencies in the cylinder undergo a drastic change. The baffle divides the liquid region into four in each of which boundary value problems are set up. Using matching conditions across the virtual interfaces and setting up a system of linear equations, the natural frequencies are determined.

**CP-We-D-62-4**
14:30–14:50

Mason, David  
Univ. of the Witwatersrand, Johannesburg

Abstract: Two conservation laws for the nonlinear diffusion equation describing a two-dimensional PKN hydraulic fracture are derived. The first is the elementary conservation law while the second is new. The Lie point symmetry associated with each conserved vector is derived and the solution generated by each symmetry is obtained. The first solution describes a hydraulic fracture evolving with constant volume. The second solution describes the limiting case of fluid extraction in which a jet of fluid escapes from the fracture at the fracture entry.

**CP-We-D-62-5**
14:50–15:10
Traveling Wave Exact Coherent States in Plane Poiseuille Flow

Wall, D. P  
Nippon Burui Univ.

Abstract: Three travelling wave exact coherent states in plane Poiseuille flow are obtained by homotopy from solutions to plane Poiseuille flow subject to a spanwise system rotation recently presented by Wall & Nagata (J. Fluid Mech. 727: 533 – 581, 2013). Two of the solutions are asymmetric with respect to the channel centreplane while the third satisfies a half-turn rotational symmetry about a point on this plane. This latter solution can further be continued to a spanwise-localised flow. In addition, one of the asymmetric flows is found to exist down to a Reynolds number of 665, significantly reducing the previous known minimum for channel flow solutions other than the basic state of 806.

**CP-We-D-62-6**
15:10–15:30
Thin-film Flow in Helical Channels

Arnold, David  
Stokes, Yvonne  
Green, Edward  
The Univ. of Adelaide  
The Univ. of Adelaide  
The Univ. of Adelaide

Abstract: Flows in helical channels have applications ranging from spiral separators used in the mineral processing industry, to spiral microchannels used in lab-on-a-chip technology to separate different types of cells in blood samples. We consider flows of Newtonian fluid in helically wound channels of arbitrary centreline torsion and curvature. The free-surface inherent in such flows means analytical progress is more difficult than in the better-known study of flow in helical pipes. By making the physically realistic assumption that the fluid depth is small relative to the channel width, we are able to find an analytic solution for flow in a channel with rectangular cross-section. This allows us to quantify the effects of the geometric parameters and the fluid flux on the flow. In some parameter regimes we see the emergence of multiple rotating cells of fluid, a novel result that may have important consequences for particle transport.

**CP-We-D-63**
13:30–15:30
Numerical Analysis

Chair: Abreu, Eduardo  
Univ. of Campinas - UNICAMP

**CP-We-D-63-1**
13:30–13:50
A Conservative Unsplitting Scheme for Nonlinear Balance Laws: Application to Euler System with Stiff Relaxation Source Terms

Abreu, Eduardo  
Campinas, Brazil  
Univ. of Campinas - UNICAMP

Alvarez, Abel  
Campinas, Brazil  
Univ. of Campinas - UNICAMP

Lambert, Wanderson  
Federal Univ. Rural of Rio de Janeiro

Abstract: We study traveling wave solutions for Euler systems with relaxation linked to many objectives in mind ranging from mathematical theory to numerics with applications. We developed a cheap unsplitting finite volume scheme that reproduces the same traveling wave asymptotic structure as that of the Euler solutions of the continuous system at the discrete level as well as consistent to solutions for more general Euler equations with gravity and friction found in current literature.

**CP-We-D-63-2**
13:50–14:10
A NON-ITERATIVE IMPLICIT ALGORITHM FOR THE SOLUTION OF ADVECTION-DIFFUSION EQUATION ON A SPHERE

Skiha, Yuri  
National Autonomous Univ. of Mexico

Abstract: A numerical algorithm for solving advection-diffusion equation on a sphere is suggested. The discretization of problem in space is carried out with the finite volume method and the Gauss theorem. The discretization in time is performed with the splitting method and Crank-Nicolson schemes. The numerical algorithm is of second order approximation and unconditionally stable. In the absence of forcing and dissipation, it conserves the total mass and solution norm. The split periodic problems in longitudinal direction are solved with Sherman-Morrison’s formula and Thomas’s algorithm. The split problems in the latitudinal direction are solved by the bordering method that requires a prior determination of the solution at the poles. The resulting linear systems have tridiagonal matrices and are solved by Thomas’s algorithm. The method is direct (without iterations) and rapid in realization. It can also be applied to linear and nonlinear diffusion problems, some elliptic problems and adjoin advection-diffusion problems.

**CP-We-D-63-3**
14:10–14:30
An Approach to the Construction of Iterative Methods for Solving Nonlinear Differential Equations

Dang, Quang A  
Inst. of Information Tech., VAST

Abstract: In this paper we propose an approach to the construction of iterative methods for solving nonlinear differential equations. It is based on an iterative scheme applied to the integral equation with the kernel being the Green function for a linear part of the differential equations. This kernel serves as an efficient Lagrange multiplier in the variational iteration method. A number of examples for initial value problems of first, second and higher orders show that this method is more general and simpler than the variational iteration method, which now is widely and effectively used for nonlinear problems.

**CP-We-D-63-4**
14:30–14:50
Stability and Temporal Accuracy of Semi-implicit Projection Methods for the Time-Dependent Incompressible Navier-Stokes Equations

Pan, Xiaomin  
Yonsei Univ.

Lee, Changhoon  
Yonsei Univ., Department of Computational Sci. & Engineering

Kim, Kyoungyoun  
Hanbat National Univ., Department of Mechanical Engineering

Choi, Jung-II  
Yonsei Univ., Department of Computational Sci. & Engineering

Abstract: The present study focuses on analyzing the stability property and temporal accuracy of two semi-implicit projection methods such that iterative and fully decoupled methods for solving the time-dependent incompressible Navier-Stokes equations. In the projection methods, the Crank-Nicolson scheme is used for both the convection and diffusion terms, and pressure-velocity decoupling is achieved based on a block LU decomposition. Moreover, the intermediate velocity components are also decoupled in the fully decoupled method. We prove that the two methods are second-order accurate in time. In order to demonstrate the stability property, we consider kinetic energy estimation for fully-discrete Navier-Stokes equations and von Neumann analysis for linearized Navier-Stokes equations. Three types of discrete convective terms are considered in the analytical discussions. Finally, we perform numerical simulations for the well-established benchmark problems and validate the present theoretical assertions.
Mography is an emerging, in vivo non-invasive 3-D imaging technique which is used to assess the diffusion of contrast material in biological tissues.

Nutrient Uptake by Roots of Crops in Fixed and Variable Soil Volume

Three-Dimensional Simulation and Visualization of Steam Flow and Heat Transfer in Power Plant Condensers

Transfer in Power Plant Condensers

Nutrient Uptake by Roots of Crops in Fixed and Variable Soil Volume

Moving boundary model is solved by adaptive finite element method. Comparison of predicted cumulative uptake in fixed and variable soil volume versus observed results are shown. For low concentrations the moving boundary produces better predictions particularly for K. For P the moving boundary produces better predictions only at low concentrations being these predictions comparable to the obtained by 3D-dimensional architectural models. Obtained improvements are due to use a generalized formula for the cumulative nutrient uptake, to use a same dynamics to obtain infuxes and the cumulative uptake and, the use of finite element method assuring that only our model satisfies the mass balance.

Innovative Weak Galerkin Finite Element Methods with Application in Fluorescence Tomography

Numerical Investigation of Compressibility Coefficients of Gas Transport Models in Unconventional Hydrocarbon Reservoirs

Mathematical modelling of the flow mechanism of natural gas through unconventional hydrocarbon reservoirs, such as, shale gas or tight gas, results into nonlinear time-dependent convection-diffusion equations, with highly nonlinear coefficients. These coefficients are unknown and accurate and precise determination of these coefficients play crucial role in the success of the reservoir simulations. In this study, we numerically investigate several compressibility coefficients and determine which of them are most important in describing the pressure distribution in a reservoir.

Three-Dimensional Simulation and Visualization of Steam Flow and Heat Transfer in Power Plant Condensers

Z-Chebyshev Optimal Approximation and Method

About: In discrete data processing, Chebyshev optimal approximation has constituted Minimax approximation (minimizing the maximum absolute error approximation). According to the law of unity and opposites, there must be an approximation called “Mini-mini approximation” (minimizing the minimal absolute error approximation). From the best approximation point of view, the result of “Mini-mini approximation” must be zero, so called “zero-error approximation”. Kneading the two together constitutes a new finite element method. Comparison of predicted cumulative uptake in fixed and variable soil volume versus observed results are shown. For low concentrations the moving boundary produces better predictions particularly for K. For P the moving boundary produces better predictions only at low concentrations being these predictions comparable to the obtained by 3D-dimensional architectural models. Obtained improvements are due to use a generalized formula for the cumulative nutrient uptake, to use a same dynamics to obtain infuxes and the cumulative uptake and, the use of finite element method assuring that only our model satisfies the mass balance.

Active Disturbance Rejection Control Approach to the Stabilization of Euler-Bernoulli Beam with Pointwise Input Disturbance

Abstract: We consider the stabilization of Euler-Bernoulli beam with pointwise input disturbance. The active disturbance rejection control (ADRC) approach is adopted in this investigation. We estimate the disturbance and cancel it by constructing an extended state observer. It is shown that the closed-loop system is asymptotically stable in the feedback loop with its online estimation.

A Parallel Tempering-Multicanonical Sampling Approach for Studying the Aggregation of Bead Polymers

Abstract: In discrete data processing, Chebyshev optimal approximation has constituted Minimax approximation (minimizing the maximum absolute error approximation). According to the law of unity and opposites, there must be an approximation called “Mini-mini approximation” (minimizing the minimal absolute error approximation). From the best approximation point of view, the result of “Mini-mini approximation” must be zero, so called “zero-error approximation”. Kneading the two together constitutes a new finite element method. Comparison of predicted cumulative uptake in fixed and variable soil volume versus observed results are shown. For low concentrations the moving boundary produces better predictions particularly for K. For P the moving boundary produces better predictions only at low concentrations being these predictions comparable to the obtained by 3D-dimensional architectural models. Obtained improvements are due to use a generalized formula for the cumulative nutrient uptake, to use a same dynamics to obtain infuxes and the cumulative uptake and, the use of finite element method assuring that only our model satisfies the mass balance.
Abstract: For response and survival in the market, competition is needed and the organizations should be flexible to variations of market. In addition, they ought to utilize their maximum capacity and reduce storage costs. According to the demand of product, choosing the appropriate production strategy can help to achieve these goals. In this paper, we examine the market to identify competitors. Then, we examine different strategies and present a model for selecting production strategy. In this paper, the idea of the algorithm “Knapsack” is used to select production strategy. Moreover, we have attempted to utilize simple numerical method for solving model. The diverse production strategies which we interpret them in this paper are: MTS, MTO, ATO and ETO. Finally, the numerical experiments reveal to show the advantages of the applied mathematical programming model.

Abstract:Structured Low Rank Approximation (SLRA) problem is a well-known problem in the field of numerical linear algebra with applications in theoretical computer science, control theory, and image processing. The SLRA problem is the problem of finding the nearest low rank approximation to a given structured matrix preserving structure. Various approaches of computing SLRA are discussed in the literature; for instance total least squares formulation as well as computational results are presented. Such problems arise in both theoretical considerations and in practical problems. For the first and the second problem, a necessary and sufficient condition is proved for a feasible solution to be an optimal solution to the respective problem, and a sufficient condition is proved for a feasible solution to be an optimal solution to the third problem. Algorithm of polynomial complexity for solving the three problems are proposed and convergence of these algorithms is proved. Some particular problems of the considered forms as well as computational results are presented.

Abstract:Modelling Plant Cell Invasion by the Rice Blast Fungus

Abstract:We present a mathematical model for plant cell invasion by the rice blast fungus. The model couples an evolution law for the growth of a tumour on the plant leaf to a reaction diffusion system that holds on the surface of the blast fungus. The model couples an evolution law for the growth of a tumour on the plant leaf to a reaction diffusion system that holds on the surface of the tumour. We derive a finite element approximation to the model and we show some computational results.

Abstract:We present a mathematical model for plant cell invasion by the rice blast fungus. We derive a finite element approximation to the model and we show some computational results.

Abstract:We present a numerical scheme for a class of coupled PDEs on complex-shaped, time-dependent domains and their surfaces, which possibly undergo strong anisotropic deformations and changes in topology. It decouples geometry and computational mesh by using an implicit level set description of the geometrical setup and employing the unfitted DG method, together with a consistent extension for surface PDEs which is inspired by the Eulerian surface FEM. Biological processes yield model problems for numerical experiments.

Abstract:We present a mathematical model for plant cell invasion by the rice blast fungus. The model couples an evolution law for the growth of a tumour on the plant leaf to a reaction diffusion system that holds on the surface of the tumour. We derive a finite element approximation to the model and we show some computational results.

Abstract:We present a mathematical model for plant cell invasion by the rice blast fungus. The model couples an evolution law for the growth of a tumour on the plant leaf to a reaction diffusion system that holds on the surface of the tumour. We derive a finite element approximation to the model and we show some computational results.
Bayesian inference in high-dimensional chaotic dynamical systems,

Abstract:
Currents Hierarchical Bayesian Learning for Two-Dimensional Turbulent Bottom Gravity CP-We-E-03-3 17:00–17:20

least-squares approximations. Recent developments will be reviewed. UQ applications. We will first discuss a general framework of stochastic collo-

statistics and nonlinear dynamics in high-dimensional multiscale ocean flows. our hierarchical Bayesian learning methodology for capturing non-Gaussian
dimensionality one. A new lattice support transformation algorithm is proposed for

curves and surfaces defined on proper lattice supports are proper with prob-

Approximately Proper Reparametrization of Rational Curves and Surfaces IM-We-E-04-3 17:00–17:20

Hierarchical Bayesian Learning for Two-Dimensional Turbulent Bottom Gravity Currents CP-We-E-03-3 17:00–17:20

Abstract: Bayesian inference in high-dimensional chaotic dynamical systems, such as turbulent fluid flows, is challenging because of the high computational costs in capturing the multiscale dynamics and integrating over high-dimensional state variables to compute posteriors. To overcome this difficulty, we developed a novel hierarchical Bayesian learning methodology. The methodology propagates uncertainty in a reduced subspace using the dynamically orthogonal (DO) equations, and jointly infers state variables and model parameters by the Gaussian mixture model-DO filter. Based on the evolving statistics and the sequential observations, the underlying models are learned dynamically in a hierarchical Bayesian way. This methodology is applied to a two-dimensional realistic turbulent bottom gravity current. The learning targets include initial and boundary functional data, domain geometry and model parameters. The numerical results indicate the capability and efficiency of our hierarchical Bayesian learning methodology for capturing non-Gaussian statistics and nonlinear dynamics in high-dimensional multiscale ocean flows.
improper supports.

**Abstract:** Recent years have witnessed the rapid development of distributed control of multi-robot systems because the multi-robot system has some distinguished features such as the flexibility, low-cost and high tolerance to disturbances. As the number of robots increases, the centralized organization of multi-robot systems encounters many disadvantages. A promising way is to optimize the multi-robot system in a distributed manner. This will bring difficulties in the design of corresponding control approaches. This minisymposium aims at attracting contributions of distributed control of multi-robot systems and provides a forum for researchers in this field.

**MS-We-E-05-1**

**Synchronized Control for Multiple Lagrange System**

Zhaoyong, Dongya [China Univ. of Petroleum] 16:00–16:30

**Abstract:** With the advances in production, more and more tasks require cooperation in the mechanical systems. The multiple machines are required to work in cooperative manner. For high-precision machineries, the moving parts are required to work in coordinated mode. Synchronized control approach is an effective solution for cooperation in mechanical systems. It becomes a hot issue in academia and industry.

**MS-We-E-05-2**

**Leader-Follower Flocking Based on Distributed Event-triggered Hybrid Control**

Yu, Pian [Wuhan Univ.] 16:30–17:00

**Abstract:** A novel hybrid control algorithm is proposed in this paper to achieve leader-follower flocking in multi-agent systems. The proposed algorithm only uses position state continuously while the velocity state is utilized discretely. The sampling instant is governed by a distributed event-triggered mechanism in which neighbors’ velocity is not required to verify the event-triggered condition. It is shown that stable flocking is achieved asymptotically while the connectivity of networks can be preserved for the whole process.

**MS-We-E-05-3**

**On the Task-space Consensus of Networked Robotic Systems without Task-space Velocity Measurement**

Wang, Hanlei [Beijing Inst. of Control Engineering] 17:00–17:30

**Abstract:** In this paper, we investigate the task-space consensus problem for multiple robotic systems with both the uncertain kinematics and dynamics in the case of existence of constant communication delays. We propose an observer-based adaptive control scheme to achieve the consensus objective without relying on the measurement of task-space velocities. By Lyapunov-like analysis and iBIBO-stability-based analysis, we demonstrate that the task-space positions of the robotic systems converge to the scaled weighted average of their initial values.

**MS-We-E-05-4**

**Containment Control of Continuous-time Linear Multi-agent Systems with Aperiodic Sampling**

Liu, Huiyang [Univ. of Sci. & Tech. Beijing] 17:30–18:00

**Abstract:** In this paper, the containment control problem of continuous-time linear multi-agent systems is investigated. An aperiodic sampled-data based protocol for containment control is induced by using neighboring information with uncertainly time-varying sampling intervals. By using the proposed protocol, the closed-loop multi-agent system is transformed into a discrete-time system with the discrete way. Utilizing properties of Laplacian matrix, the containment control problem is equivalent to a stability problem. The stability analysis is based on the robustness of related discrete-time systems against perturbation caused by the variation of sampling intervals. By using small-gain theorem, sufficient conditions are obtained to guarantee the stability of uncertain discrete-time systems. Furthermore, two special cases are given to illustrate the method proposed in this paper. The theoretical results are verified by some simulations.

**MS-We-E-06**

**Analysis of Nonsmooth PDE Systems with Applications to Material Failure - Part II of II**

Knares, Dorothy [Univ. of Kassel] 16:00–18:00

**Abstract:** The understanding and modeling of failure processes in solids is a central task in materials sciences. Mathematical models typically result in highly nonlinear, coupled systems of partial differential equations, where additional nonsmooth constraints, as for instance the unidirectionality of evolution processes or the impenetrability of the material, have to be taken into account. This minisymposium intends to discuss recent advances in the mathematical treatment of failure phenomena, and brings together scientists from the fields of modeling, analysis, and numerics. Analytical methods and numerical strategies both for (quasi-)static and rate-dependent, non-smooth failure models will be presented.

**MS-We-E-06-1**

**Analysis of Crystalline Defects**

Ortner, Christoph [Univ. of Warwick] 16:00–16:30

**Abstract:** I will present a general framework for the analysis of material defects embedded into a homogeneous crystalline environment. A key result in this framework is a generic regularity estimate that gives qualitatively sharp bounds on the “defect core”. I will then show examples how this framework can be employed in the analysis of dislocation models, in multi scale simulation, and in the construction of atomistic models of material failure.

**MS-We-E-06-2**

**Phase-field Approach for Quasi-static Evolutions in Fracture Mechanics**

Negri, Matteo [Univ. of Pavia] 16:30–17:00

**Abstract:** We consider a couple of quasi-static evolutions obtained by sequences of time-discrete incremental minimization problems generated by a locally minimizing movement (w.r.t. $H^1$ and $L^2$ norm) and by the alternate minimization scheme. We characterize their time-continuous limits as parameterized BV-evolutions in terms of stationarity and energy balance. We provide some physical properties in terms of energy release and thermodynamical consistency of the irreversibility constraint.

**MS-We-E-06-3**

**An Irreversible Gradient Flow and Its Application to a Crack Propagation Model**

Kimura, Masato [Kanazawa Univ.] 17:00–17:30

**Abstract:** We consider a nonlinear diffusion equation with irreversible property and construct a unique strong solution by using implicit time discretization. A new regularity estimate for the obstacle problem is established and is used in the construction of the strong solution. An application to a crack propagation model is also presented.

**MS-We-E-06-4**

**Dynamics of Microstructure: the Example of a Damage Model**

Garroni, Adriana [Sapienza, Univ. of Rome] 17:30–18:00

**Abstract:** Many models in material science (as plasticity, damage, phase transition or fracture), involve nonconvex energies. This lack of convexity is responsible for the formation of microstructure and represents a serious issue in the study of evolution problems. I will focus on a simple, but yet enough rich, model for elastic brittle damage introduced by Francfort and Marigo in which many of main questions related to evolution of microstructure can be successfully addressed.

**MS-We-E-07**

**Uncertainty Quantification for Applications in Earth Sciences - Part I of II**

For Part 2, see MS-Th-BC-07 16:00–18:00

**Abstract:** Uncertainty Quantification for Applications in Earth Sciences - Part I of II

Organizer: Tong, Charles Lawrence Livermore National Laboratory, Beijing Normal Univ.
Organizer: Duan, Qingyun Beijing Normal Univ.
Organizer: Thomas, Marita Stochastics (WIAS Berlin)

**Abstract:** The understanding and modeling of failure processes in solids is a central task in materials sciences. Mathematical models typically result in highly nonlinear, coupled systems of partial differential equations, where additional nonsmooth constraints, as for instance the unidirectionality of evolution processes or the impenetrability of the material, have to be taken into account. This minisymposium intends to discuss recent advances in the mathematical treatment of failure phenomena, and brings together scientists from the fields of modeling, analysis, and numerics. Analytical methods and numerical strategies both for (quasi-)static and rate-dependent, non-smooth failure models will be presented.
The focus of the minisymposium is on mathematical problems regarding uncertainty quantification (UQ) is widely used in environmental engineering to propagate and quantify uncertainty. Here we describe a UQ platform collected called UQ-PyL (Uncertainty Quantification Python Laboratory), a flexible, user-friendly GUI platform designed to quantify uncertainty of complex dynamical models. UQ-PyL integrates different kind of UQ methods, including experimental design, uncertainty analysis, sensitivity analysis, surrogate modeling and parameter optimization. We illustrate the different functions of UQ-PyL by applying it to the calibration of a hydrological model.

**Abstract:** Uncertainty quantification (UQ) is widely used in environmental engineering to propagate and quantify uncertainty. Here we describe a UQ platform called UQ-PyL (Uncertainty Quantification Python Laboratory), a flexible, user-friendly GUI platform designed to quantify uncertainty of complex dynamical models. UQ-PyL integrates different kinds of UQ methods, including experimental design, uncertainty analysis, sensitivity analysis, surrogate modeling and parameter optimization. We illustrate the different functions of UQ-PyL by applying it to the calibration of a hydrological model.

**MS-We-E-07-1**
16:00–16:30
UQ-PyL - A GUI Platform for Uncertainty Quantification of Complex Environmental Models
Wang, Chen Beijing Normal Univ.
Duan, Qingyun Beijing Normal Univ.
Tong, Charles Lawrence Livermore National Laboratory
Wei, Gong Beijing Normal Univ.

Abstract: Uncertainty quantification (UQ) is widely used in environmental engineering to propagate and quantify uncertainty. Here we describe a UQ platform called UQ-PyL (Uncertainty Quantification Python Laboratory), a flexible, user-friendly GUI platform designed to quantify uncertainty of complex dynamical models. UQ-PyL integrates different kinds of UQ methods, including experimental design, uncertainty analysis, sensitivity analysis, surrogate modeling and parameter optimization. We illustrate the different functions of UQ-PyL by applying it to the calibration of a hydrological model.

**MS-We-E-07-2**
16:30–17:00
Multi-Objective Adaptive Surrogate Modeling-Based Optimization for Parameter Estimation of Large Complex Geophysical Models
Wei, Gong Beijing Normal Univ.
Duan, Qingyun Beijing Normal Univ.
Wang, Chen Beijing Normal Univ.

Abstract: Geophysical models usually simulate many processes, and require a multi-objective optimization (MOO) approach to parameter estimation. MOO algorithms usually require a large number of model runs and can be computationally prohibitive for large complex models. To reduce the total number of model runs while maintaining optimization effectiveness, we developed a Multi-Objective Adaptive Surrogate Modeling based Optimization (MO-ASMO) and tested it against the classical NSGA-II algorithm with 10 test functions and a land surface model.

**MS-We-E-07-3**
17:00–17:30
A Variance-based Decomposition and Global Sensitivity Index Method for Uncertainty Quantification: Application to Retrieved Ice Cloud Properties
Zhao, Chuanfeng Beijing Normal Univ.
Chen, Xiao Lawrence Livermore National Laboratory

Abstract: We present a UQ method for cloud microphysical property retrievals using an empirical orthogonal function with a variance-based sensitivity analysis on the US Atmospheric Radiation Measurement program’s remote-sensing measurements. This method enables an objective validation of climate models against cloud retrievals under a rigorous statistical inference framework. Sensitivity analysis provides directions for improving retrieval algorithms and observation strategies. Results will be given for the ice cloud retrievals at ARM's SGP site on March 9, 2000.

**MS-We-E-07-4**
17:30–18:00
Surrogate-based Uncertainty Analysis and Data-value Assessment for Integrated Surface-water Groundwater Modeling
Zheng, Yi Peking Univ.

Abstract: Probabilistic Collocation Method (PCM) was adopted to analyze the parametric sensitivity and uncertainty of integrated surface water-groundwater (SW-GW) models. Based on PCM, a data-value evaluation approach for integrated SW-GW modeling was also proposed. Through a case study in Zhangye Basin, the approaches’ applicability have been demonstrated. The surrogate-based uncertainty analysis and data-value assessment are highly valuable to understanding hydrological processes, improving model calibration, prioritizing data collection activities, as well as to making management decisions.

**MS-We-E-08**
16:00–18:00
The Ginzburg-Landau Model and Related Topics - Part II of IV
For Part 1, see MS-We-D-08
For Part 3, see MS-Th-BC-08
For Part 4, see MS-Th-D-08

Organizer: Kovalyov, Dmitry The Univ. of Akron
Organizer: Giorgi, Tiziana New Mexico State Univ.

Abstract: The focus of the minisymposium is on mathematical problems related to Ginzburg-Landau model with application in physics and materials science including but not limited to: superconductivity, superfluidity, liquid crystals, and polymers. The speakers in this minisymposium will describe their recent research, including the development and structure of singular solutions of the Ginzburg-Landau-type problems and the dynamics of vortex motion. This minisymposium is sponsored by the SIAM Activity Group on Mathematical Aspects of Materials Science (SIAG/MS).

**MS-We-E-08-1**
16:00–16:30
Exponential Decay of Superconductivity in the Presence of Strong Currents
Amlod, Yaniv LSU

Abstract: We study the time-dependent Ginzburg-Landau equations in the presence of strong currents, but weaker than the critical current where the normal state loses its stability. In the large $\gamma$ limit, we prove that the superconductivity order parameter is exponentially small in a significant part of the domain, and small in the rest of it. Some results in the large domain limit will be presented as well. Joint work with Bernard Helffer and Xingbin Pan

**MS-We-E-08-2**
16:30–17:00
A Thin-film Limit in the Landau-Lifshitz-Gilbert Equation Relevant for the Formation of Neel Walls
Ignat, Radu Universite Paul Sabatier - Toulouse III

Abstract: We consider an asymptotic regime for 2D ferromagnetic films that is consistent with the formation of transition layers, called Neel walls. We establish compactness of $H^1$-valued magnetizations in the energetic regime of Neel walls and characterize the set of accumulation points. We prove that Neel walls are asymptotically the unique energy minimizing configurations. We finally study the corresponding dynamical issues, namely the compactness properties of the magnetizations under the flow of the Landau-Lifshitz-Gilbert equation.

**MS-We-E-08-3**
17:00–17:30
Nonlocal Ginzburg-Landau-Allen-Cahn Models: Analytical and Numerical Studies
YANG, Jiang Du, Qiang Penn State Univ. Columbia Univ.

Abstract: We present some recent studies of a time-dependent nonlinear nonlocal Ginzburg-Landau-Allen-Cahn equation based on analytical and numerical approaches. We also analyze the convergence of Fourier spectral methods for problems defined on a periodic cell and show that they are asymptotically compatible so as to provide convergent approximations to both the nonlocal model and the local limit. Numerical examples also reveal some interesting phenomena associated with steady state solutions of the nonlocal model.

**MS-We-E-08-4**
17:30–18:00
Analysis of the Lawrence-Doniach Energy for Layered Superconductors in Magnetic Fields
Peng, Guanying Unv. of Cincinnati
Bauman, Patricia Purdue Univ.

Abstract: We analyze minimizers of the Lawrence-Doniach energy for layered superconductors occupying a bounded generalized cylinder in the three-dimensional space. For a magnetic field perpendicular to the layers in the intermediate regime, we prove an asymptotic formula for the minimum Lawrence-Doniach energy as the reciprocal of the Ginzburg-Landau parameter and the interlayer distance tend to zero. Our formula also describes the minimum three-dimensional anisotropic Ginzburg-Landau energy as the reciprocal of the Ginzburg-Landau parameter tends to zero.

**MS-We-E-09**
16:00–18:00
Nonlocal problems: modeling, analysis and computation - Part III of III
For Part 1, see MS-Tu-E-09
For Part 2, see MS-We-D-09

Organizer: Lipton, Robert LSU
Organizer: Du, Qiang Columbia Univ.
Organizer: Mengesha, Tadele The Univ. of Tennessee

Abstract: The goal of this minisymposium is to bring together researchers working on problems related to the nonlocal modeling of physical phenomena and their mathematical analysis. The theme is on modeling, analysis and simulation with a focus on nonlocal continuum equations that arise from applications. The session will be multifaceted so as to cover work related nonlocal modeling and computational simulations of models, and analytical and numerical aspects such as well-posedness of nonlocal stationary and evolution equations, regularity of solutions and numerical approximations. Nonlocal mathematical models arise naturally in many important fields and they are found to be useful where classical (local) models cease to be predic-
tive. Moreover, nonlocal models are suitable for multiscale modeling as they can be effective in capturing the underlying nonsmooth microscale fields. An example is peridynamics, a nonlocal reformulation of the basic equations of motion of continuum mechanics, which is being used to model cracks and discontinuous fields in solid mechanics. Other areas of application include image processing, modeling population aggregation, wave propagation, pattern formation, and porous media flow. In this minisymposium, research works which have produced novel analytical and numerical methods for nonlocal problems will be presented.

**MS-We-E-09-1** 16:00–16:30  
**Cohesive Dynamics and Fracture**  
Lipton, Robert  
Said, Eyad  
Louisiana State Univ.  
**Abstract:** We introduce a new nonlocal, nonlinear deformation cohesive model for describing dynamic fracture. In this peridynamic model the deforming body is split into a process zone exhibiting nonlinear force-strain behavior and a complementary zone exhibiting elastic behavior. We show using energy estimates and Gamma convergence that the length scale of nonlocal interaction controls the size of the process zone. This gives rise to the size effect seen in quasibrittle materials such as polymers.

**MS-We-E-09-2** 16:30–17:00  
**A PDE Approach to Numerical Fractional Diffusion**  
Salgado, Abner  
Univ. of Tennessee  
**Abstract:** We study solution techniques for problems involving fractional powers of elliptic operators by realizing them as the Dirichlet to Neumann map of a nonuniformly elliptic problem posed on a semi-infinite cylinder. We derive optimal error estimates for anisotropic discretizations. We explore extensions and applications: a posteriori error analysis and adaptivity, parabolic equations with fractional diffusion and Caputo fractional time derivative and obstacle problems.

**MS-We-E-09-3** 17:00–17:30  
**Surface Effect Corrections in Peridynamic Solid Mechanics**  
Selensoy, Pablo  
Oak Ridge National Laboratory  
**Abstract:** The peridynamics theory of solid mechanics is a nonlocal generalization of classical continuum mechanics, suitable for material failure and damage simulation. Even though peridynamics enable engineering simulations involving cracks and their propagation, many problems of interest based on systems with free surfaces exhibit undesired surface effects, due to the nonlocal nature of interactions in peridynamics. In this talk, we will analyze the sources of those surface effects and propose a method to correct them.

**MS-We-E-09-4** 17:30–18:00  
**Nonlocal Calculus of Variations Involving High Order Nonlocal Operators**  
Du, Qiang  
Tian, Xiaochuan  
Columbia Univ.  
**Abstract:** We extend recently developed nonlocal calculus of variations for the basic nonlocal operators to problems that involve high order nonlocal operators. We establish a number of nonlocal integral identities and some embedding inequalities which are extensions of their local counterpart. We discuss their applications to nonlocal beam and plate models.

**MS-We-E-10** 16:00–18:00  
**Evolutionary game dynamics on complex networks: Modeling, analysis and control**  
Organizer: Tan, Shaolin  
Hunan Univ.  
**Abstract:** Networked games prevail in a wide range of evolutionary collective phenomena on biological, social, and engineering networks. One important and challenging problem is to model, analyze and further intervene in the networked game dynamics. Recently, the above problem has attracted increasing interest in a variety of areas. This mini-symposium mainly focus on the recent advances on modeling, analysis and control in evolutionary game dynamics on complex networks. It also aims at providing a communication platform for applications of evolutionary networked game dynamics.

**MS-We-E-10-1** 16:00–16:30  
**An Evolutionary Game Dynamic Approach for Determination of the Structural Conflicts in Signed Networks**  
Tan, Shaolin  
Hunan Univ.  
**Abstract:** Social or biochemical networks can often divide into two opposite alliances in response to structural conflicts between positive (friendly, activating) and negative (hostile, inhibiting) interactions. Yet, the underlying dynamics how the opposite alliances are spontaneously formed to minimize the structural conflicts is still unclear. Here, we report that evolutionary game dynamics provides a felicitous tool to characterize the evolution and formation of alliances in signed networks.
can be solved via a numerical method related to the Sakurai-Sugiura method as well as Polizzi’s FEAST algorithm for generalized eigenvalue problems. This method is based on contour integrals. These are approximated numerically by a quadrature formula, which corresponds to a filter function. In this talk the properties of such a filter function as well as its implications on the nonlinear eigenvalue approximation problem will be investigated.

**MS-We-E-11-3 17:00–17:30**

**Solving the Quadratic Eigenvalue Problem with Low-Rank Damping**

Liu, Ding \*Fudan Univ.\*

Bai, Zhaojun \*Univ. of California, Davis\*

Su, Yangfeng \*Fudan Univ.\*

**Abstract:** We propose a Padé Approximate Linearization (PAL) technique to solve the quadratic eigenvalue problem (QEP) with low-rank damping. The PAL technique leads to a linear eigenvalue problem of dimension $n + n^r$, which is substantially smaller than the dimension $2n$ by standard linearization scheme, where $n$ is the dimension of the QEP. $r$ and $m$ are the rank of the damping matrix and Padé approximant order, respectively. Efficiency of this approach will be shown by numerical examples.

**MS-We-E-12 16:00–18:00**

Mathematical modeling and statistical analysis of biological systems

Organizer: Wang, Pei \*Henan Univ.\*

Organizer: Lu, Jinhua \*Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.\*

**Abstract:** Biological networks are typical real-world complex networks. Gene regulatory networks, protein-protein interaction networks, signal transduction networks, and biological networks can be explored through mathematical modeling and statistical analysis. Based on the underlying biochemical reactions in biological networks, one can establish differential equation models to describe the evolution of the system, the functional characteristics of some biological circuits and so on. Further based on the complex network theory and statistical method, some more information can be mined from complex biological networks, such as explaining the topological organization of biological networks, clarifying the evolutionary mechanism of some frequently appeared biological circuits, constructing new measures to weigh the importance of nodes in biological networks. The related investigations can help us to understand the organization and functional principle of complex biological networks, which have potential implications in the artificial design and reengineering of some biological networks. Through this mini-symposium, we expect to provide a platform for researchers to exchange ideas and information on mathematical modeling and statistical analysis of biological networks.

**MS-We-E-12-1 16:00–16:30**

**Cooperative Design of Networked Observers for Stabilizing Continuous-LTI Plants**

Liu, Kexin \*Chinese Acad. of Sci.\*

Zhu, Henghui \*Chinese Acad. of Sci.\*

Lu, Jinhua \*Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.\*

**Abstract:** This paper aims at developing a unified framework for cooperative design of networked observers to stabilize LTI plants. Apart from the traditional centralized design of MIMO system, the proposed cooperative design approach only utilizes the local information of each sensor. To four kinds of networked observers to stabilize LTI plants. Apart from the traditional centralized design of MIMO system, the proposed cooperative design approach only utilizes the local information of each sensor. To four kinds of networked observers to stabilize LTI plants. Apart from the traditional centralized design of MIMO system, the proposed cooperative design approach only utilizes the local information of each sensor. To four kinds of networked observers to stabilize LTI plants. Apart from the traditional centralized design of MIMO system, the proposed cooperative design approach only utilizes the local information of each sensor. 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systems, individuals can not only make acquaintance and interact with the software, share knowledge, and provide quick and high-quality answers in the social networks, there is a typical wealth of other data about these communities. In this minisymposium, we will introduce several experts in Electronic Commerce, Social Network, and Software Engineering to present their work on data mining in such task-oriented networks, and hope to provide some useful insights for the network research.

Abstract:

Task-Oriented Networks are communities of people who are virtual organizations and have the online cooperation as the main subject. This minisymposium focuses the latest progress on numerical and theoretical approaches for solving linear and nonlinear eigenvalue problems, eigenvalue optimization, and their applications in several different and important scientific areas including mechanical vibration, optimal conductivity, photonic crystals, and shape classification and recognition.


Abstract: Nowadays, social networking oriented tools have been widely applied to various scenarios. One of the significant applications is the e-commerce systems, in which individuals can not only make acquaintance and interact with friends, but also accelerate marketing goods via the social channel. Therefore, social marketing and relevant topics will be discussed in this session.


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Noether’s theorem and its inverse problem of nonholonomic systems with fractional derivatives
Jing-Li, Fu Zhejiang Sci-Tech Univ.

Abstract: In this paper, the Noether symmetry and the Noether inverse the problems of nonholonomic systems with fractional derivatives are studied. Basic on the quasi-invariance of Hamilton action under the infinitesimal group of transformations without the time variable and the general transformations of time-reparametization, then the fractional Noether theorem of nonholonomic system are established respectively. Further, the fractional Noether inverse problems are firstly presented for the nonholonomic system. An example is designed to illustrate the application of the results.

Application of Lie Symmetry and Symmetry Solving Approach to Electrical Networks with Dissipation

MS-We-E-16-3 17:00–17:30

Symmetry Analysis and Conservation Laws for A Generalized Coupled Hyperbolic System
Khaliq, Chaudry Masood North-West Univ., Mafikeng Campus

Abstract: We carry out the Noether symmetry classification of a generalized coupled hyperbolic system. In addition conservation laws for several cases which admit Noether point symmetries are established for the generalized system under consideration.

Conservation Laws of A Semilinear Radial Wave System
Muatjetjeja, Ben North-West Univ.

Abstract: In this talk we perform Noether symmetry classification of a semi-linear radial wave system. It is shown that four main cases arise with respect to the standard Lagrangian. Moreover, conservation laws are derived for the cases which admit Noether point symmetries.

Conservation Laws of Partial Differential Equations and Their Connections to Symmetries
Anco, Stephen Brock Univ.

Abstract: This talk presents a modern approach to finding conservation laws and symmetries for general PDE systems. As a main result, a kind of generalization of Noether’s theorem to non-variational PDE systems will be shown, which provides a general algorithmic method to find all conservation laws for any given PDE system (whether or not it has a variational structure). A recent formula of Ibragimov will be shown to be a special case of this method. Examples from nonlinear diffusion, nonlinear waves, integrable systems will be used to illustrate the ideas.

Singular limits in mathematical physics - Part I of V
For Part 2, see MS-Th-BC-17
For Part 3, see MS-Th-D-17
For Part 4, see MS-Th-E-17
For Part 5, see MS-Fr-D-17
Organizer: Cheng, Bin Univ. of Surrey
Organizer: Secchi, Paolo Univ. of Brescia
Organizer: Ju, Qiangchang Inst. of Applied Physics & Computational Mathematics (IAPCM)
Organizer: Jiang, Ning Tsinghua Univ., Beijing

Abstract: This minisymposium will address recent advances in analytical and numerical studies of singular limits of multiscale physical models as certain parameters approach zero or infinity. It shall cover such areas as incompressible and fast rotating limits in fluid dynamics, hydrodynamical limits of complex fluid and kinetic models, and relaxations. The singular nature of these models makes it challenging to rigorously justify and quantify their limits and to numerically simulate them in a way consistent with theory. Novel techniques and results in partial differential equations, stochastic differential equations and numerical analysis will be discussed.
MS-We-E-18-3
17:00–17:30
Gaussian Process Emulators in Bayesian Inverse Problems
Teckentrup, Aretha
Univ. of Warwick
Stuart, Andrew
Univ. of Warwick
Abstract: We consider the approximation by Gaussian Process emulators of the posterior distribution in Bayesian inverse problems.

MS-We-E-18-4
17:30–18:00
Dimension Independent Likelihood Informed MCMC
Law, Kody
ORNL
Cui, Tiangang
MIT
Marzouk, Youssuf
Massachusetts Inst. of Tech.
Abstract: This talk concerns function-space MCMC methods for sampling the posterior distribution arising from Bayesian inverse problems. A general class of operator-weighted proposal distributions are introduced, which are dimension and covariance-independent, and may include local gradient information. These proposals can utilize Hessian information to identify a subspace in which the posterior measure concentrates, and adaptively scale the proposal distribution according to the posterior covariance in this space. Their accuracy and the robustness of the developed methods will be presented as well.

MS-We-E-19
16:00–18:00
Women in Applied Mathematics: Recent Advances in Modeling, Numerical Algorithms, and Applications - Part I of IV
For Part 2, see MS-Th-BC-19
For Part 3, see MS-Th-D-19
For Part 4, see MS-Th-E-19
Organizer: LI, Fengyan
Rensselaer Polytechnic Inst.
Organizer: Cheng, Juan
Inst. of Applied Physics & Computational Mathematics
Abstract: This mini-symposium aims at bringing women mathematicians to share recent progress and to inspire new ideas in applied mathematics. Talks may address modeling, theoretical and computational aspects of numerical methods, as well as various applications arising from biomedical problems, fluid dynamics, electromagnetism, rarefied gas dynamics, and constrained optimal control problems, and besides the scientific aspects, the fourth part of this mini-symposium is a career panel session, which is to create a platform for women mathematicians at different stages with different career paths to network, to exchange experiences and advice on career advancement, and to discuss challenges and strategies for a successful career.

MS-We-E-19-1
16:00–16:30
Symmetry-preserving Lagrangian Schemes for Compressible Fluid Flow in Two-dimensional Cylindrical Coordinates
Cheng, Juan
Inst. of Applied Physics & Computational Mathematics
Abstract: In this talk, we develop a second order cell-centered Lagrangian scheme for solving compressible Euler equations in cylindrical coordinates, based on the control volume discretizations, which is designed to have uniformly second order accuracy and capability to preserve one-dimensional spherical symmetry in a two-dimensional cylindrical geometry when computed on an equal-angle-zoned initial grid. The scheme maintains several good properties such as conservation for mass, momentum and total energy, and the geometric conservation law.

MS-We-E-19-2
16:30–17:00
Difference Potentials Method for Interface/Composite Domain Problems
Epshteyn, Yekaterina
Univ. of Utah
Abstract: Designing numerical methods with high-order accuracy for problems with interfaces (for example, models for composite materials or fluids, etc), as well as models in irregular domains is crucial to many physical and biological applications. We will discuss recently developed efficient numerical schemes based on the idea of the Difference Potentials for elliptic and parabolic composite domain/interface problems. Numerical experiments to illustrate high-order accuracy and the robustness of the developed methods will be presented as well.

MS-We-E-19-3
17:00–17:30
Is Normalized Line Search Rule Really Suitable for Finding Multiple Solutions of Semilinear PDEs?
Xie, Ziqing
Hunan Normal Univ., China
Abstract: Inspired by the work in Zhou and Li (SISC, 2001,2002) and the line search rules in optimization theory in $H^1$ aiming at the global convergence, in this talk we propose a modified Local Minimix Method (LMM) based on a normalized Goldstein line search rule to find multiple minimix-type solutions. The feasibility of our approach is provided and its corresponding convergence is proven. The numerical results indicate that our approach is efficient.

MS-We-E-19-4
17:30–18:00
A Simple and Efficient Metaheuristic to Solve the Weighted Set Covering Problem
Lu, Yun
Kutztown Univ. of PA
Abstract: A new metaheuristic based on the relationship between teacher and learners has recently been proposed by Rao, Savsani and Vakharia (2011). This metaheuristic is designed to solve continuous nonlinear optimization problems. It has been shown to be an efficient and effective approach for solving various structural and mechanical design problems. It is of particular interest because it is a population-based metaheuristic that requires no parameter fine-tuning other than determining the size of the population and convergence criteria. In this paper, we adapt this metaheuristic, designed for continuous problems, to solve the weighted set covering problem. Empirical results demonstrate the competitiveness of this approach both in terms of solution quality and execution time. The advantage to this approach is its relative simplicity.

MS-We-E-20
16:00–18:00
Theory, Computation, and Application of Transmission Eigenvalues - Part II of III
For Part 1, see MS-We-D-20
For Part 3, see MS-Th-BC-20
Organizer: Sun, Jiguang
Michigan Technological Univ.
Organizer: Cakoni, Fioralba
Univ. of Delaware
Abstract: Transmission eigenvalue problem is a new research area arising from the inverse scattering theory of inhomogeneous media. The problem is non-selfadjoint, non-standard and not covered by any classical partial differential equation. Since 2007, the problem received significant attention including a special issue of transmission eigenvalues of Inverse Problems. This mini symposium will bring top researchers from America, Europe, and Asia to present the recent advances of the theory, computation, and applications of transmission eigenvalues. It will also be a great chances for these researchers to exchange new ideas and discuss the future development for the transmission eigenvalue problem.

MS-We-E-20-1
16:00–16:30
Error Estimates of the Finite Element Method for Interior Transmission Problems
Wu, Xinming
Fudan Univ.
Abstract: The interior transmission problem (ITP) plays an important role in the investigation of the inverse scattering problem. In this paper we propose the finite element method for solving the ITP. Based on the coercivity, we derive both priori error estimate and a posteriori error estimate of the finite element approximation. Numerical experiments are also included to illustrate the accuracy of the finite element method.

MS-We-E-20-2
16:30–17:00
Boundary Integral Equations for the Transmission Eigenvalue Problem for Maxwell's Equations
Cakoni, Fioralba
Univ. of Delaware
Haddar, Houssem
Ecole Polytechnique/INRIA
Meng, Shixu
Univ. of Delaware/Ecole Polytechnique
Abstract: We consider the transmission eigenvalue problem for Maxwell's equations corresponding to non-magnetic inhomogeneities with contrast in electric permittivity that changes sign inside its support. We formulate the transmission eigenvalue problem as an equivalent homogeneous system of boundary integral equations. Under the assumption that the contrast is constant near the boundary of the support of the inhomogeneity, we prove that the set of transmission eigenvalues is discrete with positive infinity as the only accumulation point.

MS-We-E-20-3
17:00–17:30
A Recursive Integral Method for Transmission Eigenvalues
Sun, Jiguang
Michigan Technological Univ.
Abstract: Many computer models contain unknown parameters which need to be estimated using physical observations. Tuo and Wu (2014) shows that the calibration method based on Gaussian process models proposed by Kennedy and O’Hagan (2001) may lead to unreasonable estimate for imperfect computer models. In this work, we extend their study to calibration problems with stochastic physical data. We propose a novel method, called the L2 calibration, and show its semiparametric efficiency. The conventional method
Zhang, Ruming  Michigan Technological Univ.

Abstract: Recently, a new eigenvalue problem, called transmission eigenvalue problem, has attracted many researchers. The problem arose in the inverse scattering theory for inhomogeneous media and has importance in a variety of inverse problems in target identification and nondestructive testing. Since the problem is non-selfadjoint and nonlinear, it is very challenging to develop effective numerical methods for it. In this paper, using continuous finite elements, we propose a recursive integral method to compute several transmission eigenvalues.

▶ MS-We-E-20-4 17:30–18:00
The Multigrid Method for Transmission Eigenvalue Problems
Xie, Hehu  Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: In the lecture, we will propose a type of multigrid method for solving transmission eigenvalue problems. In this method, the solution of transmission eigenvalue problem is transformed to a series of solution of boundary value problems and a very small scale transmission eigenvalue on the coarsest finite element space. Since the high efficiency of the multigrid method for boundary value problems, the proposed multigrid method can improve the overall efficiency of transmission eigenvalue problem solving.

▶ MS-We-E-21 16:00–18:30
Minisymposium on discontinuous Galerkin method: recent development and applications - Part IV of VIII
For Part 1, see MS-Tu-D-21
For Part 2, see MS-Tu-E-21
For Part 3, see MS-We-D-21
For Part 5, see MS-Th-BC-21
For Part 6, see MS-Th-D-21
For Part 7, see MS-Th-E-21
For Part 8, see MS-Fr-D-21
Organizer: Xu, Yan  Univ. of Sci. & Tech. of China
Organizer: Shu, Chi-Wang  Brown Univ.

Abstract: Over the last few years, discontinuous Galerkin (DG) methods have found their way into the mainstream of computational sciences and are now being successfully applied in almost all areas of natural sciences and engineering. The aim of this minisymposium is to present the most recent developments in the design and theoretical analysis of DG methods, and to discuss relevant issues related to the practical implementation and applications of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

▶ MS-We-E-21-1 16:00–16:30
Discontinuous Galerkin Method for Free Surface Flows That Develop Singularities
Van Der Vegt, Jacobus  Univ. of Twente
Medvedeva, Tatiana  Univ. of Twente

Abstract: In this presentation we will discuss a new discontinuous Galerkin method, combined with a diagonally implicit Runge-Kutta method, to solve a system of strongly nonlinear third order partial differential equations modeling the flow and droplet formation of thin liquid jets. A key feature of these equations is the occurrence of singularities that present severe numerical difficulties, both in the DG discretization and in the solution of the algebraic equations resulting from the DIRK method.

▶ MS-We-E-21-2 16:30–17:00
Local Discontinuous Galerkin Method for Parabolic Equations with Blow-up Solutions
Yang, Yang  Michigan Technological Univ.

Abstract: We apply the local discontinuous Galerkin method for parabolic equations with blow-up solutions. The model yield positive exact solutions and are commonly used in biology and combustion. In our work, we apply the positivity-preserving technique to the scheme, and construct high-order approximations. Numerical experiments will be given to demonstrate that high-order schemes yield better numerical blow-up time and accurate blow-up sets.

▶ MS-We-E-21-3 17:00–17:30
An HDG Method for the P-Laplacian
Shen, Jiguang  Univ. of Minnesota, Twin Cities

Abstract: We propose a hybridizable Discontinuous Galerkin (HDG) method for the p-Laplacian equation. The approximations to $u$, $\nabla u$, $|\nabla u|^{p-2}\nabla u$ exhibit optimal order of convergence in $L^2$ and $L^p$ norms, when solution is sufficiently regular. We rewrite our scheme into minimization problems and solve them with preconditioned gradient descent type algorithms, which demonstrate mesh independent, polynomial degree independent convergence rate. Numerical results for non-smooth solutions are displayed to show the benefit of hybridization.

▶ MS-We-E-21-4 17:30–18:00
Discontinuous Galerkin Solutions for the Electromagnetic Waves in Metallic Nanostructures
Xu, Liwei  Chongqing Univ.

Abstract: In this talk, we introduce a hydrodynamic model describing the propagation of electromagnetic waves in metamaterial. A discontinuous Galerkin method has been designed for the solution of the model. Several numerical solutions, including the second and third harmonics generation, are reproduced using the method and the model.

▶ MS-We-E-21-5 18:00–18:30
Multiscale Hybridizable DG Methods for Flows in in Heterogeneous Media
Shi, Ke  Texas A&M Univ.

Abstract: In this talk, we will review a recently introduced finite element method: multiscale hybridizable Discontinuous Galerkin (HDG) method. We motivate by Darcy flow in porous media to illustrate the main features of the multiscale HDG method. Both theoretical and numerical results will be presented. Finally, we will discuss the current work on other problems such as Brinkman flow, linear elasticity.
otherwise reduced learning ability is considered.

**MS-We-E-22-4 17:30–18:00**

__Probabilistic Sharing Solves the Problem of Costly Punishment__

Chen, Xiaojie
Univ. of Electronic Sci. & Tech. of China

**Abstract:** Cooperators that refuse to participate in sanctioning defectors create the second-order free-rider problem. Such cooperators will not be punished because they contribute to the public good, but they also eschew the costs associated with punishing defectors. Altruistic punishers—their cooperative behavior punishes—-are at a disadvantage, and it is puzzling how such behavior has evolved. In this talk, I will show how the consideration of probabilistic sanctioning solves the problem of costly punishment.

**MS-We-E-23 16:00–18:00**

**Organizer:** Wang, Lin
Shanghai Jiao Tong Univ.

**Organizer:** Dong, Hairong
State Key Laboratory of Rail Traffic Control & Safety, Beijing Jiaotong Univ.

**Organizer:** Wang, Junhuan
Hebei Univ. of Tech.

**Abstract:** Over the past years, pedestrian dynamics has attracted much attention in several discourses, such as transport studies, urban planning and architecture. With increasing technological sophistication, substantial experimental efforts have revealed quantitative details of pedestrian interactions, which have led to a deeper understanding of how collective behavior emerges from individual interactions. In this mini-symposium, we will focus on modeling, analysis and intervention of pedestrian dynamics. We will first present a new optimization-based collision avoidance model for pedestrian dynamics, and then discuss how do small group behaviors impact on pedestrian evacuation, thirdly propose some intervention strategies for crowd panic, and finally from a theoretical perspective, study the averaging-based consensus of multi-agent systems under switching topologies.

**MS-We-E-23-1 16:00–16:30**

**Averaging-Based Consensus of High-Order Linear Multi-Agent Systems under Switching Topologies**

Ni, Wei
Nanchang Univ.

**Abstract:** The averaging theory is a fundamental tool to investigate the stability of time-varying systems. The application of averaging theory to the field of consensus control of multi-agent systems under switching topology has just started, and there are many important issues to be solved. In this talk, we provide some averaging-based consensus control algorithms and corresponding convergence analysis for high-order linear multi-agent systems under switching topology.

**MS-We-E-23-2 16:30–17:00**

**Small Group Behaviors and Their Impacts on Pedestrian Evacuation Based on the Modified Social Force Model**

Wang, Jinhuan
Hebei Univ. of Tech.

Zhang, Lei
Hebei Univ. of Tech.

Li, Nan
Hebei Univ. of Tech.

**Abstract:** A modified social force model is proposed to simulate the impacts of small group behaviors on pedestrian evacuation. We define an exponential formulation of the group attractive force among the small group. Simulation results show that the small group behaviors will cause negative effects on pedestrian evacuation. The panic case is further considered, under which the agents crowd together and the evacuation efficiency becomes lower.

**MS-We-E-23-3 17:00–17:30**

**Analysis and Intervention on Crowd Panic via Modified Social Force Model**

Cao, Lei
Shanghai Jiao Tong Univ.

Wang, Lin
Shanghai Jiao Tong Univ.

**Abstract:** In this paper, we modify the classical social force model to be more realistic in the emergent situations, and use it to investigate the crowd panic under full vision and limited vision. We study the effects of different pedestrian behaviors on the crowd evacuation, and find that following the wall is always a better strategy. Furthermore, we intervene in the crowd panic by deploying information sources.

**MS-We-E-23-4 17:30–18:00**

**A New Optimization-based Collision Avoidance Model for Pedestrian Dynamics**

Wang, Qianling
Beijing Jiaotong Univ.

Dong, Hairong
State Key Laboratory of Rail Traffic Control & Safety, Beijing Jiaotong Univ.

Chen, Yao
Beijing Jiaotong Univ.

**Abstract:** This paper proposes an optimization-based collision avoidance model for pedestrian dynamics. In this model, the behaviors of pedestrian-odians are governed by their desired walking direction and speed. By combining the critical factors of pedestrian movement, such as positions of the exit and velocities of the neighbors, the choice of desired velocity has been rendered to a discrete optimization problem. The new model is verified by comparing with the fundamental diagram and actual data.
### Numerical Methods for Stochastic PDE and Uncertainty Quantification - Part III of IV

**MS-We-E-25**
16:00–18:30
210A

**Numerical Methods for Stochastic PDE and Uncertainty Quantification - Part III of IV**

For Part 1, see MS-Tu-E-25
For Part 2, see MS-We-D-25
For Part 4, see MS-Th-BC-25

**Organizer:** ZHOU, TAO AMSS, the Chinese Acad. of Sci.
**Organizer:** YU, Xiun Inst. of Applied Physics & Computational Mathematics

**Xiu, Dongbin Univ. of Utah**
**Abstract:** Efficient solution strategy for stochastic partial differential equations (SPDE) has been a classical topic, as many physical phenomena are inherently random. The topic has received an increasing amount of attention in recent years, driven by the need for uncertainty quantification (UQ). In UQ, even seemingly deterministic problems need to be modeled as random because of the uncertainty in the system inputs. Stochastic problems become more challenging to solve, as they often reside in high dimensional random space. The purpose of this mini-symposium is to gather researchers from mathematics and computer science and engineering to interchange the latest advances in simulation techniques for SPDE and UQ. The focus will be on efficient algorithms for practical systems, particularly those arising from multidisciplinary problems.

#### Dealing with Uncertainty in Space Awareness Problems

**Hesthaven, Jan** EPFL

**Abstract:** We shall discuss treatment of uncertainty in space awareness problems, illustrated by orbiting satellites. We discuss the elements of the models, sources of uncertainty, the development low dimensional reduced models, various examples on collision detection and, time permitting, object identification under uncertainty.

#### Local Polynomial Chaos Expansion for Linear Stochastic PDE with High Dimensional Random Inputs

**Zhu, Xueyu** Univ. of Utah
**Xiu, Dongbin** Univ. of Utah

**Abstract:** We present a localized polynomial chaos expansion for PDE with high dimensional random inputs. The method employs a domain decomposition technique to approximate the problem locally. The subdomain problems are solved independently and in much lower random dimensions. Accurate global solution can then be obtained by enforcing the correct statistical dependence. We present its theoretical foundation, along with examples to demonstrate its ability to handle very high dimensional stochastic PDE.

#### Transport Map Accelerated Markov Chain Monte Carlo

**Marzouk, Youssef** Massachusetts Inst. of Tech.

**Abstract:** We present a new approach for efficiently characterizing complex probability distributions, using a combination of optimal transport maps and Metropolis corrections. We use continuous transportation to transform typical Metropolis proposal mechanisms into non-Gaussian proposal distributions. Our approach adaptively constructs a Knothe-Rosenblatt rearrangement using information from previous MCMC states, via the solution of convex and separable optimization problems. We discuss the construction of transport maps in high dimensions and demonstrate order-of-magnitude speedups over standard MCMC.

#### Sparse Interpolation via $L_1$ Minimization and Its Applications in UQ

**Zhou, Tao** AMSS, the Chinese Acad. of Sci.

**Abstract:** The talk is concerned with sparse interpolation by means of $l_1$ minimization. Some basic approximation results for sparse interpolation will be presented, and the design of interpolation points will also be discussed. We will finally present some applications of the sparse interpolation methods for parameentric uncertainty quantification.

#### Response-Excitation Joint PDF Theory and Applications

**Karniadakis, George** Brown Univ.

**Abstract:** TBA
stiffness is removed by a small-scale decomposition, following prior work on 2D interfacial flow with surface tension. A convergence proof for a version the numerical method will be discussed.

**MS-We-E-26-6 18:05–18:30**

**Wrinkling Dynamics of Vesicles in Stokes Fluids**  
Li, Shuangwu  
Illinois Inst. of Tech.

**Abstract:** We consider the wrinkling dynamics of a vesicle in Stokes flow. We first perform linear analysis and simulations to investigate the deterministic wrinkling dynamics, then include thermal fluctuations to study the stochastic wrinkling dynamics. Preliminary results show (1) negative surface tension introduces wrinkles on the membrane surface; (2) thermal fluctuations break the geometric symmetry of the vesicle and excite higher order odd mode wrinkles. This is a joint work with Kai Liu and John Lowengrub.

**MS-We-E-27 16:00–18:00**  
Decoupling methods for multi-physics and multi-scale problems - Part III of VIII  
For Part 1, see MS-Tu-E-27  
For Part 2, see MS-We-D-27  
For Part 4, see MS-Th-BC-27  
For Part 5, see MS-Th-D-27  
For Part 6, see MS-Th-E-27  
For Part 7, see MS-Fr-D-27  
For Part 8, see MS-Fr-E-27

**Organizer:** He, Xiaoming  
Missouri Univ. of Sci. & Tech.

**Organizer:** Xu, Xuejun  
Inst. of Computational Mathematics, AMSS, CAS

**Abstract:** The inherent multi-physics and multi-scale features of many real world problems accentuate the importance to develop efficient and stable numerical methods for the relevant PDEs, especially the decoupling method. Although great efforts have been made for solving these problems, many practical and analytical challenges remain to be solved. This mini-symposium intends to create a forum for junior and senior researchers from different fields to discuss recent advances on the decoupling methods for multi-physics and multi-scale problems with their applications.

**MS-We-E-27-1 16:00–16:30**  
Computations of Some Optimal Control Problems for Stochastic Partial Differential Equations  
Lee, Hyung-Chun  
Ajou Univ.

**Abstract:** In this talk, we propose some numerical methods for solving optimal control problems for elliptic partial differential equations with random coefficients and forcing terms. These input data are assumed to be dependent on a finite number of random variables. We set up three different kind of problems and prove existence of optimal solution and derive an optimality system. In the methods, we use a Galerkin approximation in physical space and a sparse grid collocation in

**MS-We-E-27-2 16:30–17:00**  
PHASE-FIELD MODELING AND SIMULATION OF THE ZONE MELTING PURIFICATION PROCESS#8727;  
Wang, Xiaoping  
Hong Kong Univ. of Sci. & Tech.

**Abstract:** Zone melting is an efficient purification method that is widely used in the manufacture of semiconductors. In this paper, we propose a variational phase-field model to model the zone melting process. We present our numerical results for the zone melting process and show the feasibility of our model by comparing with the experimental results.

**MS-We-E-27-3 17:00–17:30**  
Higher Order Finite Element Methods for A Class of Interface Problems  
Guzman, Johnny  
Brown Univ.

**Abstract:** We present higher-order piecewise continuous finite element methods for solving a class of interface problems in two dimensions. The method is based on correction terms added to the right-hand side in the standard variational formulation of the problem. We prove optimal error estimates of the methods on general quasi-uniform and shape regular meshes in maximum norms. In addition, we apply the method to a Stokes interface problem, adding correction terms for the velocity and the

**MS-We-E-27-4 17:30–18:00**  
Decoupling and Monolithic Approaches for Fluid-structure Interaction (FSI) Problems  
Lee, Hyesuk  
Clemson University

**Abstract:** Simulating fluid-structure interactions is challenging due to the tight coupling between the solid and fluid substractures in a moving domain. Explicit and implicit decoupling methods often either fail or require relaxation when densities of the two materials are close. In this talk both monolithic and decoupling approaches are considered for analytical and numerical studies of FSI problems where a fluid is governed by a Newtonian or non-Newtonian model. An optimization based method which allows FSI problems to be stably decoupled is discussed and numerical results are presented.

**MS-We-E-28 16:00–18:05**  
Numerical Analysis for Forward-Backward Stochastic Differential Equations and Related Problems - Part I of II  
For Part 2, see MS-Th-BC-28

**Organizer:** Zhao, Weidong  
Shandong Univ.

**Organizer:** ZHUO, Tao  
AMSS, the Chinese Acad. of Sci.

**Abstract:** Backward stochastic differential equations (BSDE’s) were first introduced by J.M. Bismut in 1973 and generalized to the nonlinear form by Pardoux and Peng in 1990. Since then, BSDEs and coupled FBSDEs have been widely studied and used in connection with partial differential equations, stochastic optimal control theory, nonlinear filtering and mathematical finance. The numerical analysis of FBSDEs is more complicated than that of classical SDEs, so that there are many interesting and challenging open problems. The mini-symposium aims at exploring efforts related to numerical analysis for F-BSDEs and related problems such as SPDEs, nonlocal diffusions, nonlinear filtering, stochastic optimal control, mathematical finance, etc.

**MS-We-E-28-1 16:00–16:25**  
Regression Monte-Carlo with Adaptive Approximation Selection Applied to BSDE-FBSDE  
Gobet, Emmanuel  
Ecole Polytechnique

**Abstract:** We design regression schemes for decoupled FBSDE, using a s election point of view, taking the best estimator among a family, accounting automatically for the regularity of the unknown solution. Tight error estimates are given. This is a joint work with Laurent Zwald.

**MS-We-E-28-2 16:25–16:50**  
Layer Methods for Stochastic Navier-Stokes Equations Using Simplest Characteristics  
Tretyakov, Michael  
Univ. of Nottingham

**Abstract:** We propose and study a layer method for stochastic Navier-Stokes equations with spatial periodic boundary conditions and additive noise. The method is constructed using conditional probabilistic representations of solutions to SNSE and exploiting ideas of the weak sense numerical integration of stochastic differential equations. We prove some convergence results for the proposed method. Results of numerical experiments on two model problems are presented. The talk is based on a joint paper with G.N. Milstein.

**MS-We-E-28-3 16:50–17:15**  
Monotone Schemes for Fully Nonlinear Parabolic Path Dependent PDEs  
Zhang, Jianfeng  
Univ. of Southern California

**Abstract:** We extend the results of the seminal work Barles and Souganidis (1991) to path dependent case. Based on the recently developed viscosity theory of path dependent PDEs, we show that a monotone scheme converges to the unique viscosity solution of the fully nonlinear parabolic path dependent PDE. Moreover, in the case that the solution is smooth, we obtain the rate of convergence of our scheme.

**MS-We-E-28-4 17:15–17:40**  
Numerical Solution of Backward Stochastic Differential Equations with Jumps for A Class of Nonlocal Diffusion Problems  
Zhang, Guanann  
Oak Ridge National Laboratory

**Zhai, Weidong  
Shandong Univ.

**Webster, Clayton  
Oak Ridge National Laboratory

**Abstract:** We propose a novel numerical approach for linear nonlocal diffusion equations with integrable kernels, based on the relationship between the backward Kolmogorov equation and a class of backward stochastic differential equations (BSDEs) driven by Levy processes with jumps. The nonlocal diffusion problem under consideration is converted into a BSDE, for which numerical schemes are developed and applied directly.

**MS-We-E-28-5 17:40–18:05**  
Numerical Scheme for Regular Semilinear Stochastic PDEs via Backward Doubly Stochastic Differential Equations  
Mnih, Mohamed  
Ecole Nationale d’ Ingenieurs de Tunis

**Abstract:** TBA
Abstract: In this mini-symposium, we gather together researchers in the areas of high-order numerical approximation methods for PDEs and their applications. The mini-symposium will present recent progress in high-order methods including ENO/WENO methods, spectral methods, discontinuous Galerkin methods, and radial basis function methods. Particularly we are interested in the recent development of the hybrid methods that combine the different high order methods in a single frame. The proposed mini-symposium will gain a significant attention since it will provide a valuable opportunity for researchers from different areas to investigate the idea of hybridization of their methods.

**WENO-Z+: Improving the Numerical Dissipation of WENO Schemes**

**Borges, Rafael**

**NUGUI**

Abstract: WENO schemes based on the WENO-Z weight formula are less dissipative than (and as stable as) the classical WENO scheme. The improvement offered by WENO-Z near critical points of the solution is particularly remarkable. We discuss the main reason for this improvement — contrary to common belief, it is not linked to the order of accuracy at critical points. — and present a modified WENO-Z scheme, which improves the results near critical points even further.

**A New Adaptive Weighted Essentially Non-oscillatory WENO-θ Scheme for Hyperbolic Conservation Laws**

**Nguyen, Thien Binh**

**Jung, Chang-Yeol**

**UNIST**

Abstract: A new adaptive WENO-θ scheme is proposed. Depending on the smoothness of the large stencil used in the reconstruction procedure, a parameter θ is set adaptively to switch the scheme between a 5th-order upwind and 6th-order central approximation. A new set of smoothness indicators for both the sub-stencils and the large one is introduced. These are constructed symmetrically around x_j in Taylor expansions. Numerical results show that WENO-θ substantially improves other comparing WENO schemes.

**Adaptive RBF ENO and WENO Finite Volume Methods for Hyperbolic Problems**

**Guo, Jingyang**

**Jung, Jae-Hun**

**SUNY at Buffalo**

Abstract: Adaptive ENO and WENO methods are proposed based on the radial basis function (RBF) interpolation replacing the polynomial interpolation. The free parameter provided by RBF interpolation is determined by canceling the leading error term. To achieve essentially non-oscillatory property, RBF-ENO is reduced into ENO scheme. A monotone polynomial method is proposed to determine non-smooth regions. Numerical results show that the algorithm improves the order of convergence and provides a sharper solution profile near discontinuity.

**Optimized Schwarz Methods for Radial Basis Function Methods**

**Kwok, Felix**

**Hong Kong Baptist Univ.**

Abstract: Radial basis function (RBF) methods for PDEs remain challenging computationally because they produce matrix problems that are dense and ill conditioned as the number of nodes increases. In this talk, we consider preconditioning the problem using an optimized Schwarz method, which is known to possess superior convergence properties to classical additive Schwarz methods. We study the convergence of this new method by comparing it with additive Schwarz and other known preconditioners for RBF methods.
minisymposium should stimulate the exchange between both communities.

**MS-We-E-31-1** 16:00–16:30
**L_p-discrepancy of Higher Order Digital Sequences**
Markhasin, Lev
Univ. of Stuttgart

Abstract: Higher order digital sequences as proposed by Dick are constructions of infinite sequences with very well distribution modulo one. Dick and Pillichshammer proved that for order at least 3 they satisfy optimal upper bound for the $L_p$-discrepancy. We show that even for order at least 2 digital sequences satisfy optimal bounds for the $L_p$-discrepancy.

**MS-We-E-31-2** 16:30–17:00
**Linear Versus Non-linear Approximation in the Average Case Setting**
Plaskota, Leszek
Univ. of Warsaw, Inst. of Applied Mathematics & Mechanics

Abstract: We compare the averages of error of linear and non-linear approximations assuming that the coefficients in an orthogonal expansion are scaled i.i.d. random variables. We show that generally $n$-term non-linear approximation can be much better than linear approximation. On the other hand, if the scaling parameters decrease no faster than polynomially then the average error of non-linear approximations does not converge to zero faster than that of linear approximations, as $n \to \infty$.

**MS-We-E-31-3** 17:00–17:30
**An Implementation of the Multivariate Decomposition Method**
Gilbert, Alexander
The Univ. of New South Wales

Abstract: This talk is on implementing the Multivariate Decomposition Method (MDM) for approximating integrals over the infinite-dimensional unit cube, see “The multivariate decomposition method for infinite-dimensional integration” by Kuo, Nuyens, Plaskota, Sloan and Wasilkowski. Loosely, by decomposing an infinite-dimensional function into a sum of finite-dimensional functions its integral can be approximated by summing over separate cubature rules applied to each term in the decomposition. We focus on truncating this sum and explicitly constructing the cubature rules.

**MS-We-E-31-4** 17:30–18:00
**Quasi-Polynomial Tractability for Standard Information**
Wozniakowski, Henryk
Columbia Univ. & Univ. of Warsaw

Abstract: QPT (quasi-polynomial tractability) is well understood for linear multivariate problems in various settings when linear information is used. We present current results for QPT in the case of standard information. This will allow us to compare the power of linear and standard information for QPT. The talk is based on joint work with Erich Novak.

**MS-We-E-32** 16:00–18:00

**Structured-mesh methods for interface problems. - Part III of VIII**
For Part 1, see MS-Tu-E-32
For Part 2, see MS-We-D-32
For Part 4, see MS-Th-BC-32
For Part 5, see MS-Th-D-32
For Part 6, see MS-Th-E-32
For Part 7, see MS-Fr-D-32
For Part 8, see MS-Fr-E-32

Organizer: Chen, Huanzhen
College of Mathematical Sci. Shandong Normal Univ.

Organizer: He, Xiaoming
Missouri Univ. of Sci. & Tech.

Organizer: KWA, Do Young
Korea Advanced Inst. of Sci. & Tech.

Organizer: Zhang, Xu
Purdue Univ.

Abstract: In many real world applications it is more convenient or efficient to utilize structured meshes for solving different types of interface problems. Since the structured meshes may not fit the non-trivial interfaces, special methods need to be developed to deal with the difficulties arising from the interface problems in order to solve them on these meshes. Therefore, great efforts have been made for solving interface problems and tracing the moving interfaces based on structured meshes in the past decades. This mini-symposium intends to create a forum for researchers from different fields to discuss recent advances on the structured-mesh numerical methods for interface problems and their applications.

**MS-We-E-32-1** 16:00–16:30
**Dissipation Sand Dispersion Errors of Discontinuous Galerkin Method and Its Application to Level Set Equations**
Yan, Jue
Iowa State Univ.

Abstract: The discontinuous Galerkin (DG) method is known to provide high resolution properties, especially when applying after long time run. In this talk, we consider analyzing the error behavior of the DG method with P2 quadratic polynomial approximations, the dissipation error is on the order of 5 and the dispersion error is on the order of 6. The part of the error that grows linearly in time is on the order of 6. When solving interface problems in a complex incompressible flow, the DG method is shown to dramatically improve the mass conservation property of the level set method. Numerical examples demonstrate the high order accuracy of the scheme and the high resolution property especially when the interface undergoes large topological changes.

**MS-We-E-32-2** 16:30–17:00
**A Parallel Solution Approach for Crack Propagation Using Adaptive Mesh Refinement**
Heister, Timo
Clemson Univ.

Abstract: We present an algorithm based on the active set strategy to simulate crack propagation using a quasi-static fracture model. The crack is discretized using a phase-field approach, which allows merging and joining of cracks. The non-linear system is discretized using the Finite Element method and solved in a monolithic fashion. We include a new strategy for adaptive mesh refinement. The whole scheme is parallelized and scales to a large number of cores.

**MS-We-E-32-3** 17:00–17:30
**Reliable and Efficient Error Control for An Adaptive Galerkin-characteristic Method for Convection-dominated Diffusion Problems**
Cui, Ming
College of Applied Sci., Beijing Univ. of Tech.

Abstract: An efficient and reliable a-posteriori error estimator is developed for a characteristic-Galerkin FEM for time-dependent convection-dominated problems. An adaptive algorithm with variable time and space steps is proposed. It is proved that at each time step this adaptive algorithm is capable of reducing errors below a given tolerance in a finite number of iteration steps. Numerical results are presented to check the theoretical analysis.

**MS-We-E-32-4** 17:30–18:00
**An Adaptive Local Basis for Elliptic Problems with Complicated Discontinuous Coefficients**
Sauter, Stefan
Univ. of Zurich

Weymouth, Monika
Univ. of Zurich

Abstract: We will present a generalized finite element method for the discretization of elliptic partial differential equations in heterogenous media. An adaptive local finite element basis (AL basis) on a coarse mesh which does not resolve the matrix of the media is constructed by solving finite dimensional localized problems. This method requires $O(\log((1/H)^d + 1))$ basis functions per mesh point. We will prove that the optimal convergence rates are preserved and give some complexity estimates.

**MS-We-E-33** 16:00–18:00

**Mathematical Modelling, Analysis and Computation for Bose-Einstein condensation - Part II of III**
For Part 1, see MS-We-D-33
For Part 3, see MS-Th-BC-33

Organizer: Wang, Hanquan
Yunnan Univ. of Finance & Economics

Abstract: Recently, modeling and simulation of Bose-Einstein condensates (BEC) at zero temperature are one of most interesting research topics in physics as well as applied mathematics. At such low temperature, different kinds of BEC can be modeled by the famous Gross-Pitaevskii equation (GPE) or coupled GPEs or nonlocal GPE(s). How to analyze and solve the GPE(s) for understanding the physics of BEC is interested by mathematicians and physicists. In this minisymposium, we aim to discuss the mathematical properties of these nonlinear Schrodinger type models, find solutions to those models both analytically and numerically, do numerical analysis for efficient numerical methods, and show their applications into simulation of BEC and related physics. This minisymposium is intended to be helpful for applied mathematician to share their latest research work with physicists who are working on research of BEC and related physics.

**MS-We-E-33-1** 16:00–16:30
**Spectral Method for Computing Dynamics of Rotating Two-component Bose-Einstein Condensates via Coordinate Transformation**
Yanzhi, Zhang
Missouri Univ. of Sci. & Tech.

Tang, Qingsin
INRIA - Univ. of Lorraine

Abstract: In this talk, we present an efficient and accurate numerical method for computing the dynamics of rotating two-component Bose-Einstein condensates which is described by coupled Gross-Pitaevskii equations (CGPEs) with an angular momentum rotation term and an external driving field. By introducing rotating Lagrangian coordinates, we eliminate the angular momentum...
rotation term from the CGPES. Our method has spectral accuracy in all spatial dimensions and moreover it can be easily implemented in practice.

**MS-We-E-33-2**

**Optimal Error Estimate of A Symplectic and Energy Conserving Finite Difference Scheme for the Nonlinear Schrödinger Equation**

Wang, Tingchun  
Nanjing Univ. of Information Sci. & Tech.

Abstract: Up to now, the mathematicians think that the symplectic finite difference schemes for solving nonlinear partial differential equations could not preserve the total energy in the discrete sense. In this talk, we put forward a new viewpoint that the symplectic finite difference scheme of the nonlinear Schrödinger equation can preserve both the total mass and the total energy in the discrete sense, and establish the optimal error estimate in the maximum norm.

**MS-We-E-33-3**

**Error Estimates of Numerical Methods for Nonlinear Schroedinger Equation with Wave Operator**

Cai, Yongyong  
Purdue Univ.
Hanquan, Wang  
Yunnan Univ. of Finance & Economics

Abstract: The nonlinear Schroedinger equation (NLS) with wave operator (NL-SW) is NLS perturbed by the wave operator with strength described by a dimensionless parameter $\varepsilon \in (0,1]$. In this talk, I will start with the error analysis of finite difference methods for NLSW and the uniform bounds w.r.t. $\varepsilon$. Then I will show the error analysis of an exponential wave integrator sine pseudospectral method for NLSW, with improved uniform error bounds.

**MS-We-E-33-4**

**Bloch Decomposition Based Method for Quantum Dynamics in Periodic Media**

HUANG, ZHONGYI  
Tsinghua Univ.

Abstract: In this talk, we will give a short review of our Bloch based method for quantum dynamics in heterogeneous media with periodic microstructures. Furthermore, we will also discuss the applications of our method to some physical problems.

**MS-We-E-34**

**Structure-preserving methods for nonlinear Hamiltonian systems I-III**

Organizer: Feng, Biao-Feng  
The Univ. of Texas-Pan American
Organizer: Hu, Xing-Biao  
Inst. of Computational Mathematics, Chinese Acad. of Sci. (CAS), China
Organizer: Shang, Zaiju  
AMSS, CAS
Organizer: Hong, Jialin  
Inst. of Computational Mathematics, Chinese Acad. of Sci. (CAS), China

Abstract: During the last 50 years, there has been a wide interest in the study of nonlinear Hamiltonian systems, especially Hamiltonian PDEs. Among which an important class are integrable, in the sense that they can be solved exactly, admit enough number of conservation laws. On the other hand, there have been major advances in the numerical methods of integrable Hamiltonian systems. Symplectic, multi-symplectic and energy-preserving methods have been popular in simulating these equations. Nevertheless, an important question still deserve to be explored is how to appropriately discretize nonlinear Hamiltonian systems and to gain a superior performance for long time simulations while keeping their common features as many as possible. The purpose of this organized minisymposium is to bring together researcher's from both integrable system and numerical analysis to discuss recent advances on numerical aspects of nonlinear Hamiltonian systems.

**MS-We-E-34-1**

**Noether’s Laws for Finite Element Variational Problems**

Mansfield, Elizabeth  
Univ. of Kent

Abstract: I will show recent work with Tristan Pryer, in which we demonstrate conservation of energy, and linear and angular momenta for variational problems, which is exact for the approximate problem and which converges to the smooth law. I will then show that particle relabelling group symmetries which yields conservation of potential vorticity for shallow water problems, yields an exact FE-potential vorticity which converges to the smooth law.

**MS-We-E-34-2**

**A Structure-preserving Numerical Integrator Based on the Hodograph Transform for the Short-pulse Equation**

Matsuo, Takayasu  
Univ. of Tokyo

Abstract: In this talk, we consider the numerical integration of the short pulse equation. For this, Feng et al. (2011) considered an integrable discretization based on hodograph transform, which enables beautiful simulation of loop type solitons. In this talk, we employ the same transform, and then apply an energy-preserving method. As a good consequence of this approach, the curve length in the short pulse equation, which is also an invariant, is preserved.

**MS-We-E-34-3**

**Asymmetric Numerical Schemes Based on the Discrete Variational Derivative Method and A Practical Application**

Furihata, Daisuke  
Osaka Univ.

Abstract: In general, structure-preserving methods for partial differential equations have some mathematically rigorous properties, but the cost to obtain solutions of them are relatively expensive since those methods are the equivalents of systems of nonlinear equations. An asymmetric discrete variational derivative method weakens the nonlinearity and may lower this cost. We introduce this asymmetric method and indicate its practical utility as predictors in the predictor-corrector context.

**CP-We-E-34-4**

**Free Boundary Problem in 3D Geometry**

Humaloja, Jukka-Pekka  
Tampere Univ. of Tech.
Hamaalainen, Timo  
Tampere Univ. of Tech.
Pohjalainen, Seppo  
Tampere Univ. of Tech.

Abstract: We present a numerical method for detecting perfectly conducting objects in a homogeneous medium in 3D. The method is based on minimizing an objective function that depends on Cauchy data given on the surface of a sensor, near which the conducting objects are located. The objective function is derived from Green’s second identity with the fundamental solution of the three-dimensional Laplacian. The functional has linear and nonlinear parts, which is utilized in the minimization.

**MS-We-E-35**

**Monte Carlo Methods for Solving Partial Differential Equations - Part II of III**

For Part 1, see MS-We-D-35  
For Part 3, see MS-Th-BC-35

Organizer: Cai, Wei  
Univ. of North Carolina at Charlotte
Organizer: Mascagni, Michael  
Florida State Univ. CS Dept

Abstract: Monte Carlo (MCMs) have been used extensively in diverse computational applications in the sciences, engineering, and finance. This is due to their natural parallelism, data parsimony and locality, and their capability to tackle high dimension problems that are otherwise intractable. In this mini-symposium, we will present several talks that study the use of MCMs to solve partial differential equations (PDEs). These include using the Feynman-Kac formula to develop MCMs for PDEs, using polynomial chaos for solving stochastic PDEs, Monte Carlo linear solvers that arise from PDEs, algorithmic issues of the walk-on-sphere method, fault tolerance in multilevel MCMs, stability analysis of MCMs for mixed type PDEs, estimation of diffusion process sensitivities, as well as the application of MCMs in capacitance calculation of microchip ICs and multi-asset finance options.

**MS-We-E-35-1**

**Monte Carlo Simulations for the Structure of Dielectric Spheres**

Xu, Zhenli  
Shanghai Jiao Tong Univ.

Abstract: We reported a hybrid algorithm for electrostatic energies of charged dielectric spheres. It is composed of method of images, method of moments and FMM, which provides high accuracy for closely compacted spheres. The high speed is ensured by using images thus only a small number of multipoles is needed in the method of moments. This algorithm allows MC simulation for equilibrium structures of dielectric spheres at room temperature, e.g., PMFs of colloids and their self-assembly.

**MS-We-E-35-2**

**A Multi-scale Reaction-Potential Monte Carlo Simulation Method of Electrolytes**

Xing, Xiangjun  
shanghai jiao tong Univ.

Abstract: In this work we present a novel multi-scale Monte Carlo simulation strategy for the electrolytes. We introduce a spherical simulation domain, and then integrate all ions outside the domain to obtain an effective theory for the ions inside. The resulting multi-scale grand canonical Monte Carlo method is not only efficient in terms of computation resources, but also captures correlation effects between ions faithfully.

**MS-We-E-35-3**

**The Floating Random Walk Algorithms for Capacitance Extraction Problems in IC and FPD Design**

Yu, Wenjian  
Tsinghua Univ.

Abstract: The floating random walk (FRW) algorithms for capacitance extraction of metal interconnects in integrated circuits and flat panel display are
presented. The method is scalable to full-chip / full-net extraction task. The techniques for handling structures with multiple dielectrics, the variance reduction techniques based on importance sampling and stratified sampling, and the techniques handling non-Manhattan geometries are discussed. They largely accelerate the computation and extend the application of the random walk method.

**Computational Geometry Problems Arising in Walk on Spheres Monte Carlo Techniques**

Mascagni, Michael
Florida State Univ. CS Dept

Abstract: The efficient and popular method known as Walk on Spheres (WoS) is useful for solving a variety of elliptic and parabolic partial differential equations. The WoS algorithm is efficient, but the computational bottleneck is the geometrical geometry required to create optimal WoS paths. In this paper, we present results on the best computational algorithms for this aspect of WoS.

**Revisit of Monte Carlo Methods on Solving Large-Scale Linear Systems**

Ji, Hao
Li, Yishang

Organizer: Shih, Yin-Tzer
National Chung Hsing Univ.

Abstract: We present an approach of embedding Monte Carlo sampling into the Krylov subspace methods, where the extreme eigenvalues/eigenvectors of the large coefficient matrix can be estimated and continuously refined during the course of iterations via importance sampling to accelerate the convergence of the linear solvers. The resulted Krylov subspace-based solver with Monte Carlo deflation is memory-bounded, matrix pass-efficient, and can be efficiently implemented on CPU-coprocessor architectures.

**Some Open Problems in the Numerical Analysis of Singularly Perturbed Differential Equations**

Stynes, Martin
Beijing Computational Sci. Research Center

Abstract: Some open problems in the numerical analysis of singularly perturbed differential equations will be discussed. This is joint work with Hans-Goerg Roos.

**An Equation Decomposition Based Tailored Finite Point Method for Fluid Dynamics**

HUANG, ZHONGYI
Tsinghua Univ.

Abstract: In this talk, we propose a tailored-finite-point method for Oseen equations in two dimensions based on the equation-decomposition technique. Unlike the usual vorticity-stream function formulation, the velocities are decomposed into irrotational and rotational parts. We only need to solve a system of two elliptic equations which are decoupled in the interior domain. Our scheme satisfies the discrete maximum principle automatically. We also gives one remarks on more memory incompressible flow.

**Tailored Finite Point Method for Solving One-dimensional Burgers’ Equation**

Shih, Yin-Tzer
Lin, Yu-Tien
Tai, Chih-Ching

Organizer: Shih, Yin-Tzer
National Chung Hsing Univ.

Abstract: We propose two versions of tailored finite point (TFP) methods for solving a time-dependent nonlinear Burgers equation. The first scheme implements the Hopf-Cole transformation, and then discretize the problem by the TFP with fourth order approximation on the boundary. In the second scheme we uses some hyperbolic functions to discretize Burgers’ equation directly. Numerical results indicate that both schemes are efficient and robust for solving Burgers’ equation.

**An Efficient Stabilized Linear Finite Element Method for Solving Reaction-convolution-diffusion Equations**

Hsieh, Po-Wen
Chung Yuan Christian Univ.

Abstract: We propose an efficient stabilized linear FEM for solving reaction-convolution-diffusion equations with arbitrary magnitudes of reaction and diffusion. The key feature of the method is that the test function in the stabilization term is taken in the adjoint-operator-like form. The analysis shows that the method is suitable for a wide range of mesh Peclet and Damkohler number-s. Numerical examples exhibiting boundary or interior layers are given to demonstrate the high performance of the method.

**Analysis and control of multi-agent systems**

Organizer: Liu, Zhixin
AMSS, Chinese Acad. of Sci.

Abstract: In the investigation of multi-agent systems (MAS), a central issue is to understand how local interactions among agents lead to collective behavior of the system. We introduced a random framework and some mathematical tools such as multi-array martingale theorem and estimation of spectral gap of random geometric graphs, to study the synchronization of a basic class of MAS with large population. Meanwhile, I present some quantitative results on how we intervene in MAS such that the system exhibits the expected behavior. On the other hand, we introduce how to design the distributed control law for each agent such that the system exhibits the expected behavior; On the other hand, we introduce how to design the distributed control law for each agent such that the system exhibits the expected behavior.
global information of the network, for example the spectrum of its Laplacian matrix. A challenging problem is how the network structure affects the network dynamics in a distributed way especially for directed networks, which is still unclear today. In this talk, we will investigate the impact of the network structure for synchronization on an undirected complex network, a second-order multi-agent system with undirected topology, and a general directed complex network. We will also develop a scheme to change the weights in a local manner to achieve a desired behavior. In particular, network synchronization is investigated, for which some distributed adaptive laws are designed on the coupling weights for reaching synchronization.

**MS-We-E-38** 16:00–18:00 302A
Analysis and design of hybrid dynamical systems
Organizer: Kang, Yu  
Univ. of Sci. & Tech. of China
Abstract: Control theory and corresponding technologies have seen their great success in wide areas of applications in real world for many decades. In this minisymposium, several distinct systems are discussed, including the photovoltaic array, service robots for rehabilitation, systems over communication networks, and the remote sensing of exhaust gas of vehicles. Each discussion focuses on one or several aspects of the modelling, identification, sensing or control of such systems, together presenting a fairly comprehensive picture of the state of the art applications of the modern control technologies.

**MS-We-E-38-1** 16:00–16:30
Time-Varying Control Design for Nonlinear Systems with Unknown Nonlinearities
Liu, Yungang  
Shandong Univ.
Abstract: This report is devoted to the time-varying control design with prescribed performance for uncertain nonlinear systems. Differently, the system under investigation are of unknown control directions, and possess inherent nonlinearities with non-parametrizable unknowns. A new time-varying framework is developed to effectively handle the serious unknowns and strong nonlinearities, and to achieve global stabilization and practical tracking with prescribed performance for two representative classes of uncertain nonlinear systems, respectively.

**MS-We-E-38-2** 16:30–17:00
The Research and Industrialization of Wearable Upper Arm Robotic System for Medical Rehabilitation
Li, Zhijun  
South China Univ. of Tech.
Abstract: This project will be based on the nerve repair theory, combined with hemiplegia rehabilitation methods commonly used in the clinic, using robot technology, intelligent control theory, computer technology, to develop the wearable arms robot for medical rehabilitation. The project will provide theoretical guidance and practical verification for a new type of medical rehabilitation robot which has independent intellectual property rights and the value on clinical application. This project will improve the medical rehabilitation robot level and its market competitiveness, and change the situation of dependence on imports. The project has important practical significance of accelerating the industrialization of the medical rehabilitation robot.

**MS-We-E-38-3** 17:00–17:30
Parameter Identification Method of Photovoltaic Array Based on Measured Data
Wang, Bing  
Hohai Univ.
Abstract: Based on the I-V equation of photovoltaic cell and basic circuit theories, this paper identifies four undetermined coefficients of photovoltaic array, including photo current, negative saturation current, ideality factor and the series resistance of cells, via the output characteristics of maximum power point tracking, by using parameter identification method with the known input and output data of photovoltaic. According to the solved I-V equation, it can predict the output power of photovoltaic plant. At last, it verifies the feasibility and accuracy of the proposed method by numerical examples and data simulation.

**MS-We-E-39** 16:00–18:00 302B
Data-based industrial modelling, control and optimization
Organizer: Ding, Jinliang  
Northeastern Univ.
Organizer: Han, Honggui  
Beijing Univ. of Tech. & City Univ. of Hong Kong
Abstract: With application of the automation and information management systems, numerous historical or real-time data related to industrial production operation are stored. Mining of the information (knowledge) hidden in data and automatically data-driven approaches is a challenging problem for modelling, control and optimization of complex industrial processes. The minisymposium aims to present some recent developments in data-based industrial modelling, control and optimization approaches, including 1) plant-wide performance optimization of industrial processes; 2) hierarchical model to predict sludge volume of wastewater treatment; 3) data-driven predictive scheduling for energy system of steel industry; 4) sampled-data synchronization control of chaotic systems with time delays.

**MS-We-E-39-1** 16:00–16:30
Data-based Multi-objective Plant-wide Performance Optimization of Industrial Processes under Dynamic Environments
Ding, Jinliang  
Northeastern Univ.
Abstract: In order to guarantee performance in terms of prescribed multi-objective plant-wide production indices, an approach for selecting optimal operational indices for unit processes is proposed using measured data and without knowing dynamical models of the unit process. Techniques from reinforcement learning are used to provide a data-driven optimization technique that guarantees optimal plant-wide process performance. The effectiveness of this automated decision procedure has been demonstrated by implementation on a large mineral processing plant.

**MS-We-E-39-2** 16:30–17:00
Hierarchical Modeling Approach to Predict Sludge Volume Index of Wastewater Treatment Process
Han, Honggui  
Beijing Univ. of Tech. & City Univ. of Hong Kong
Abstract: Sludge volume index (SVI) monitoring is a key challenge that will become even more crucial in the years ahead to quantify the sludge bulking. This contribution presents a SVI predicting plant which uses a hierarchical radial basis function neural network (HRBF) to predict SVI in a wastewater treatment process (WWTP). Experimental results show that the HRBF can be used to predict the wastewater quality online. The results demonstrate its effectiveness.

**MS-We-E-39-3** 17:00–17:30
Data-driven Predictive Scheduling for Energy System of Steel Industry
Zhao, Jun  
Dalian Univ. of Tech.
Wang, Wei  
Dalian Univ. of Tech.
Abstract: With the application of automation system based on information technology, a large number of historical or real-time data related to the production scheduling in industry are generated and stored. Mining and making full use of the information (knowledge) implicitly involved in the data will provide scheduling problem with a class of data-driven methods. In this study, a data-driven predictive scheduling approach will be studied, which will be practically attempted to apply to the steel enterprises.

**MS-We-E-39-4** 17:30–18:00
Sampled-data Synchronization Control of Chaotic Systems with Time Delays
Wu, Jun-Guang  
Inst. of Cyber-Sys. & Control, Zhejiang Univ.
Su, Hongye  
Inst. of Cyber-Sys. & Control, Zhejiang Univ.
Abstract: The problem of sampled-data synchronization control is investigated for chaotic systems with time delays. It is assumed that the sampling periods are variable but bounded. In order to take full advantage of the available information about the actual sampling pattern, a novel Lyapunov functional is proposed, based on which an exponential synchronization criterion is derived by analyzing the corresponding synchronization error systems and the design method of the desired sampled-data controller is also given.

**MS-We-E-40** 16:00–18:00 303A
Communication and Control for Complex Networked Systems
Organizer: Peng, Chen  
Shanghai Univ.
Organizer: Ding, Jinliang  
Northeastern Univ.
Organizer: Han, Honggui  
Beijing Univ. of Tech. & City Univ. of Hong Kong
Abstract: Networked control systems (NCSs) are a class of complex dynamical systems wherein the distributed system components, such as sensors, controllers and actuators are connected over a communication network. In the past decade, we have already witnessed interesting results in the literature for NCSs. However, many problems such as the necessary communication for NCSs with limited bandwidth, communication and control design under the limited network resources, and the application of NCSs in the real world still require in-depth investigation to reveal the effects of networks on the operation of NCSs and widen their application domains. The goal of this minisymposium is to gather recent event/self-triggered communication and controller design and separation principle for complex networked control systems field obtained by researchers from academia, research labs, and industry. The central theme of the minisymposium will be advanced communication and control design for NCSs with limited network and computational resources. This theme is strongly interdisciplinary, involving competencies from several science fields, such as communications, control and computing. Therefore, a minisymposium devoted to it will be of high interest both for the academic and industrial communities.
Abstract: A novel self-triggered sampling scheme is proposed for networked control systems with network-induced delays and data dropouts. By using this scheme, the next sampling instant, which does not depend on the continuous measurement of the system state and on-line estimation of an event-triggered condition, can be dynamically determined with respect to the desired performance, the transmitted time-stamped packet, and the allowable number of successive data dropouts and the network-induced delays. Consequently, the sampling interval can be adaptively adjusted. Therefore, the communication burden can be reduced and the energy efficiency can be improved while maintaining the desired performance.

Controller Design and Separation Principle of Networked Control Systems
Li, Hongbo Tsinghua Univ.
Abstract: Communication technology and digital computation have shown remarkable progress in recent years, which facilitates the emergence and development of the so-called networked control systems (NCSs). This talk will present some recent works on the stability analysis and controller synthesis of NCSs with time delays and packet losses, and offer a perspective on separation principle of NCSs.

Distributed Event Triggered Control of Multi-agent Systems with Switching Topologies
Wang, Dong Dalian Univ. of Tech.
Abstract: A switched Lyapunov function method is proposed for distributed event-triggered control of multi-agent systems under the switching topology. Although an arbitrary switching topology is obtained, there is a self-Lyapunov function for each topology. This is in fact a multi-Lyapunov function, which reduces the conservatism of common Lyapunov function method.

Xie, Xiangpeng Nanjing Univ. of Posts & Telecommunications
Abstract: With the rapid development of networking communication technologies, networked control systems have received increasing interest in recent years. Compared with traditional point-to-point control systems, the main advantages of NCSs are low cost, easy maintenance, and increased system flexibility. More recently, much attention has also been paid to event-triggered control design of nonlinear networked systems. This talk will present some recent works on event-triggered control design of nonlinear networked systems. The talk will present some recent works on event-triggered control design of nonlinear networked systems via an efficient approach (named as multi-instant homogenous matrix polynomials approach), which could offer a perspective on reducing the conservatism of existing results.

Distributed Control of Electrical Power Networks
Johansson, Karl H. Royal Inst. of Tech.
Organizer: TCCT
Technological Committee on Control Theory, CAA
Abstract: Dynamics and robotic Systems have been object of widespread research in the last decades. Their applications span over service, industrial, military and civil fields and involve missions like exploration, transportation and mobile manipulation. In spite of the many advancements in the field of dynamics and robotic systems, several challenging issues are still open. The minisymposium aims to present some methodic, functional, procedural or algorithmic search, find and processing approach of dynamics and robotsystemcontrol, including: 1) eigenaxis maneuver strategy for flexible spacecrafts; 2) hypersonic vehicle control; 3) the property of selfishness to the robots; 4) neural network for convex optimization.

Modeling, Control and Simulation of Hypersonic Vehicle
Zong, Qun Tianjin Univ.
Abstract: Our research of Hypersonic Vehicle(HSV) modeling is carried out to calculate the complete aerodynamic data and then obtain the 6-DOF model by mechanism analysis and CFD technique. Our research of HSV control is mainly focused on the sliding mode control(SMC) and adaptive backstepping control in the cruise and reentry phase. Combining with the 3D scene technique, dSPACE-based real-time simulations are carried out to prove the validity of the controllers.

Distributed Event Triggered Control of Multi-agent Systems under the Switching Topology
A switched Lyapunov function method is proposed for distributed event-triggered control of multi-agent systems under the switching topology. Although an arbitrary switching topology is obtained, there is a self-Lyapunov function for each topology. This is in fact a multi-Lyapunov function, which reduces the conservatism of common Lyapunov function method.
where the graph topology is directed and the leader is the neighbor of only a small portion of followers, distributed tracking control laws are designed. By using the algebra graph theory, it is shown that all the states of the closed-loop system are bounded, and the tracking errors can be tuned to be arbitrarily small.

**MS-We-E-42-4**

**Stochastic Control with Transmission Delay**
Zhang, Huanshui
Shandong Univ.
Abstract: This paper study stochastic control for systems with transmission delay. A sufficient and necessary stabilizing condition is presented for the stochastic system with delayed state. The analytical controller is given in terms of the optimal state prediction and the solution to a coupled nonlinear equation.

**MS-We-E-42-5**

**Heterogeneous Multi-Agent Systems: Geometry and Dual Design**
Lewis, Frank
Univ. of Texas at Arlington
Abstract: We study the geometry and duality of multiple interacting heterogeneous multi-agent systems where the agent dynamics may not be the same. A geometric theory is given using Kalman observable form decomposition and a characterization of that portion of the leader’s dynamics that is hidden within the dynamics of each agent. These new geometric ideas are used to design efficient reduced-order synchronizers. It is shown that the synchronization problem can be approached by two dual methods.

**MS-We-E-43**

**Black-box and derivative-free optimization**
Organizer: Zhang, Zaikun
Institut de Recherche en Informatique de Toulouse (IRIT)
Abstract: Black-box optimization problems arise frequently in real-world applications. In these problems, the function values are provided by black-boxes (typically simulations or experiments), and there is no access to derivatives. They have stimulated optimization methods that do not use derivatives, which are commonly referred to as derivative-free optimization methods. This mini-symposium intends to present the latest advances on black-box and derivative-free optimization both in theory (convergence analysis and complexity control) and in practice (software developments and applications). The talks will be particularly focused on large-scale problems, constrained problems, parallel methods, subspace methods, and randomized methods.

**MS-We-E-43-1**

**Using Concurrent Function Evaluations to Identify Local Minima of A Derivative-Free Optimization Problem**
Larson, Jeffrey
Argonne National Laboratory
Wild, Stefan
Argonne National Laboratory
Abstract: We present software that uses concurrent evaluations of the objective function to identify all of its local minima. The method is based on a multi-list algorithm that almost surely finds all local minima of the function while starting only finitely many local optimization runs. We specifically highlight rules in our software that pause local optimization runs to help our method more efficiently search the domain, while not interfering with its underlying theoretical properties.

**MS-We-E-43-2**

**Direct Search Based on Probabilistic Descent**
Gratton, Serge
Univ. of Toulouse, IRIT-CERFACS joint laboratory
Royer, Clement
Univ. of Toulouse, IRIT-CERFACS joint laboratory
Vicente, Luis Nunes
Univ. of Coimbra
Zhang, Zaikun
Institut de Recherche en Informatique de Toulouse (IRIT)
Abstract: Direct-search methods are a class of derivative-free algorithms based on evaluating the objective function along directions in positive spanning sets. We study a more general framework where the directions are only required to be probabilistic descent, meaning that with a significantly positive probability at least one of them is descent. This framework enjoys almost-sure global convergence and a global rate of $1/sqrt(k)$ (like in gradient methods) with overwhelmingly high probability.

**MS-We-E-43-3**

**A Subspace Decomposition Framework for Nonlinear Optimization**
Gratton, Serge
Univ. of Toulouse, IRIT-CERFACS joint laboratory
Vicente, Luis Nunes
Univ. of Coimbra
Zhang, Zaikun
Institut de Recherche en Informatique de Toulouse (IRIT)
Abstract: We present a parallel subspace decomposition framework for non-linear optimization, which can be regarded as an extension of the domain decomposition method for PDEs. A feature of the framework is that it incorporates the restricted additive Schwarz methodology into the synchronization phase of the algorithm. We establish the global convergence and worst case iteration complexity of the framework, and illustrate how this framework can be applied to design parallel algorithms for derivative-free optimization problems.
cooperative teamwork in real applications. The focus of this mini-symposium will be on new and existing distributed control approaches in networked agent systems.

**MS-We-E-45-1** 16:00–16:30

**Distributed Finite-time Tracking of Multiple Euler-Lagrange Systems without Velocity Measurements**

Yu, Zhao  
Peking Univ.

Wen, Guanghui  
Southeast Univ.

Abstract: This paper investigates the distributed finite-time tracking problem of networked agents with Euler-Lagrange dynamics. To achieve finite-time tracking, with the aid of second-order sliding-mode observer approach, a new class of finite-time tracking protocols based only on the relative position measurements are developed and employed. It is proved that the multiple agents equipped with the designed protocols can track the target location in finite time. The effectiveness of the theoretical results is finally illustrated by numerical simulations.

**MS-We-E-45-2** 16:30–17:00

**Node-to-node Consensus of Multi-agent Systems under Directed Topology**

Wen, Guanghui  
Southeast Univ.

Yu, Wenwu  
Southeast Univ.

Abstract: Consensus of multi-agent system has recently received considerable attention from various scientific communities due to its potential applications in engineering. In this talk, distributed node-to-node consensus for multi-agent systems with directed topology is introduced and discussed. The multi-agent systems in the present framework consist of two layers, i.e., the leader’s layer and the follower’s layer, where the coordination goal is to make each follower asymptotically track its corresponding leader by designing some local-information-based protocol. Both theoretical and numerical results on node-to-node consensus of such a multi-agent system will be provided in this talk.

**MS-We-E-45-3** 17:00–17:30

**Convergence Rate of the Consensus of Linear Multi-agent Systems with Communication Noises**

Cheng, Long  
Inst. of Automation, Chinese Acad. of Sci.

Abstract: This study mainly focuses on the convergence rate of the consensus of linear multi-agent systems. It is assumed that each agent is described by the generic linear dynamics, and communication channels are corrupted by additive noises. A time-varying gain is adopted to attenuate the noise effect. It has been found that the convergence rate of the consensus has a strong relationship with the convergence rate of this time-varying gain.

**MS-We-E-45-4** 17:30–18:00

**General Algebraic Connectivity in Consensus of Multi-agent Systems**

Yu, Wenwu  
Southeast Univ.

Abstract: This talk will discuss general algebraic connectivity representing consensus convergence rate in multi-agent systems with directed topologies. First, a new concept, general algebraic connectivity is proposed to study the global consensus problem with first-order dynamics in strongly connected networks and also in a broad class of networks containing spanning trees, for which ideas from algebraic graph theory, matrix theory, and Lyapunov methods are utilized. Based on this result, consensus in multi-agent systems with second-order nonlinear systems can be obtained.

**MS-We-E-46** 16:00–18:00

**Inverse Problems for Image Reconstruction and Processing - Part II of IV**

For Part 1, see MS-We-E-46-1  
For Part 2, see MS-We-E-46-2  
For Part 3, see MS-We-E-46-3  
For Part 4, see MS-We-E-46-4

Organizer: Wei, Suhua  
Inst. of Applied Physics & Computational Mathematics

Organizer: Nikolova, Mila  
CMLA, CNRS - ENS Cachan

Organizer: Tai, Xue-Cheng  
Department of Mathematics, Univ. of Bergen

Organizer: Shi, Yuying  
North China Electric Power Univ.

Abstract: Many image reconstruction tasks amount to solve ill-posed inverse problems. Indeed, measurement devices typically cannot record all the information needed to recover the sought-after object; furthermore, the operators that model these devices are seldom accurate and data are corrupted by various perturbations. A common approach to find an approximate to the unknown object is regularization. The key points are the correct choices of the data fidelity term and the regularization term, as well as the trade-off between these terms. This is a challenging problem since the optimal solutions of the whole functional should correctly reflect the knowledge on the data-production process and the priors on the unknown object. The optimal solutions usually cannot be computed explicitly and iterative schemes are used. This symposium focuses on imaging inverse problems' mathematical models, numerical algorithms, theoretical analysis and various applications, especially, applied to CT reconstruction and some processing techniques for images.

**MS-We-E-46-1** 16:00–16:30

**Domain Decomposition for Total Variation Minimization**

Tai, Xue-Cheng  
Department of Mathematics, Univ. of Bergen

Abstract: This talk is concerned with overlapping domain decomposition methods (DDMs), based on successive subspace correction (SSC) and parallel subspace correction (PSC), for the Rudin, Osher and Fatemi (ROF) model in image restoration. In distinct contrast with recent attempts along this line, we work with a dual formulation of the ROF model, where one significant difficulty lies in the decomposition of the global constraint of the dual variable. We propose a stable unit decomposition which

**MS-We-E-46-2** 16:30–17:00

**A Reconstruction Method of Intra-Ventricular Flow Velocity Using Color Flow Ultrasound**

Ahn, Chi Young  
National Inst. for Mathematical Sci.

Abstract: We propose a 2D Navier-Stokes model to reconstruct intra-ventricular flows using color flow images and left ventricular boundaries extracted from echocardiography data. The proposed model considers both in-plane and out-of-plane blood flows for an imaging plane in apical long-axis three-chamber view. Blood flows in the imaging domain are reconstructed through solving a system of equations, which include a 2D incompressible Navier-Stokes equation with a mass source term and the color flow data measurement equation.

**MS-We-E-46-3** 17:00–17:30

**Adaptive Regularization Method for Tomography Reconstruction**

Lu, Yao  
Sun Yat-sen Univ.

Abstract: The purpose of this study was to implement the adaptive regularization rooted from traditional discrete Total Variation (TV) regularization for iterative tomography reconstruction in mesh domain to suppress image noise accumulation with increasing iteration number. In order to accomplish these aims we used reconstruction algorithms in mesh domains that employed TV priors applied in a continuous form. A computationally efficient approach for the proposed continuous regularization was derived for piece-wise linear basis functions.

**MS-We-E-46-4** 17:30–18:00

**An Alternating Minimization Model for Tomography Reconstruction in Hydrodynamic Experiments**

Kong, Linghai  
Inst. of Applied Physics & Computational Mathematics

Abstract: Flash radiography with CCD-based camera plays an important role in studying the dynamical behavior of material under a shock through tomographic reconstruction techniques, where the map is degraded by blur and noise. A new regularized alternating minimization model is proposed by exploiting the EM algorithm and the augmented Lagrangian method. Numerical tests are illustrated to validate the model.

**MS-We-E-47** 16:00–18:00

**Numerical methods for compressible multi-phase flows - Part III of VI**

For Part 1, see MS-Mo-D-08  
For Part 2, see MS-Mo-E-08  
For Part 4, see MS-Th-BC-47  
For Part 5, see MS-Th-D-47  
For Part 6, see MS-Th-E-47

Organizer: Deng, Xiaolong  
Beijing Computational Sci. Research Center

Organizer: Wei, Suhua  
Inst. of Applied Physics & Computational Mathematics

Organizer: Tian, Baolin  
Institute of Applied Physics & Computational Mathematics

Organizer: Tiegang, Liu  
Beihang Univ.

Organizer: Sussman, Mark  
Florida State Univ.

Organizer: Wang, Shuanghu  
IAPCM

Abstract: Compressible multi-phase flows appear in many natural phenomena, and are very important in many applications, including space science, aerospace engineering, energy, homeland security, etc. Numerical calculation is a key for understanding many related problems. More and more numerical methods are being developed and improved. In this mini-symposium, novel numerical methods will be presented to show the progress in the area of compressible multi-phase flows, including interface capturing/tracking methods, phase change calculations, mixing methods, fluid-structure interaction
methods, multi-physics calculations, adaptive mesh refinement, and high performance computing.

**MS-We-E-47-1 16:00–16:30**

**RKDG Methods with Cut Cell for Compressible Multi-phase Flows: Full Navier-Stokes Equations**

Li, Maojun  
Chongqing Univ.  
Deng, Xiaolong  
Beijing Computational Sci. Research Center

**Abstract:** Following our earlier works with Euler equations, full Navier-Stokes equations are realized in the cut-cell based RKDG method to simulate compressible multi-phase flows, by including viscosity and conductivity effects. In this method, material interface is represented by cut faces and evolved with the help of Level Set function. Sharp interface makes it more naturally to satisfy all the jump conditions, including normal and tangential shear forces and heat balance, and DG makes it more accurate.

**MS-We-E-47-2 16:30–17:00**

**The Bubble Dynamics Near A Solid Boundary in A Compressible Fluid**

Shiping, Wang  
Harbin Engineering Univ.  
Xi, Ye  
Harbin Engineering Univ.  
Zhang, Aman  
Harbin Engineering Univ.

**Abstract:** Currently the BEM model ignores the compressibility of the fluid which assumes that the fluid particle velocity is much smaller than sound velocity. But a bubble’s jet velocity would reach over 100 m/s. The fluid compressibility should not be ignored. Recently, we have extended this model which considers the weak compressibility of the fluid solving linear wave equation. Finally, this numerical model is used to analyze the 3D bubble motion under acoustic travelling waves.

**MS-We-E-47-3 17:00–17:30**

**Exact Solutions to Riemann Problems of Gas-water-solid-vacuum Systems and Constructions of Numerical Algorithms**

Tang, Hansong  
City College, City Univ. of New York, Changsha, Hunan  
Sci. of & Techn.

**Abstract:** A review will be given on exact solutions of Riemann problems we obtained for flows of gas, water, solid, and vacuum systems (JCP 1996; 1999). Then, the solutions are employed to develop MUSCL-type schemes for flows of gas-water-solid systems associated with cavitation and rupture and deal with grid interfaces in domain decomposition methods for gaseous flows. Finally, discussion on relevant work and outlook for further development in this direction will be given.

**MS-We-E-47-4 17:30–18:00**

**A Multi-Material ALE Method for Compressible Rayleigh-Taylor Instabilities**

Tian, Baolin  
Institute of Applied Physics & Computational Mathematics

**Abstract:** Rayleigh-Taylor Instabilities can be found in a variety of science areas and practical applications, such as astrophysics and ICF. In this work, a Multi-Material ALE(Alternative Lagrangian-Eulerian) method coupled with five-equation model is proposed based on a novel closure model for multifluid mixed cells. With the proposed methods and code, compressible Rayleigh-Taylor Instabilities were simulated, and the effects of different Atwood numbers and acceleration history were studied.

**MS-We-E-48 16:00–18:00**

**Structural analysis and collective dynamics on complex networking systems**

Organizer: Chengyi, Xia  
Tianjin Univ. of Tech.  
Organizer: Zengqiang, Chen  
Nankai Univ.

**Abstract:** In the past years, network science has successfully characterized the interactions among the components of a great number of real-world systems which include natural, social, biological, technological and engineering systems. Among them, the node represents the constituting components and link mimics the interaction between components. However, as real-world systems continuously evolve and novel data analysis or processing technologies emerge, it is necessary to further explore the structure of and collective dynamics taking upon complex networking systems. In this miniSymposia, we invite 4 speakers to talk about the collective dynamics of multi-agent’s systems, the analysis and optimization of interdependent networks, global dispersal of emerging infectious diseases all over the world, and application of complex network theory into the detection and identification of industrial multiphase flow. The current symposia will contribute to deeply understanding the structure and dynamical evolution of realistic networking systems.

**MS-We-E-48-1 16:00–16:30**

**Consensus of Heterogeneous Multi-agent Networks with Singular Dynamic Systems**

Zengqiang, Chen  
Nankai Univ.

**Abstract:** In this paper, consensus of singular multi-agent systems with heterogeneous dynamics is investigated. The definition of quasi-homogeneous singular first-order multi-agent systems is introduced via the coordinate transformation. Necessary and sufficient condition on consensus ability is given between the heterogeneous system and quasi-homogeneous system. Then the consensus problem of singular multi-agent system is discussed when the communication topology is fixed and directed. Under some assumptions, a sufficient condition of consensus for the singular multi-agent system is presented.

**MS-We-E-48-2 16:30–17:00**

**Complex Network from Multivariate Time Series for Characterizing Experimental Two-phase Flow**

Gao, Zhong-Ke  
Tianjin Univ.

**Abstract:** We design a new multi-sector conductance sensor and measure multivariate signals from gas-liquid/oil-water two-phase flow experiments. Then, we propose two novel methods to derive multiscale complex network and multi-frequency complex network from multivariate time series. The results indicate the analysis of multiscale complex network recovers deeper insights into the dynamic behavior governing the transitions of gas-liquid flow patterns, and the community structures of multi-frequency complex network allows uncovering the complicated oil-water flow structures.

**MS-We-E-48-3 17:00–17:30**

**Interdependent Networks: Modeling, Vulnerability Analysis and Optimization**

Sun, Shiwen  
Tianjin Univ. of Tech.

**Abstract:** Attack vulnerability of isolated and interdependent networks has been investigated extensively. Optimized networks with onion structure have improved robustness to resist malicious attacks. In our study, we investigate two important dynamical properties: synchronization behavior and structural controllability of optimized onion networks. Then, a new interdependent system composed of two optimized networks is proposed. The effect of different coupling patterns (such as random, assortative, disassortative) is analyzed.

**MS-We-E-48-4 17:30–18:00**

**The Dynamics Underlying Global Spread of Emerging Infectious Diseases**

WANG, Lin  
The Univ. of Hong Kong

**Abstract:** Understanding the dynamics underlying global transmission of emerging infectious diseases via international mobility is evidently pivotal in infectious disease epidemiology as seen in past pandemics as well as the ongoing spread of Ebola and from West Africa via air travel. Here we use the global epidemic model to establish a theory, explicitly characterising how global spread of EIDs depends on the mobility network and local epidemic factors.

**MS-We-E-50 16:00–18:00**

**Synchronization of complex networks and multi-agent systems**

Organizer: Huang, Chi  
Taiyuan Univ. of Tech.  
Organizer: Qingying, Miao  
Shanghai jiao tong Univ.  
Organizer: Tang, Yang  
East China Univ. of Sci. & Tech.

**Abstract:** Complex networks and multi-agent systems have, in recent years, brought many innovative impacts to large-scale systems. However, great challenges also come forth due to distinct complex situations and imperative requirements in human life nowadays. This session attempts to present recent progress of synchronization of complex dynamical networks and multi-agent systems. We focus on synchronization of multiplex networks, synchronization of networks with random event-sampling scheme, leader-following consensus of multi-agent systems and consensus of switched system multi-agent systems.

**MS-We-E-50-1 16:16–16:30**

**Leader-following Consensus of Nonlinear Multi-agent Systems with Mixed Delays and Uncertain Parameters via Adaptive Pinning Intermittent Control**

Hongjie, Li  
zhejiang Univ.

**Abstract:** The paper investigates leader-following consensus problem of multi-agent systems with delayed nonlinear dynamics and uncertain parameters, where only a small fraction of followers can sense the leader’s information on a sequence of disconnected time intervals. A novel distributed adaptive pinning intermittent control protocol is proposed based only on local information of the network structure, and some novel criteria are derived. Finally, a numerical example is provided to demonstrate the effectiveness of the obtained theoretical results.

**MS-We-E-50-2 16:30–17:00**

**A Unified Switched System Approach to Consensus Control of Multi-Agent Systems and Constructions of Numerical Algorithms**

Tianjin Univ. of Tech.  
Tianjin Univ.
that for users who just enter the system their tastes are increasingly diverse.

Evolution Properties of Online User Preference

utation from social networks to bipartite networks. The experimental results extend the method adopting the beta probability distribution to model the rep-

Results show that for movies and reviews, the correlation between the user rating and the object quality presents specific pattern in the given system, which suggests that users would rapidly develop their different preference for different objects.

MS-We-E-51-4 17:30–18:00 Locating Influential Nodes via Dynamics-sensitive Centrality Lin, Jianhong Univ. of Shanghai for Sci. & Tech.

Abstract: In this paper, we present a dynamics sensitivity (DS) centrality that integrates topological features and dynamical properties. The DS centrality can be directly applied in locating influential spreaders. According to the sim-

ulation results on four real networks for both susceptible-infected-recovered (SIR) and susceptible-infected (SI) spreading models, the DS centrality is more accurate than degree, k-shell index and eigenvector centrality.

MS-We-E-52 16:00–18:00

Topological identification of complex networks

Organizer: Xiaojun, Wu Wuhann Univ.

Abstract: Network topology plays a crucial role in determining a network’s intrinsic dynamics and function, thus understanding and modeling the topol-

ogy of a complex network will lead to greater knowledge of its evolutionary mechanisms and to a better understanding of its behaviors. In the past few years, topology identification of complex networks has received increasing in-

terest and wide attention. Many approaches have been developed for this purpose, including adaptive control based identification, information-theoretic methods, and intelligent optimization algorithms. We hope to have more re-

searchers or engineers to present and discuss the latest development on this topic, which could provide more convenient approaches to recovering network topology and reduce application costs.

MS-We-E-52-1 16:00–16:30

Collective Behaviours Through Social Interactions in Bird Flocks

Wang, Xiong Chinese Acad. of Science
Mao, Yuanyuan Chinese Acad. of Science
Lu, Jinhu Acad. of Mathematics & Sys. Sci., Chinese Acad. of Science

Abstract: Collective behaviours of multi-agent systems(MAS) often exhibit through social interactions among their agents. We concentrate on several models of collective behaviours in bird flocks, a representative MAS. This article is aimed at providing a discussion of the various facets of this interdisciplinary field, including simulation models, mathematical methods and control theory. The purposes are to offer readers a better understanding of complex systems and to promote this emerging topic on MAS.

MS-We-E-52-2 16:30–17:00

Interpreting Topologies via Driving-Based Generalized Synchronization of Two-Layer Networks

Xiaojun, Wu Wuhann Univ.

Abstract: In this presentation, we will report topology identification of complex dynamical networks with coupling delay via generalized synchronization of a two-layer network. Particularly, based on the LaSalle-type invariance princi-

ple, an adaptive control technique is proposed to infer the underlying network topology by constructing an auxiliary layer and designing proper control input and updating laws. The method is also applicable to infer topology of a sub-

network embedded within a large-scale network and locate hidden sources.

MS-We-E-52-3 17:00–17:30

Structural Reduction for Controlling Complex Networks

Wang, Wen-Xu Beijing Normal Univ.

Abstract: By implementing 1st- and 2nd-order structural reduction, we pre-

serve a minimum set of driver nodes for achieving full control of any networks. The framework has advantages compared to recently developed approaches. Applying our tools to complex networks yields several interesting results, in-

cluding a phase transition at natural logarithm when carrying out the 1st-order structural reduction and two phase transitions in node classification. We also offered analytical predictions of all the results based on network theory.

MS-We-E-53 16:00–18:00

Mathematical analysis of algorithmic trading and limit order markets

Organizer: Ludkovski, Mike UC Santa Barbara
Organizer: Leung, Tim Columbia Univ.
Organizer: Gao, Xuelong The Chinese Univ. of Hong Kong

Abstract: The availability of high frequency financial data opens up new are-

nas for the application of continuous time stochastic modeling and introduces new problems. Modeling: How should limit order book data be incorporated in tick-by-tick modeling? Information: How do agents process and act up-
on this vast information set? Trading: How can algorithmic trading strategies take advantage of this knowledge? Mathematics: How to construct limiting scales of microstructure models to obtain a macroscopic description of price dynamics? This mini symposium will address several of these interesting issues bringing together expertise in applied mathematics, operations research and statistics.

**Hydrodynamic Limit of Order Book Dynamics**

**Gao, Xuefeng**

The Chinese Univ. of Hong Kong

Abstract: We investigate the dynamics of the limit order book shape on the "macroscopic" time scale, motivated by study of price impact and optimal execution. We develop a fluid approximation for the sample path behavior of order book shape in certain asymptotic regime. Our main result states that a pair of measure-valued processes, representing the sell-side shape and buy-side shape of the order book, converges to a pair of deterministic measure-valued processes in a certain sense.

**Stochastic Model for Spread-price Dynamics in Order-driven Markets**

**Chen, Xinyun**

State Univ. of New York at Stony Brook

Abstract: We construct and study a continuous time model that incorporates the whole limit order book to inform the joint evolution of the spread and the price processes. The construction of our model is guided by empirical data. In particular, empirical observations suggest a multi-scale asymptotic regime, under which we obtain a jump-diffusion processes governing the evolution of the spread-price dynamics. The simulation results reproduce stylized features observed empirically.

**Optimal Exposure Problem in Limit Order Book**

**Lin, Donghua**

Management Department of Shanghai Open Univ.

Abstract: With the continuous development of economic globalization and regionalization, urban agglomeration, whose economic efficiency directly affects the competitiveness of a country, has become a basic regional unit of a country’s participating in the global competition and international division of labor. This paper, under the background of new industrialization, conducts an empirical analysis of China’s 13 major urban agglomerations’ economic efficiency in the years 2008-2012 by applying DEA method and related panel data. The research shows that from the dynamic aspect, the comprehensive economic efficiency of China’s urban agglomerations has been fluctuating over the past five years, with their gaps widening further. From the regional aspect, eastern urban agglomerations are generally better at integrated management and resource allocation and utilization, followed by those in central and then western areas. But central urban agglomerations are almost at the same level as eastern regions in terms of scale agglomeration effects, while the western regions are still backward. Further study shows that there is a weak positive correlation between scale efficiency and urban agglomeration scale. Therefore, to improve the scale efficiency of China’s urban agglomerations, we should take the new industry as a starting point and focus on the inner cluster aggregation effect, but not others like denotive development. From the urban agglomeration aspect, the following three agglomerations, namely the Yangtze River Delta, the Pearl River Delta, and the Ordos regions, are in the efficient frontier, but most other urban agglomerations’ economic efficiency is far from validity. The invalid economic efficiency of those agglomerations, represented by Beijing, Tianjin and Hebei, is mainly caused by invalid pure technical efficiency. Therefore, to further improve the regional economy centered on urban agglomeration, we should first effectively enhance the ability of resource allocation and utilization and scale aggregation by perfecting the management system of urban agglomeration. Then is the key to upgrade the economic efficiency of China’s urban agglomerations.
Abstract: This minisymposium intends to bring together new progresses in different aspects of model order reduction (MOR): methods, algorithms and applications. The topics include various MOR methods: interpolatory method, reduced basis method, POD, for various complex systems: linear, nonlinear, parametric, and for various applications: flow control, population balance system, neutral delayed system, chromotography, uncertainty quantification, electromagnetics, vibro-acoustics systems, coupled systems. The speakers are quite international and have senior research experiences in MOR.

MS-We-E-55-1 16:00–16:30
Parameterized Model Order Reduction of Delayed Systems by Means of An Enhanced Interpolation Approach with Scaling Coefficients
Ferranti, Francesco
Vrije Universiteit Brussel
Abstract: High-speed systems require electromagnetic methods as analysis and design tools, which often generate large systems of equations. When the frequency content of signals increases or the geometrical dimensions become electrically large, time delays must be taken into account. In this talk, a parameterized model order reduction method for neutral delay differential equations is presented. It is based on the use of a model order reduction technique, amplitude and frequency scaling coefficients and positive interpolation schemes.

MS-We-E-55-2 16:30–17:00
A New Error Bound for Parametrized Nonlinear Dynamical Systems
Feng, LiHong
Max Planck Inst. for Dynamics of Complex Technical Sys.
Zhang, Yongsin
Max Planck Inst. for Dynamics of Complex Technical Sys.
Benner, Peter
Max Planck Inst. for Dynamics of Complex Technical Sys.
Abstract: In this work we propose an efficient output error bound for reduced-order modeling of parametrized nonlinear dynamical systems. The error bound estimates the error of the output of the reduced-order model at each time integration step. It is an error bound in time domain, and is applicable to both linear and nonlinear systems. Based on a primal-dual approach, the error bound is shown to be much sharper than the existing error estimations.

MS-We-E-55-3 17:00–17:30
Application of POD to Population Balance Systems in Chemical Engineering
Mangold, Michael
Max Planck Inst. for Dynamics of Complex Technical Sys.
Abstract: Particle systems are important in the chemical industry. Particle processes are often described by population balance models containing partial integro differential equations in time, space, and additional property coordinates like particle size or composition. The numerical solution of such models is expensive and time consuming and hence hardly applicable to process design and control. This contributions shows that POD is an attractive method for obtaining nonlinear reduced models. Examples from crystallization and granulation are discussed.

MS-We-E-55-4 17:30–18:00
Using Krylov-type Parametric Model Reduction to Accelerate Uncertainty Quantification of Electro-Thermal Circuit Models
Yue, Yao
MPI-Magdeburg
Feng, LiHong
Max Planck Inst. for Dynamics of Complex Technical Sys.
Meurs, Peter
MAGWEL NV
Schoenmaker, Wim
MAGWEL NV
Bennet, Peter
Max Planck Inst. for Dynamics of Complex Technical Sys.
Abstract: Uncertainty quantification for high-order electro-thermal models of power-MOS devices is computationally expensive. To reduce the computational cost, we employ a Krylov-type parametric model reduction method, which builds a reduced model of high accuracy for parameter values within a certain range. We embed the reduced model into a Latin hypercube sampling method and a stochastic collocation method for uncertainty quantification. Numerical results validate the efficiency and high accuracy of the proposed method.
worked unmanned aerial crop-dusters. The pest spreading is considered as an anomalous diffusion process governed by a partial differential equation with both spatial and temporal fractional orders. The control objective is to optimize administer the networked unmanned aircraft crop-dusters for pest control. Numerical simulation studies are presented when the spatial fractional order dynamics is anisotropic.

**MS-We-E-56-5** 18:00–18:30

**Second-order Approximations for Variable Order Fractional Derivatives: Algorithms and Applications**

Zhao, Xuan  
Sun, Zhi-zhong  
Karniadakis, George  
Brown Univ.

Abstract: We derive two second-order approximation formulas for the fractional time derivatives involved in anomalous diffusion and wave propagation. Simulations of wave propagation in a truncated domain to demonstrate how erroneous wave reflections at the boundaries can be eliminated by super-diffusion, and also simulations of the Burgers equation that serve as a testbed for studying the loss and recovery of monotonicity using again variable rate diffusion as a function of space and/or time.

**MS-We-E-57** 16:00–18:00 402A

Advances in Numerical Methods for Porous Media Flow - Part IV of IV

For Part 1, see MS-Tu-D-57  
For Part 2, see MS-Tu-E-57  
For Part 3, see MS-We-D-57

Organizer: Wang, Hong  
Univ. of South Carolina  
Organizer: Sun, Shuyu  
King Abdullah Univ. of Sci. & Tech.  
Organizer: Rui, Hongxing  
Department of Mathematics, Shandong Univ.

Abstract: Porous media flow has wide applications in many areas, including environmental, energy, biological and engineering applications. They lead to strongly coupled transport processes also with nonlinear chemical reactions, which are computationally challenging, for it demands high accuracy and local mass conservation. Porous media manifest dramatically differently at different spatial and temporal scales. Heterogeneity, anisotropy, and discontinuity of medium properties require special treatment. The aim of this minisymposium is to bring together researchers in the aforementioned field to highlight the current developments, to exchange the latest research ideas, and to promote further collaborations in the community.

**MS-We-E-57-1** 16:00–16:30

Mathematical Modeling and Simulation for PPG Flooding in Oil Recovery

CHENG, Aijie  
Shandong Univ.

Abstract: In this talk, we first introduce the mechanism of PPG (Pre-formed Particle Gel) flooding in oil recovery, then the transport behavior of PPG, the evolution of the physical properties of underground fluids and oil-water two-phase flow in porous media are governed with a system of PDEs. Some numerical results are presented in comparison with laboratory experiments and field data.

**MS-We-E-57-2** 16:30–17:00

A probabilistic collocation Eulerian - Lagrangian localized adjoint method on sparse grids for assessing CO2 leakage through wells in randomly heterogeneous porous media

Ren, Yongqiang  
School of Mathematics, Shandong Univ.  
Wang, Hong  
Univ. of South Carolina

Abstract: We develop a probabilistic collocation Eulerian - Lagrangian localized adjoint method on sparse grids for assessing CO2 leakage through wells in randomly heterogeneous porous media, by utilizing the intrinsic mathematical, numerical, and physical properties of the mathematical model. We model the process in which CO2 is injected into a deep aquifer, spreads within the aquifer and, upon reaching a leaky well, rises up to a shallow aquifer, to quantify the leakage rate, which depends on the pressure build-up in the aquifer due to injection and the buoyancy of CO2. The underlying Eulerian - Lagrangian framework has high potential to improve the efficiency and accuracy for the numerical simulation of complex flow and transport processes in CO2 sequestration. The sparse grid probabilistic collocation framework adds computationally efficient uncertainty quantification functionality onto pre-existing Eulerian - Lagrangian methods in a noninvasive manner. It also provides a scalable framework to consider uncertainty in a straightforward parallel manner. Preliminary numerical experiments show the feasibility and potential of the method.

**CP-We-E-57-3** 17:00–17:20

Shock Propagation Through Inhomogeneous Media with Smoothed Particle Hydrodynamics

Koren, Barry  
Van Der Linden, Bas  
Zisis, Iason  
Eindhoven Univ. of Tech.

Abstract: Hypervelocity impacts of space debris onto orbiting spacecraft are typically simulated through the Smoothed Particle Hydrodynamics (SPH) method. Hypervelocity impacts are shock-propagation problems, which involve complex computational challenges due to compressibility and the presence of shock waves at hypersonic speeds. In this talk, we will present an SPH formulation that includes a new advection method for shock waves, which is based on the Runge-Kutta method. The method is designed to accurately capture the shock fronts and to handle the complex fluid dynamics of hypervelocity impacts.

**CP-We-E-57-4** 17:20–17:40

THERMAL CONVECTION OF MAGNETO COMPRESSIBLE COUPLE-STRESS FLUID SATURATED IN A POROUS MEDIUM WITH HALL CURRENT

Mehta, Chander  
Govt College Sanjauli Distt Shimla (H.P)-171006, India

Abstract: An investigation is made on the effect of Hall currents on thermal instability of a compressible couple-stress fluid in the presence of horizontal magnetic field saturated in a porous medium is considered. The analysis is carried out within the framework of linear stability theory and normal mode technique. A dispersion relation governing the effects of viscoelasticity, Hall currents, compressibility, magnetic field and porous medium is derived.

**MS-We-E-58** 16:00–18:30 401

Numerical Methods for Multi-physics Problems - Part III of III

For Part 1, see MS-Tu-E-58  
For Part 2, see MS-We-D-58

Organizer: Bazilevs, Yuri  
Univ. of California, San Diego  
Organizer: Xu, Jinchao  
PKU, and The Pennsylvania State Univ.  
Organizer: Zhang, Shuo  
Inst. of Computational Mathematics, Chinese Acad. of Sci.

Abstract: Most systems targeted by mathematical modeling in modern science and engineering are multi-physical and multi-scale. These models involve complex coupled nonlinear systems of PDEs built from different physical processes at different scales. Developing robust, efficient, and practical numerical algorithms that can tackle these complex models is one central task of modern computational sciences and also a challenging one. This minisymposium will gather together experts from around the world in the related fields in industrial and applied mathematics to exchange ideas regarding the development of robust and efficient numerical schemes that preserve the key physics of these models, and to study the development of fast and efficient linear and nonlinear solvers that are scalable and optimal.

**MS-We-E-58-1** 16:00–16:30

A Fictitious Domain Method with A Hybrid Cell Model for Simulating Motion of Cells in Fluid Flow

Hao, Wenrui  
Ohio State Univ.

Abstract: This talk will deliver a hybrid model to represent membranes of biological cells and use the distributed-Lagrange-multiplier/fictitious-domain formulation for simulating the fluid/cell interactions. The hybrid model representing the cellular structure consists of a continuum representation of the lipid bilayer, from which elastic forces are calculated through energetic variational approach, a discrete cytoskeleton model representing network filament, and area/volume constraints. Numerical results show that our method is suited to the simulation of the cell motion.

**MS-We-E-58-2** 16:30–17:00

Structure-Preserving and Energy Stable Finite Element Methods for MHD Systems

Hu, Kaibo  
Ma, Yicong  
Peking Univ.  
Penn State Univ.
Materials are characterized by only two nonzero eigenvalues of the Hooke tensor. This study concerns optimal distribution of two materials and void in a two-dimensional load-bearing structure. The goal is to minimize the weighted sum of structural compliance (work of the load) and area occupied by materials (total cost of the structure). Mathematically, the task involves determination of a divergence-free second-order symmetric tensor field minimizing the functional whose argument is a quasiconvex envelope of a multwell Lagrangian representing structural stress energy density plus cost of material fraction.

**Optimal Design of Three-phase Elastic Structures**

**Structures of Optimal Multimaterial Composites**

The paper concerns optimal design of anisotropy of elastic continua for the structure-preserving discretization of the incompressible MHD system. We study preconditioners for both MinRes and GMRes methods, and prove the uniform convergence in both cases. We also present preliminary numerical results to support the theoretical conclusions and demonstrate the robustness of the proposed preconditioners.

**The Hemodynamic Simulation for Cardiovascular Disease**

**Solving the Two-dimensional Navier-Stokes Cahn-Hilliard System Using Divergence-conforming Spaces**

**Optimal Design of Inhomogeneous Anisotropic Materials and the Shape Forming Methods - Part I of II**

**Free Material Design in the Stress-based Setting**

**Robust Compliance Optimal Design for Viscoelastic Composites**

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**Optimal Design of Inhomogeneous Anisotropic Materials and the Shape Forming Methods - Part I of II**

**Free Material Design in the Stress-based Setting**
Chen, Shuxing  
Fudan University

Abstract: Abstract: When a supersonic flow passes a given body, there will appear a shock ahead of the body generally. To clearly understand the wave structure, as well as the flow field between the shock and the surface of the body is a fundamental problem in gas dynamics. In this lecture I will introduce the history and the recent progress of the mathematical study on Fluid-Structure Interaction Problems

CP-We-E-61-3  
16:40–17:00

Group Similarity for Image Segmentation

Xu, Haiping  
Fuzhou Univ.

Wang, Jingyue  
Fuzhu Univ.

Wang, Meiqing  
Fuzhu Univ.

Abstract: We propose to use the group similarity of object shapes from a series of similar images as a prior to aid variational segmentation models. We show that the rank of the matrix consisting of multiple shapes is a good measure for the group similarity of the shapes. We also develop a fast algorithm to solve the proposed model.

CP-We-E-61-4  
17:00–17:20

A Numerical Comparison of Some Multiscale Finite Element Type Approaches for Convection-dominated Problems in Heterogeneous Media

Madiot, Francois  
Univ. Paris Est

Abstract: Advection-diffusion equations arise in many engineering applications, including e.g. pollutants transport into a flow. In various applications, convection dominates over the diffusion. In that regime, standard numerical approaches loose their accuracy, and stabilized methods are required. In this work, we consider the case when the problem is multiscale, in addition to being convection-dominated. Groundwater pollution through infiltration of a fluid in a porous medium is one example. MsFEM-type approaches are thus in order to cope with the multiscale nature of the problem. The objective of this work is to understand how to adapt the stabilized methods and the MsFEM-like multiscale methods to efficiently solve multiscale advection-diffusion problems in the convection-dominated regime. We will describe different possibilities to simultaneously treat both difficulties. The proposed methods will be compared in terms of accuracy and cost. This is a joint work with C. Le Bris and F. Legoll.

CP-We-E-61-5  
17:20–17:40

Drawing of Microstructured Optical Fibres with Elliptical Channels

Buchak, Peter  
Imperial College London

Crowdy, Darren  
Imperial College London

Stokes, Yvonne  
The Univ. of Adelaide

Chen, Michael  
Univ. of Adelaide

Ebenbrod-Heidepriem, Heike  
Univ. of Adelaide

Abstract: Microstructured optical fibres (MOFs) derive novel optical capabilities from having a large number of channels running along their length. They are fabricated by drawing a molten glass preform at low Reynolds number, during which the cross section deforms under surface tension, with the result that the configuration of the channels in the fibre may differ from the preform. This unintended deformation is inadequately understood and is difficult to investigate experimentally, necessitating extensive trial and error. In this talk, we describe a model we have developed to predict the deformation for MOFs with elliptical channels. Our model circumvents the need for expensive computational methods. More importantly, it can be used to determine the preform configuration required to produce a fibre with a desired arrangement of channels. We show comparisons with numerics and experiment and describe software tools we have developed that can be used by fabricators to design preforms.

CP-We-E-61-6  
17:40–18:00

Drawing of Microstructured Optical Fibres with Pressurisation of the Internal Channels

Chen, Michael  
Univ. of Adelaide

Stokes, Yvonne  
The Univ. of Adelaide

Buchak, Peter  
Imperial College London

Crowdy, Darren  
Imperial College London

Ebenbrod-Heidepriem, Heike  
Univ. of Adelaide

Abstract: Microstructured optical fibres are distinguished from solid optical fibres by the large number of internal air channels running along their length. These fibres are manufactured by heating and stretching a preform, which has some cross-sectional pattern of holes. In stretching the preform with a diameter of 1-3cm to a fibre with a diameter of the order of 100 micrometers, the cross-sectional hole pattern changes in scale but is also deformed due to surface tension. A practical way of countering this deformation is to introduce pressurisation in the internal channels. This pressure acts against surface tension and potentially provides an extra degree of control over the shape of the internal channel geometry. We generalise an existing model of fibre drawing to include channel pressurisation and present examples of pressurised fibre drawing for several cross-sectional geometries of practical importance,
including a comparison between our model and the results of some recent experiments.

CP-We-E-62 16:00–18:20 102

**Fluids**

**Chair:** Gupta, Neelam  
Indian Inst. of Tech. Bombay

**Abstract:**

Dissipative Waves with Mixed Nonlinearity in Real Fluids

Gupta, Neelam  
Indian Inst. of Tech. Bombay

Sharma, Vishnu Dutt  
IIT Bombay

Abstract: We exploit weakly nonlinear theory and the method of multiple scales to arrive at an evolution equation that governs the wave amplitude in a two-dimensional dissipative flow of a real gas; the evolution equation exhibits quadratic as well as cubic nonlinearity. The real fluid effects are characterized by a van der Waals type equation of state. Some basic features of the Kholikov-Zabolotskaya-Kuznetsov equation and the nature of the flow pattern (influenced by the real gas effects) that finally evolve are elucidated.

CP-We-E-62-2 16:20–16:40

Electro-osmotic Flow and Heat Transfer in Microchannels with Interfacial Slip

Shit, Gopal Chandra  
Jadavpur Univ., Kolkata

Abstract: In this paper we have investigated the two layer \#64258;uid \&#64258;ow and heat transfer in a microchannel. The fluid is flowing under combined \&#64258;uid pressure gradient and electro-osmotic force. The velocity slip condition at the channel wall as well as in the interfacial region of two layer \#64258;uid has been taken into account. The governing equations consisting with the linearized Poisson Boltzmann equation, the Cauchy momentum equation and thermal energy equation are solved analytically within the framework of the Debye-Hückel approximation. The medium is assumed to be under a gravitational field due to heavy nucleus at the origin (Roche Model). The effects of the variation of the gravitational parameter, non-idealness of the gas gravitational field. Based on the numerical computations of temperature, density of solid particles to the initial density of the gas on the flow variables and the mass concentration of solid particles in the mixture and the ratio of the effects of the variation of density of the fluid along the horizontal and vertical lines through geometric center of the rectangular domain have been studied. The transience of temperature and concentration indicate that, the transient flow though dominates initially, it finally settles down to steady state solutions after elapse of some time. Based on the numerical computations of temperature, concentration, Nusselt and Schmidt numbers, we found that the heat and mass transfer for different fluids increased towards left side of the domain.

CP-We-E-62-4 17:00–17:20

NUMERICAL STUDY OF TRANSIENT 2-D COMPRESSIBLE FLOW WITH HEAT AND MASS TRANSFER USING THE FINITE VOLUME METHOD

Vusala, Ambethkar  
Univ. of Delhi

Srivastava, Mohit  
Univ. of Delhi

Abstract: In this paper, we used a finite volume method to investigate the problem of transient 2-D compressible flow, with heat and mass transfer in a rectangular domain. We have used this method to solve the governing equations with given initial and wall slip boundary conditions. We implemented the SIMPLE-TS algorithm in order to compute the numerical solutions for the flow variables viz. velocity, pressure, temperature, concentration and density. The variation of density of the fluid along the horizontal and vertical lines through geometric center of the rectangular domain has been studied. The transient solutions of temperature and concentration indicate that, the transient flow though dominates initially, it finally settles down to steady state solutions after elapse of some time. Based on the numerical computations of temperature, concentration, Nusselt and Schmidt numbers, we found that the heat and mass transfer for different fluids increased towards left side of the domain.

CP-We-E-62-5 17:20–17:40

Scale Truncation in Large-eddy Simulation of Turbulent Flow by Regularization

Verstappen, Roel  
Johann Bernoulli Inst., Univ. of Groningen

Abstract: This paper is about a relaxation model for large-eddy simulation of turbulent flow that truncates the too small scales of motion by making sure that they do not get energy from the larger eddies. To verify that a box filter is introduced and the relaxation parameter is determined in such a way that the production of small, box-fitting scales is counteracted by the modeled dissipation. This dissipation-production balance is worked out with the help of Poincaré’s inequality, which results in a relaxation model that depends on the invariants of the velocity gradient. This model is discretized and equipped with a Schumann filter. It is successfully tested for isotropic turbulence as well as for turbulent channel flow.
Crouzeix-Raviart elements. The convergence of the iterative scheme is obtained by proving that the spectral radius of the matrix associated with the fixed point iterations is less than 1. We derive the upper bound of the rate of convergence which is of order $O(h^{1/2}H^{-1/2})$, where $h$ is the finite element mesh parameter, $H$ is the maximum diameter of the subdomains and $\Delta t$ is the time step. Finally the numerical experiments confirm the theoretical results.

**CP-We-E-63-3**

16:40–17:00

A Double Exponentially Convergent Method for Solving ODEs

Lu, Tzon-Tzer
National Sun Yat-sen Univ.

Abstract: The traditional numerical methods for differential equations, including finite difference, finite element, finite volume, boundary element and Runge-Kutta methods, all possess polynomial convergence. Modern methods like spectral method, radial basis, method of fundamental solution and Trefftz method, all have exponential convergence, and even super-geometric convergence in very special cases. In this talk, we present a Newton-like method in power series domain for ODEs. It has the speed of double-exponential convergence, which will be the fastest among all existing numerical ODE methods.

**CP-We-E-63-4**

17:00–17:20

Iterative Schemes Based on Hierarchical Tensor Representations: Rank and Complexity Estimates

Bachmayr, Markus
UPMC Paris 06

Abstract: A widespread approach for solving high-dimensional problems using low-rank tensor representations is to modify a conformal standard iterative method by a rank reduction in each step. It is then crucial to ensure convergence while maintaining control of the resulting growth of tensor ranks. We present fully adaptive algorithms that provably achieve this (joint work with Wolfgang Dahmen) and recent developments based on soft thresholding of hierarchical tensors (joint work with Reinhold Schneider).

**CP-We-E-63-5**

17:20–17:40

A New Bound on the Integration Error of An Enough Smooth Function by Quasi-Monte Carlo Integration and the Existence of Point Sets to Make the Bound Small

Yoshihki, Takehito
Univ.Tokyo

Abstract: Quasi-Monte Carlo integration is one of the methods for numerical integration. In this method, we approximate the value of a function $f(x)$ over the $s$-dimensional unit cube by the average of $f(x)$ over a finite point set $P$. The purpose of this study is to make the integration error small by choosing an appropriate point set $P$. To find such a point set, we make an investigation which bounds the integrand error small by the product of some norm $—f—$ and some positive value $W(P)$ called figure of merit of $P$. If we can find $P$ with small $W(P)$, we can make the integration error small by $P$ for $f$ with $—f—$ small. In this talk, we introduce a new technique to find the bound for the average of $f(x)$ and reduce the point set size. A new bound for the integration error is obtained by the approach for the finite point set $P$ with $W(P)$ small.

**CP-We-E-63-6**

17:40–18:00

Difference Potentials Method for 2-D Elliptic and Parabolic Interface Problems

Xia, Qing
Univ. of Utah

Albright, Jason
Univ. of Utah

Epshteyn, Yekaterina
Univ. of Utah

Abstract: The Difference Potentials Method (DPM) is a framework for developing efficient, high order accurate numerical methods for boundary value problems on arbitrary domains. In this talk I will introduce DPM-based schemes for numerical solutions of 2D elliptic and parabolic interface problems. Performance and flexibility of the resulting methods will be illustrated numerically and compared against Immersed Interface Method results.

**CP-We-E-63-7**

18:00–18:20

Numerical Analysis and Fast Solutions for Fully Discrete Schemes for Conservative Diffusion Problem

Cui, Xia
Inst. of Applied Physics & Computational Mathematics, Beijing, China

Yuan, Guang-wei
Inst. of Applied Physics & Computational Mathematics, Beijing, China

Yue, Jing-yan
Inst. of Applied Physics & Computational Mathematics, Beijing, China

Abstract: Theoretical analysis on nonlinear fully implicit finite difference schemes for nonlinear conservative diffusion problem is presented. Proper iterations are designed to realize fast solutions. Difficulties arising from nonlinear conservative diffusion operator are overcome. An entire characteristic theoretical analysis system is constructed which includes the existence, convergence, stability, uniqueness of the solutions of nonlinear discrete schemes, the convergence and convergent speed of iteration schemes, and the logical relations among them. Numerical tests show obvious acceleration effects.

**CP-We-E-64**

16:00–18:20

Simulation and Modeling

Chair: Shen, Zhengdi
Cornell Univ.

**CP-We-E-64-1**

16:00–16:20

Optimal Control of Piecewise-deterministic Processes

Shen, Zhengdi
Cornell Univ.

Vladimirs, Alexander
Cornell Univ.

Abstract: The fully deterministic optimal control leads to a first-order nonlinear Hamilton-Jacobi-Bellman (HJB) equation. The standard stochastic optimal control yields a second-order semilinear HJB PDE. Unfortunately, neither of the above is suitable for modeling discrete-time random perturbations important in many applications including robotics. In contrast, the “piecewise-deterministic” model leads to a system of weakly-couple first-order HJB PDEs. We discuss its use and computational challenges in robotic path planning. (This is joint work with A. Vladimirs.)

**CP-We-E-64-2**

16:20–16:40

Numerical Study of Pulsatile Flow in Stenosed Carotid Artery Biliruina

Singh, Sarita
WIT-Uttarachand Technical Univ., Dehradun India

Abstract: Real carotid arteries are elastic and perfused with a non-Newtonian fluid. The blood flow dynamics of a stenosed subject specific carotid bifurcation were numerically simulated using finite element method computationally. A coupling effect between elastic deformation of stenosed carotid artery wall and fluid. A flow rate at various location in stenosed carotid artery (CCA & ICA) for different different frequencies 0, 60, 90, 120 pulse/min with 600 Reynolds number by FLUENT.

**CP-We-E-64-3**

16:40–17:00

Modelling for Computational Cost Reduction and Optimisation of An Impinging Swirling Jet Created by A Rotating Pipe with Application to Heat Transfer From A Heated Solid Flat Plate

Granados-Ortiz, Francisco-Javier
Univ. of Greenwich

Casanova, Joaquin
Univ. of Malaga

Lai, Choi-Hong
Univ. of Greenwich

Abstract: Swirling flows in pipes are widely used in industry. In our case, this impinging jet is generated by a rotating pipe. For the heat transfer purpose, once the jet exits the pipe, it spreads until it impinges against a heated flat plate located at a dimensionless distance H/D from the exit pipe, where D is the diameter of the pipe and H is the distance. Both the axial and azimuthal velocity profile at the exit of the pipe are mathematically modelled. The model will include equations and coefficients that depends on the input factors, which will be also modelled. The two-step CFD process of the heat transfer simulation (swirl flow generation and heat transfer itself) can now be reduced to a single-step one by adding the modelled equations to a code in the CFD solver. The optimal configuration of the set-up for the heat transfer application will also be

**CP-We-E-64-4**

17:00–17:20

Mathematical Modeling and Simulations for Future Nonvolatile Memories

Grigoriu, Andreia
Univ. Paris Diderot, lab. Jacques Louis Lions

Abstract: The increasing use of portable electronic devices that require data storage implies a strong need in developing new types of memories. Conductive-Bridge Random-Access memory (CBRAM) is a promising technology for future nonvolatile memories, that are being developed to replace the popular flash memory. The complexity of physical phenomena that take place at a nanoscale require mathematical support besides the classical experimental approach. Present work proposes two types of models: deterministic and stochastic in order to analyse different properties of the electronic devices by the mean of numerical simulations. Analysis of existence of solutions together with the analysis of the stability of the numerical schemes used for simulations is being made.

**CP-We-E-64-5**

17:20–17:40

Multiscale Modeling for Continuum Mechanics of Lungs

Saini, Anju
Indian Inst. of Tech. Roorkee

Katyar, Y. K.
IIT Roorkee

Parida, Manoranjan
IIT Roorkee

Abstract: An isotropic constitutive model for the lung parenchyma has been derived from the theory of hypo-elasticity. The objective is to make use of it
to signify the mechanical reaction of this soft tissue in sophisticated, computational, fluid-dynamic models of the lung. This demands that the continuum model be accurate, however simple and well-organized. An intent algorithm for its numeric integration is presented. The response of the model is determined for several boundary-value problems whose experiments are used for material characterization. The effective elastic, bulk, and shear moduli, and Poisson’s ratio, as tangent functions, are also derived. It is assumed that, and beginning steps have been taken toward proving that the material parameters for this hypo-elastic model will correlate with the response of a micro-mechanics based model.

**Numerical Algorithm for Simulating Hyperbolic Conservation Laws.**

Garg, Naveen Kumar  
Indian Inst. of Sci.

Sussaram, Raghurama Rao, V.  
Indian Inst. of Sci.

Sekhar, Muddu  
Indian Inst. of Sci.

**Abstract:** A simple and accurate central scheme in finite volume framework is developed for systems of hyperbolic conservation laws, using a splitting of strongly hyperbolic and weakly hyperbolic parts. This leads to the flux function of 1D inviscid Euler compressible system being split into convection and pressure parts and 1D inviscid shallow water system into convection and celerity parts. The numerical diffusion is fixed based on flux equivalence principle, which leads to the satisfaction of the jump conditions. The numerical scheme is tested on various shock tube problems of gas dynamics for 1D Euler equations and on dam breaking problems for shallow water equations. Exact upwind schemes like Roe and Godunov violate entropy condition. Similarly, Schemes based on Convection-Pressure splitting like AUSM family of schemes violate entropy condition and give sonic glitch. Novelty of our scheme is that it can capture stationary discontinuities exactly without violating entropy condition.

**Numerical Methods for Multiscale Inverse Problems**

Frederick, Christina  
Georgia Inst. of Tech.

**Abstract:** We will consider inverse problems for partial differential equations with highly oscillatory coefficients. Determining the coefficients in the equation from given observational data involves both the general difficulty of finding an inverse and the challenge of multi-scale modeling, which is hard even for forward computations. The problem in its full generality is typically ill-posed and one common approach is to replace the original problem by inversion of an effective equation. We will here include multiscale features directly in the inverse problem and avoid ill-posedness by assuming that the multiscale can be accurately represented by a low-dimensional parametrization. The basis for our inversion will be a coupling of the parametrization to analytic homogenization or a coupling to efficient multiscale numerical methods when analytic homogenization is not available.

**Optimization and Operations Research**

Chair: Wei, Dongming  
Nazarbayev Univ.

**Abstract:**

**Modeling of Advanced Material Structures by Non-linear Differential Equations**

Wei, Dongming  
Nazarbayev Univ.

**Abstract:** In this talk, we present some nonlinear PDEs arising in modeling of structures made of advanced materials including graphene and polyanime. Analytic solutions of some spring-mass equations associated with the PDEs are presented in terms of generalized trigonometric functions. Analysis and numerical solutions of some of the models are also presented, including nonlinear eigenvalue problems and nonlinear wave equations. Open problems and challenges for modeling of structural nonlinear materials without a well-defined yield are discussed.

**Multiscale Modeling on Particle-laden Flows Inside Nanomaterials**

Chan, Yue  
Univ. of Nottingham Ningbo

**Abstract:** Molecule encapsulation is an important topic in modern technology. Nanomaterials have superior mechanical, electronic and thermal properties so as to provide vital medium to store molecules such as hydrogen, PM2.5 and carbon dioxide. In this talk, we will discuss a multiscale approach to investigate particle-laden flows inside these nanomaterials and derive the centerization evolution of such molecules under various flow fields, which could currently only be done by MD simulations involving huge computational times.

**Prediction of Rock Properties Based on X-ray Computed Tomography Images**

JOUNI, Soufiane  
Petroleum Inst. of Abu Dhabi

**Abstract:** We implement two new approaches to estimate rock properties by using 3D X-ray Computed Tomography scanner images. The first method is a stochastic approach where we model image textures by implementing a parametric model. The main objective is to obtain reliable continuous rock properties estimation values along cores. Also, we classify main representative textural facies in core samples to optimize core plug extraction. The second method is a deterministic approach where we combine image processing techniques and numerical simulations to predict rock properties. The first step consists on segmenting 3D high resolutions micro-Tomography images. Then, we estimate several properties like porosity, permeability and elasticity. We implement, numerical simulations techniques such as Lattice Boltzmann approach to simulate fluid flow and Finite Element Method to solve the elasticity equation on the digital image model of rocks. Finally, we compare estimation results with experimental measurements for real data using both approaches.
often is unknown in the sense that its motion back-couples to the lateral processes. Regarding the cell biological applications we consider the formation of adhesion patches in migrating cells.

**MS-We-E-66-3** 17:00–17:30  
**Mathematical Modelling of C. Elegans Locomotion**  
Ranner, Thomas  
Univ. of Leeds  
Abstract: The nematode Caenorhabditis elegans is a microscopic roundworm found in soil in many temperate regions. It is a popular model organism in many fields, including neuroscience, due to its relatively simple nervous system and anatomy. In this talk, I will present results from an new interdisciplinary approach for the modelling and simulation of the locomotion of C. elegans using geometric partial differential equations.

**MS-We-E-66-4** 17:30–18:00  
**Free Versus Fixed: Boundaries in Stokes Flow**  
Simons, Julie  
Tulane Univ.  
Abstract: Both rigid and free boundaries are important in the study of fluids in a variety of applications, including the behaviors of swimming microorganisms and cellular motility. We will discuss how elastic free boundaries interact with rigid boundaries and the implications for nearly planar swimmers such as sperm. We use the method of images for regularized Stokeslets and a 3D model for an immersed elastic boundary to explore swimming and navigation in complex, viscous environments.

**SL-We-1** 19:00–20:00  
**Special Lecture**  
Chair: Cook, L. Pamela  
Abstract:  
**SL-We-1** 19:00–20:00  
**Once upon a graph: How to get from now to then in massive networks**  
Chayes, Jennifer Tour  
Microsoft Research  
Abstract:
Thursday, August 13, 2015

EM-Th-BC-01-1 10:00–12:00 311A
Third Workshop on Hybrid Methodologies for Symbolic-Numeric Computation - Part VII of VIII
For Part 1, see EM-Mo-D-01
For Part 2, see EM-Mo-E-01
For Part 3, see EM-Tu-D-01
For Part 4, see EM-Tu-E-01
For Part 5, see EM-We-D-01
For Part 6, see EM-We-E-01
For Part 8, see EM-Th-D-01
Organizer: Giesbrecht, Mark
Univ. of Waterloo
Organizer: Kaltofen, Erich
North Carolina State Univ.
Organizer: Safey El Din, Mohab
Univ. Pierre & Marie Curie
Organizer: Zhi, Lihong
Acad. of Mathematics & Sys. Sci.
Abstract: Hybrid symbolic-numeric computation methods, which first appeared some twenty years ago, have gained considerable prominence. Algorithms have been developed that improve numeric robustness (e.g., in quadrature or solving ODE systems) using symbolic techniques prior to, or during, a numerical solution. Likewise, traditionally symbolic algorithms have seen speed improvements from adaptation of numeric methods (e.g., lattice reduction methods). There is also an emerging approach of characterizing, locating, and solving "interesting nearby problems", wherein one seeks an important event (for example a nontrivial factorization or other useful singularities), that in some measure is close to a given problem (one that might have only imprecisely specified data). Many novel techniques have been developed in these complementary areas, but there is a general belief that a deeper understanding and wider approach will foster future progress. The problems we are interested are driven by applications in computational physics (quadrature of singular integrals), dynamics (symplectic integrators), robotics (global solutions of direct and inverse problems near singular manifolds), control theory (stability of models), and the engineering of large-scale continuous and hybrid discrete-continuous dynamical systems. Emphasis will be given to validated and certified outputs via algebraic and exact techniques, error estimation, interval techniques and optimization strategies. Our workshop will follow up on the seminal SIAM-MSRI Workshop on Hybrid Methodologies for Symbolic-Numeric Computation held in November 2010 and the Fields Institute Workshop on Hybrid Methodologies for Symbolic-Numeric Computation, November 16-19, 2011 at the University of Waterloo. We will provide a forum for researchers on all sides of hybrid symbolic-numeric computation.

EM-Th-BC-01-2 11:00–11:30
Bertini 2.0 and BertiniLab: Software for Solving Polynomial Systems Numerically
Bates, Dan
Colorado State Univ.
Abstract: Bertini is a software package for solving polynomial systems with numerical and symbolic-numeric methods. Bertini has outgrown its original scope and has become quite difficult to maintain. In this talk, I will introduce some of the features of both Bertini 2.0 (the total redevelopment of Bertini in C++, with many contributors) and BertiniLab (a new interface to Bertini from Matlab, joint with A. Newell and M. Niemerg).

EM-Th-BC-01-3 11:30–12:00
Computing Mixed Volume and All Mixed Cells in Quermassintegral Time.
Malajovich, Gregorio
Universidade Federal do Rio de Janeiro
Abstract: The mixed volume counts the roots of generic sparse polynomial systems. Mixed cells are used to provide starting systems for homotopy algorithms that can find all those roots, and track no unnecessary path. Up to now, algorithms for that task were of enumerative type, with no general non-exponential complexity bound. A geometric algorithm is introduced in this paper. Its complexity is bounded in the average and probability-one settings in terms of certain quermassintegrals.

MS-Th-BC-02 10:30–12:00 309A
Special session 1 of Chinese Conference of Complex Networks (CCCN 2015)
Organizer: Li, Xiang
Fudan Univ.
Abstract: This session contributes as a part of CIAM 2015 from the Complex networks and system control TC, which involves two 1-hour speakers as the keynote lectures of CCCN 2015. Two invited speakers are the leading researchers in the involved fields: Prof. Guanrong Chen (City University of Hong Kong) and Prof. Xiaofan Wang (Shanghai Jiao Tong University). Prof. Guanrong CHEN is Chair Professor of CityU, IEEE Fellow, and Member of European Academician, ISI highly cited scientist. Prof. Xiaofan WANG is Changjiang Scholar and distinguished professor of SJTU and deputy dean of Zhiyuan College of SJTU. Prof. Chen and Wang will give their lectures to introduce the latest advances of complex network theory and network science in China and oversea.

MS-Th-BC-03 10:00–12:00 306A
Mathematics of Evolutionary Game Theory
Organizer: Golubitsky, Martin
The Ohio State Univ.
Organizer: Lou, Yuan
Ohio State & Renmin Univ
Abstract: Evolutionary game theory is the application of game theory to understanding biological and social systems; for example, the evolution of cooperation and animal behavior. The theory involves mathematical tools from game theory, graph theory, dynamical systems, ordinary differential equation(s), partial differential equations, computational mathematics, stochastic processes, and others. Evolutionary game theory has undergone rapid and exciting developments in the recent years. The aim of this minisymposium is to bring together researchers who are interested in the mathematics, modeling and analysis of evolution games, in order to to identify new challenges and applications, and to accelerate further developments in the field.

EM-Th-BC-01-1 10:00–11:00
Software and Applications for Polynomial Homotopy Continuation
Leykin, Anton
Georgia Tech
Abstract: Numerical homotopy continuation has become one of standard choices when looking for complex solutions of a system of polynomial equations. I will showcase the polynomial system solver embedded in the computer algebra system Macaulay2 using two applications requiring real solutions. One comes from minimal problems in computer vision, the other is of interest in optimization and concerns determinantal representations of hyperbolic polynomials.

MS-Th-BC-03-1 10:00–10:30
ESS in Spatial Model
Lou, Yuan
Ohio State & Renmin Univ
Abstract: From habitat degradation and climate change to spatial spread of invasive species, dispersal plays a central role in determining how organisms cope with a changing environment. How should organisms disperse "optimally" in heterogeneous environments? We will discuss some recent development on the evolution of dispersal, focusing on finding evolutionarily stable strategies (ESS) for dispersal. This talk is based mainly on joint works with Steve Cantrell, Chris Cosner, and King-Yeung Lam.

MS-Th-BC-03-2 10:30–11:00
Effects of Protected Areas on Harvesting of Renewable Resources
Krivan, Vlastimil
Univ. of South Bohemia
Abstract: The Gordon-Schaefer harvesting model predicts that as the protected area (e.g., marine area ) increases, population abundance increases while the maximum sustainable yield (MSY) decreases. This model assumes no dispersal between the harvested area and the protected area. In my talk I will discuss the effect of various animal dispersal modes on population abun-
dance and harvest yield when a protected area is created. The models use evolutionary game approaches to describe animal distributions.

**MS-TH-BC-03-3**

**The Reduction Principle, the Ideal Free Distribution, and the Evolution of Dispersal Strategies**

Cosner, Chris

Univ. of Miami

Abstract: For reaction-diffusion models and their nonlocal and discrete analogues in spatially varying environments the strategy of not dispersing at all is often convergence stable. This is related to a “reduction principle” that in general dispersal reduces growth rates. However, strategies that generate an ideal free population distribution at equilibrium (all individuals have equal fitness, with no net movement) are known to be evolutionarily stable in various cases. I will describe past results and current work.

**MS-TH-BC-03-4**

**Normal Forms and Unfoldings of Singular Strategy Functions**

Golutskis, Martin

The Ohio State Univ.

Abstract: Xiaohui Wang and I apply singularity theory to classify normal forms and universal unfoldings of the singular strategy functions from adaptive dynamics. Specifically, we study two-player single trait games and identify the most general changes of coordinates that preserve ESS singularities, CvSS singularities, and dimorphism pairs. These changes of coordinates are unusual — but rich enough to allow us to apply standard singularity theory type arguments to obtain our classification.

**MS-TH-BC-04**

**Curves and Surfaces in Computer Aided Geometric Design - Part I of III**

For Part 2, see MS-TH-D-04

For Part 3, see MS-TH-E-04

Organizer: Jia, Xiaohong

Chinese Acad. of Sci.

Organizer: Cheng, Jin-San

Chinese Acad. of Sci.

Abstract: The symposium is aimed at bridging between people who are working theoretically on curves and surfaces in algebraic geometry and those who are endeavoring to seek for suitable modeling forms of curves and surfaces in Computer Aided Geometric Design. Therefore, the symposium includes wide-ranging topics on curves and surfaces from classic theory aspects to their applications in modern industry. The forms of curves and surfaces consist of but are not limited to: algebraic curves and surfaces, parametric curves and surfaces including NURBS as well as triangular surface patches.

**MS-TH-BC-04-1**

**Strata of Rational Curve Parametrizations**

Cox, David

Amherst College

Abstract: Parametrizations of rational curves in projective space can be grouped into strata according to their mu-type. I will report on joint work with Anthony Iarrobino about some new and old results about these strata, including their dimensions and how they fit together. I will also explore which curves lie on rational normal scrolls.

**MS-TH-BC-04-2**

**Moving Curve Ideals of Rational Plane Parametrizations**

D’Andrea, Carlos

Univeritat de Barcelona

Abstract: In the nineties, several methods for dealing in a more efficient way with the implicitization of rational parametrizations were explored in the Computer Aided Geometric Design Community. The analysis of the validity of these techniques has lead to a fruitful interaction between mathematicians and engineers, and several results have been obtained so far. In this talk, we will survey some of these methods, show their mathematical formulation, and survey current results and open questions.

**MS-TH-BC-04-3**

**Constructions of Families of Algebraic Curves Whose Jacobians Have Special Endomorphisms.**

Hoffman, Jerome W.

Louisiana State Univ.

Abstract: Let X be a projective smooth algebraic curve. The Jacobian of X, Jac (X), is a principally polarized abelian variety. We will survey various constructions of curves X of genus 2 and 3 such that the endomorphism ring \( \text{End}(\text{Jac}(X)) \) is strictly larger than the ring of integers \( \mathbb{Z} \). This is a joint project with Dun Liang, Zhibin Liang, Ryotaro Okazaki, Yukiko Suzuki and Haohao Wang.

**MS-TH-BC-04-4**

**Implicitization of Rational Curves and Surfaces**

Wang, Haohao

Southeast MO State Univ.

Abstract: The idea of using a matrix formed by the moving planes or moving lines to obtain the implicit equations for rational curves or surfaces was initiat-
New Development in Numerical Algorithms for Geophysical Science and Engineering

Organizer: Castillo, Jose San Diego State Univ.
Organizer: Tang, Hansong City College, City Univ. of New York, Changsha Univ. of Sci. & Tech.

Abstract: While many classical geophysics problems remain challenging for numerical simulation, yet there is an urgent need to develop new algorithms for emerging phenomena such as oil spill in ocean, extreme surge impinging coastal structures, and oil exploration, which are multiscale and multiphysics in general. This mini-symposium reports recent progress in numerical methods for on coastal ocean flows, waves in plastic medium, seismic waves and concentration of H+ ions as a cause of tumor invasion. The session welcomes researchers from related areas and will provide a platform for them to exchange ideas on encountered difficulties, possible approaches, and future directions.

MS-Th-BC-06-1 10:00–10:30
An Overset-grid Method to Couple Fully 3D Fluid Dynamics and Geophysical Fluid Dynamics Models for Prediction of Multiphysics and Multiscale Coastal Ocean Flows
Tang, Hansong City College, City Univ. of New York, Changsha Univ. of Sci. & Tech.
Qu, Ke Dept. of Civ. Eng., City College, City Univ. of New York

Abstract: In order to simulate emerging multiscale and multiphysics coastal ocean flow problems, an overset-grid method is developed to couple SIFOM and FVCOM, with the former capturing small-scale, local, fully 3D flows and the latter handling large-scale background currents. SIFOM and FVCOM are strongly coupled in two-way as a single modeling system via domain decomposition. Discussion will be presented on the framework of the SIFOM-FVCOM system, together with numerical experiments to illustrate its unparalleled capabilities.

MS-Th-BC-06-2 10:30–11:00
3D Viscoelastic Anisotropic Seismic Modeling with High-Order Mimetic Finite Differences
Castillo, Jose San Diego State Univ.

Abstract: We present a scheme to solve three-dimensional viscoelastic anisotropic wave propagation on structured fully staggered-grids. This allows for arbitrary anisotropy as well as grid deformation. Correct representation of surface waves is achieved using high-order mimetic operator which allow for an accurate, compact and high-order solution at the physical boundary condition. Viscoelastic attenuation is represented with a generalized Maxwell body approximation, which requires auxiliary variables to model the convolutional behavior of the stresses in lossy media.

MS-Th-BC-06-3 11:00–11:30
Discontinuous Galerkin Method and Adaptive Finite Element for A Simulation of A Mesoscale Tumor Invasion
Turn, Cristina FaMAF- Universidad Nacional Cordoba

Abstract: The methods for estimating unknown parameters appearing on a non-linear reaction-diffusion model of tumor invasion are very important due to the impact of cancer in the society. The model considers that tumor-induced alteration of micro-environmental pH provides a mechanism for cancer invasion at mesoscale level. We apply Discontinuous Galerkin and Adaptive Finite Element Method with an appropriate splitting method to solve both the direct and the adjoint problem, computing the a-posteriori error.

MS-Th-BC-06-4 11:30–12:00
Ensemble Data Assimilation Analysis System for Sub-Mesoscale Processes
Garcia, Mariangel San Diego state Univ.

Abstract: The goal in this paper is to use the power of Ensemble Kalman filters in a fully 3D non-hydrostatic model to study sub-mesoscale process and estimate accurately the state variables. Its implementation is very difficult, particularly for physical ocean models, which are highly nonlinear, very sensitive to perturbations and require a dense spatial discretization in order to correctly reproduce the dynamics. The major challenge here is the high computational cost typically incurred by a high-resolution numerical model with a three-dimensional data assimilation scheme in a complicated stratified system. Having the General Curvilinear Coastal Ocean Model (GCCOM) interfaced with the faster data assimilation framework, the Data Assimilation Research Tesbed (DART-NCAR), allowed us to assimilate very high resolution observations (10th of meters ) into the system. Aspect of the inter-face software are discussed here. An Observing System Simulation Experiments(OSSEs) is presented in a very steep seamount test case. This experiment, allow us to explore the proper initial ensemble members for the model, to estimate the observation error variance need it to reproduce the dynamics in a turbulent flow experiment, to analyze the impact of localization in such small processes. Nevertheless, because data assimilation demands quantitative estimates of model uncertainties, it forces us to confront model errors and their correlations, by attempting OSSEs for GCOM monitoring at this stage it will contribute to evaluating the strengths and weaknesses of the model and the data assimilation procedures that are used, with the goal to provide important guidance for future users to improve these systems.

MS-Th-BC-07-1 10:00–10:30
Uncertainty Propagation from CO2 Sequestration to Leakage in Groundwater Aquifers
Sun, Yunwei Lawrence Livermore National Laboratory

Abstract: We present a global sampling scheme for quantifying uncertainty propagation from CO2 geological sequestration, to leakage pathway, to groundwater system. The risk of CO2 leakage into a drinking water system is assessed with probability distribution in terms of high-dimensional parametric uncertainties and various geological conditions. Monitoring and mitigation strategies are optimized based on the reduced-order model that is developed by integrating physics-specific subsystems.

MS-Th-BC-07-2 10:30–11:00
Analysis of Parameter Sensitivity of Two Global Land Surface Models
Li, Jianduo Beijing Normal Univ.
Wang, Yingping CSIRO
Duan, Qingyun Beijing Normal Univ.

Abstract: Here we focus on the errors in model structure and model parameters, and explain the differences in the simulated global gross primary productivity (GPP) and latent heat flux (LE) by two global land surface models: CABLE and JULES. We found that the simulated annual GPP or LE by both models are most sensitive to 3 to 6 model parameters for each plant functional type. Our study highlights the importance of parameter optimization.

CP-Th-BC-07-3 11:00–11:20
Modelling the Onset of Dust Eruptions
McGuinness, Mark Victoria Univ. of Wellington

Abstract: We present a new model for the initiation of high-speed eruptive two-phase dust flows in the laboratory. Shock-tube experiments have been conducted on beds of solid particles in nitrogen under high pressure, which are suddenly decompressed. Our model is successful in explaining the slab-like structures that are often observed during initiation of bed movement, by considering the interaction between the compressible flow of gas through the bed and the stress field in the particle bed, which ruptures when bed cohesion is overcome by the effective stress in the bed generated by the gas flow. Our model includes the effects of overburden and wall friction, and predicts that all layered configurations will rupture initially in this fashion, consistent with experimental observation. We also find that the modelled dependence of
The focus of the session is on fundamental complex analysis methods.

MS-Th-BC-07-4 11:20–11:40
Modelling Surtseyan Ejecta
McGuinness, Mark
Victoria Univ. of Wellington
Abstract: Surtseyan ejecta are formed in shallow sub-aqueous eruptions. They occur when a combination of liquid water and sediments penetrates into molten magma during an eruption, and is then ejected from the volcano as an inclusion inside a ball of magma. After ejection there is a large temperature gradient between magma and inclusion. As the temperature of the inclusion increases, the liquid water vaporises causing a pressure increase inside the ejected ball. The volcanological question is whether the ball of magma ruptures. There is evidence of intact ejecta so we know that rupture does not always occur. We present partial differential equations that model the transient changes in temperature and pressure in Surtseyan ejecta. These equations are reduced by ignoring small parameters, and then solved numerically and asymptotically to explore the parametric conditions for rupture of ejecta.

MS-Th-BC-08 10:00–12:00 202B
The Ginzburg-Landau Model and Related Topics - Part III of IV
For Part 1, see MS-WD-08
For Part 2, see MS-WD-E-08
For Part 4, see MS-Th-DF-08
Organizer: Golovaty, Dmitry
The Univ. of Akron
Organizer: Giorgi, Tiziana
New Mexico State Univ.
Abstract: The focus of the mini-symposium is on mathematical problems related to Ginzburg-Landau model with application in physics and materials science including but not limited to: superconductivity, superfluidity, liquid crystals, and polymers. The speakers in this mini-symposium will describe their recent research, including the development and structure of singular solutions of the Ginzburg-Landau-type problems and the dynamics of vortex motion. This mini-symposium is sponsored by the SIAM Activity Group on Mathematical Aspects of Materials Science (SIAG/MS).

MS-Th-BC-08-1 10:00–10:30
Quasilinear Systems Involving Operator Curl
Chen, Jun
Fujian Agriculture & Forestry Univ.
Abstract: In this talk, I would like to mainly introduce an extended magneto-static Born-Infeld model, which involves functions with degree one growth in operator curl, and show the existence of solutions with Holder continuity. Some results on a q-curvature system will also be shown.

MS-Th-BC-08-2 10:30–11:00
Profiles of Liquid Crystal Point Defects.
Slaskovik, Valeriy
Univ. of Bristol
Abstract: Using methods of calculus of variations and partial differential equations we investigate stability and minimality properties of symmetric solutions corresponding to liquid crystal point defects in 2D and 3D.

MS-Th-BC-08-3 11:00–11:30
Symmetry Breaking of Nematic Umbilical Defects Through An Amplitude Equation
Kowalczyk, Michal
Universidad de Chile
Abstract: The existence, stability properties, and bifurcation diagram of the nematic umbilical defects is studied. Close to the Fredericksz transition of nematic liquid crystals with negative anisotropic dielectric constant and homeotropic anchoring, an anisotropic Ginzburg-Landau equation for the amplitude of the tilt of the director away from the vertical axis is derived by taking the 3D to 2D limit of the Frank-Oseen model. The anisotropic Ginzburg-Landau equation allows us to reveal the mechanism of symmetry breaking

MS-Th-BC-08-4 11:30–12:00
Dissipative Dynamics in Nematics: from Doi-Smoluchowski to Vortices
Fakulllin, Ibrahim
Univ. of Arizona
Slaskovik, Valeriy
Univ. of Bristol
Abstract: The basic kinetic model for nematic liquid crystals is the Doi model. It describes dissipative evolution of the probability density of molecular orientations. Another, model, the Landau-de Gennes model, describes evolution of the field of the order parameter tensor. I will discuss the similarities and differences between these models in the two-dimensional case, and will show how both models result in the vortex motion analogous to that in the Ginzburg-Landau model of super-conductivity.

MS-Th-BC-09 10:00–12:00 203A
Applied and computational complex analysis I
Organizer: Pelloni, Beatrice
Univ. of Reading
Abstract: The focus of the session is on fundamental complex analysis methods for exploring the deep mathematical connections between shapes, singularities of complex functions, and spectra. We have assembled a list of researchers that have in common the use of tools of complex analysis for uncovering the underlying structure of mathematical and physical phenomena. Such tools are fundamental, for example, in the study of boundary value problems and differential operators via the Unified Transform of Fokas, in the derivation of integral transforms for medical imaging, in Crowley’s work on the evolution of shapes in boundary value problems, such as in the famous Hele-Shaw problem, and in the study of the geometric patterns arising in the study of singularities of certain distinguished ODEs. The full impact of such approaches is only beginning to be felt and in this symposium the speakers will discuss advances and open challenges, theoretical and numerical. This is one mini-symposium in a series of two, organised by the network ACCA-UK and ACCA-Japan.

MS-Th-BC-09-1 10:00–10:30
Fast Solution of the Boundary Integral Equations with the Generalized Neumann Kernel
Nasser, Mohamed M S
King Khalid University
Abstract: We briefly review the derivation and the properties of the boundary integral equations with the generalized Neumann kernel which have been derived in the past decade by the author and his collaborators. We then present a fast numerical method for solving these integral equations. The presented method gives accurate results even for domains of very high connectivity, domains with piecewise smooth boundaries, domains with close-to-touching boundaries, and domains of real world problems.

MS-Th-BC-09-2 10:30–11:00
Augmented Eigenfunctions: A New Spectral Object Appearing in the Integral Representation of the Solution of Linear Initial-Boundary Value Problems
Smith, David
Univ. of Cincinnati
Abstract: We study initial-boundary value problems for linear, equations of arbitrary order, on a finite or semi-infinite domain, with arbitrary boundary conditions, using the Unified Transform Method of Fokas. The solution obtained is expressed as an integral, which represents a new kind of spectral transform. We compare the new solution representation, with classical Fourier transform solutions. In doing so, we discover a new species of spectral object.

MS-Th-BC-09-3 11:00–11:30
Computation of An Infinite Integral with Unbounded Integrand
Oura, Takuya
Kyoto Univ
Abstract: The infinite integral \( \int_0^\infty \frac{x^m}{\cosh^n x} \) has an unbounded integrand but is convergent. Computing the value of this integral has been a problem since 1984. We demonstrate that the method using the Hilbert transform to cancel the singularity of the integrand and compute the value of the integral with high accuracy using a superconvergent double exponential quadrature.

MS-Th-BC-09-4 11:30–12:00
Fourier-Mellin Transforms for Multiply Connected Circular Domains and Applications
Crowdy, Darren
Imperial College London
Abstract: In this talk we present new transform pairs for analytic functions defined in generally multiply connected circular domains. Circular domains are those with boundaries made up of circular arcs or straight lines. The transform pairs, which will be shown to be the natural generalizations of classical Fourier and Mellin transforms, can be used to solve boundary value problems for harmonic and biharmonic fields that are not amenable to solution by traditional techniques.

MS-Th-BC-10 10:00–12:00 206B
Singular Problems and Integral Dynamical Models in Applied Mathematics - Part I of II
For Part 2, see MS-Th-DF-10
Organizer: Sidorov, Denis
Energy Sys. Inst., Russian Acad. of Sci. (SB)
Abstract: This mini-symposium concentrates on the theory of singular equations especially applicable to stability, bifurcation and algorithmic analysis of DE/IEs in mechanics and mathematical physics. Mini-symposium addresses the recent results on existence theorems, regularization, and identification, including asymptotic, numerical and group theoretic methods. The employment of such methods in various problems in modern physics, heat-and-power engineering, and mechanics (plasma, aeroelasticity theory, phase transitions, etc.) has given the authors rich possibilities for creativity and application. The special attention will be paid to Vlasov-Maxwell systems which are in the core of relativistic models of plasma physics and Maxwell models of
In this talk, we consider a method for finding all eigenvalues located near a complex contour. We propose an Arnoldi-type contour integral-based eigensolver, which is based on the block Arnoldi method of standard eigenvalue problems, for solving nonlinear eigenvalue problems.

## Abstract

The regularising equations with vector regularisation parameter are proposed for linear operator equations with closed operator in Banach spaces. Range of operator can be non-closed, homogenous equation may have a non-trivial solution. We assume that delta-approximations of both the source function and operator are known. The uniqueness theorem is proved for the special auxiliary regularising equation. The proposed abstract scheme is applied for the stable differentiation. This is a joint work with Professor N.A. Sidorov.

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### Talks:

**MS-Th-BC-10-1**

10:00–10:30  
*Perturbation Theory and the Banach – Steinhaus Theorem for Regularisation of the First Kind Equations*

Sidorov, Denis  
Energy Sys. Inst., Russian Acad. of Sci. (SB)  
Irkutsk State Univ.

**MS-Th-BC-10-2**

10:30–11:00  
*On Application of the Lyapunov-Schmidt-Trenogin Method to Bifurcation Analysis of the Vlasov-Maxwell System*

Sidorov, Denis  
Energy Sys. Inst., Russian Acad. of Sci. (SB)  
Irkutsk State Univ.

**MS-Th-BC-10-3**

11:00–11:30  
*Evolutionary Integral Operator Equations with Piecewise Continuous Kernels*

Sidorov, Denis  
Energy Sys. Inst., Russian Acad. of Sci. (SB)  
Irkutsk State Univ.

**MS-Th-BC-10-4**

11:30–12:00  
*On Numerical Solution of Weakly Regular Integral Equations*

Sidorov, Denis  
Energy Sys. Inst., Russian Acad. of Sci. (SB)  
Irkutsk State Univ.

**MS-Th-BC-11**

10:00–12:00  
*Nonlinear Eigenvalue Problems - Part III of III*

For Part 1, see MS-We-D-11  
For Part 2, see MS-We-E-11

Organizer: Kressner, Daniel  
EPFL  
Organizer: Su, Yangfeng  
Fudan Univ.

Abstract: Nonlinear eigenproblems that are nonlinear in the eigenvalue parameter regularly appear in the analysis of vibrations and frequency-dependent material properties. It is not uncommon to find that model reduction techniques turn linear into nonlinear eigenvalue problems (NEP). Current research directions for NEPs include efficient and reliable algorithms for problems of small size, memory-efficient and robust algorithms for large-scale problems, as well as structure-preserving algorithms for structured NEPs. This MS aims to give an overview of state-of-the-art developments on the analysis, algorithms, and applications.

**MS-Th-BC-11-1**

10:00–10:30  
*Arnoldi-type Contour Integral-based Eigensolver for Solving Nonlinear Eigenvalue Problems*

Imakura, Akira  
Univ. of Tsukuba

Sakurai, Tetsuya  
Univ. of Tsukuba

Abstract: In this work, we consider a method for finding all eigenvalues located in a certain region and the corresponding eigenvectors of nonlinear eigenvalue problems. Recently, we have developed the contour integral-based eigensolvers for solving generalized and nonlinear eigenvalue problems. In this talk, we propose an Arnoldi-type contour integral-based eigensolver, which is based on the block Arnoldi method of standard eigenvalue problems, for solving nonlinear eigenvalue problems.

**MS-Th-BC-11-2**

10:30–11:00  
*A Fixed-point Characterization of the Convergence of the Self-consistent Field Iteration*

Jarlebring, Elias  
KTH

Abstract: Flavors of the self-consistent field iteration is one of the leading approaches to solve certain types of nonlinear eigenvalue problems in quantum chemistry. We present a characterization of the convergence of this iteration. The characterization gives an explicit sufficient and essentially necessary conditions for local convergence. The characterization is illustrated with examples, which also suggest new acceleration techniques.

**MS-Th-BC-11-3**

11:00–11:30  
*Constructing Strong L-iifications of Arbitrary Degree*

De Teran, Fernando  
Universidad Carlos III de Madrid

Dopico, Froilan M.  
Universidad Carlos III de Madrid

Van Dooren, Paul  
Catholic Univ. of Louvain

Abstract: We revisit the problem of constructing strong L-ifications of a given matrix polynomial P(s) of degree D and size mxn. A strong L-ification of P(s) is a matrix polynomial of degree L having the same finite and infinite elementary divisors, and the same number of left and right minimal indices as the original matrix polynomial P(s). We give a general construction of strong L-lications for very general choices of degree.

**MS-Th-BC-11-4**

11:30–12:00  
*Numerical Analysis of Cubic Formula*

Su, Yangfeng  
Fudan Univ.

LU, DING  
Fudan Univ.

Abstract: As the quadratic root formula, the cubic one may also suffer from backward instability. In this talk, we introduce some stability results for cubic root formula, including explicit expression of the tropical roots for root distributions of cubic equations, which root(s) from cubic root formula are always backward stable, and how to do deflation to compute all three roots such that they are backward stable.

**MS-Th-BC-12**

10:00–12:00  
*Bifurcation, Stability and Applications - Part I of II*

For Part 2, see MS-Th-D-12

Organizer: Loginov, Boris  
Ulyanovsk State Technical Univ.

Abstract: In applications of bifurcation theory the situation arises when the finite-dimensional branching equation (BEq) is potential, while the original nonlinear equation haven’t this property. Three articles are devoted to this phenomenon. Here sufficient conditions for BEq potentiality and pseudopotentiality are obtained, particularly under group symmetry conditions, when the bifurcation point has nontrivial stationary subgroup. For stationary and dynamic bifurcation problems general theorems are proved about the inher- itance of the group symmetry of original nonlinear equation by the relevant Lyapounov and Schmidt BEqs moving along the trajectory of the branching point, taking into account the presence of stationary subgroup of the branch- ing point. Theorems on the BEqs reduction (its order lowering) are proved at the action of continuous group symmetry, G-invariant implicit operators theorems are proved for stationary and dynamic bifurcation. Simple, but very technical examples of SO(2) and SH(2) symmetries are considered with the general form of C1-smooth BEq construction on allowed group symmetry. Simple, but very technical examples of SO(2) and SH(2) symmetries are considered with the general form of C1-smooth BEq construction on allowed group symmetry. The aid of Morse-Conley topological index theory is proved the bifur- cation existence theorem for Andronov-Hopf bifurcation. Sufficient conditions for the linearized stability of bifurcating solutions are obtained. The obtained results are applied to bifurcation problems with E. Schmidt spectrum in the linearization. Three communications are devoted to nonlinear equations, their solutions stability and bifurcation theory to problems of hydroaerelasticity. One of them considers the multiparameter bifurcation problems on the divergence of the elongated plate in supersonic flow compressed or extended by external boundary conditions in the exact statement, that is achieved by the representation of the bifurcation manifold through the roots of the charac- teristic equation of the linearized ODE. Here the most difficulties arise at the analytical proof of the divergence absence. The Fredholm property of these problems is proved also on the base of the usage of the roots of character- istic equations of the linearization. Lyapunov functions and functionals, Lyapunov vector- functions techniques is applied to the investigation of sol- utions stability in two reports to hydroaeroelasticity problems and two articles on the stabilization of nonlinear systems motions (with digital control and with aftereffect,.)
Symmetry and Potentiality in Branching Theory Problems with Stationary Subgroup of Branching Point

Loginov, Boris
Ulyanovsk State Technical Univ.
Konopleva, Irina
Ulyanovsk State Technical Univ.

Abstract: For stationary and dynamic branching in DE nonresolved under derivative generally noncompact symmetry with pseudopotential branching equations (BEqs) and stationary subgroup of bifurcation point necessary and sufficient conditions of the potential invariance are established. Cosymmetry identities of the BEqs and Lie algebra operators allow to prove theorems on BEqs reduction by the number of equations, G-invariant implicit operators’ theorems are proved. Criteria of linearized stability of bifurcation solution families and simple applications are given.

Bifurcation Problem on Schmidt Spectrum under Group Symmetry Conditions

Loginov, Boris
Ulyanovsk State Technical Univ.
Konopleva, Irina
Ulyanovsk State Technical Univ.

Abstract: At the beginning of XX century E.Schmidt had introduced for an operator and adjoint to it the spectrum notion. Here stationary and dynamic bifurcation problems on Schmidt spectrum for DEs non-resolved by the derivative under generally non-compact group symmetry are investigated. The general theorem on group symmetry inheritance by the relevant branching equations, moving along bifurcation point trajectory allows to prove G-invariant implicit operators theorem and variational types BEqs reduction by the number of equations.

Andronov-Hopf Bifurcation in Equations with Symmetrizable Operators

Kim-Tyan, Luzia
National Research Technological Univ. (Moscow Inst. of Steel & Alloys)

Abstract: For first order differential equations in Banach spaces with densely defined linear Fredholm operator before the derivative and small parameter in nonlinearity in the linearization Andronov-Hopf bifurcation problem is considered. On the base of the suggested by V.A.Trenogin symmetrizability notion for the linear operators in Banach spaces sufficient conditions for Lyapunov-Schmidt branching equation pseudopotentiality types A and B are obtained and at the usage of Conley-Morse index theory the bifurcation existence theorem is proved.

Multiparameter Bifurcation Problems on Divergence of Elongated Plate in Supersonic Gas Flow

Badokina, Tatjana
Mordovian State Univ. of N. P. Ogarev
Loginov, Boris
Ulyanovsk State Technical Univ.

Abstract: Bifurcation problem about buckling of strip-plate in supersonic gas flow under compressed/extended boundary stresses is considered. The dependence on bifurcation parameters (Mach number, compression/extension coefficient) and small normal load, expressed through the roots of the characteristic equation for the linearization, allows to give the problem exact statement, to determine the parameters critical manifolds, to construct (first for aerelasticity problems) Green functions for the linearizations and bifurcating solutions asymptotics by Lyapunov-Schmidt method.

Progress in hyperbolic problems and applications - Part II of VI

MS-Th-BC-13-1 10:00–10:30
Shock Formation at the Sonic Line

Organizer: Wang, Ying
Univ. of Oklahoma
Organizer: Tesdall, Allen
City Univ. of New York, College of Staten Island

Abstract: Hyperbolic conservation laws form the basis for the mathematical modeling of many physical systems, and describe a wide range of wave propagation and fluid flow phenomena, including shock waves in nonlinear situations. For one dimensional systems with small data, a well-posedness theory of entropy weak solutions is well known. Analysis in several space dimensions, however, remains an enormous challenge. In this minisymposium, recent results in the theory and numerical analysis of hyperbolic problems will be represented. A variety of computational techniques, including finite volume, finite element, spectral, WENO, and discontinuous Galerkin methods, will be represented.

MS-Th-BC-13-2 10:30–11:00
Derivation and Some Asymptotic Estimates of the Convergence Rate of A Schwarz Waveform Relaxation Domain Decomposition Method for Some Quantum Wave Equations

Lorin, Emmanuel
Carleton Univ. & Centre de Recherches Mathematiques (Montreal)

Abstract: This presentation is dedicated to the derivation of a Schwarz waveform relaxation domain decomposition method using high order pseudodifferential transmission conditions. This method will be applied to linear and nonlinear Schroedinger equations in real and imaginary time. We will show some numerical and analytical convergence rate estimates. This is a joint work with X. Antoine (University of Lorraine).

A High Order Finite Difference Method with Subcell Resolution for Stiff Multiphysics Reacting Flows

Wang, Wei
Florida International Univ.
Shu, Chi-Wang
Brown Univ.

Abstract: In this talk, we propose a high order finite difference WENO method with Harten’s ENO subcell resolution idea for the chemical reactive flows. The proposed method is a modified fractional step method which solves the convection step and reaction step separately. A fifth-order WENO is used in convection step. In the reaction step, a modified ODE solver is applied but with the flow variables in the discontinuity region modified by the subcell resolution idea.

Asymptotic Preserving Method for the Radiative Transfer Equation

Xing, Yulong
Oak Ridge National Laboratory & Univ. of Tennessee

Abstract: Many kinetic equations converge to macroscopic models when the mean free path $\lambda \to 0$. Asymptotic preserving (AP) methods are designed to preserve the asymptotic limits in the discrete setting. In this presentation, we consider the radiative transfer equation and present a mixed DG-FV method. Rigorous analysis will be provided to show that the proposed methods are AP and consistent with the limit equation in the asymptotic regimes. Numerical examples are presented to demonstrate their performance.
Voss, Heinrich
Hamburg Univ. of Tech.

Abstract: In this paper we examine an eigenvalue optimization problem with nonlinear dependence on the eigenparameter. We prove the existence of a solution, and we propose a numerical algorithm to obtain an approximate description of the optimizer. Such nonlinear eigenvalue problems appear as the Hamiltonian equation governing some quantum dot nanostructures.

MS-Th-BC-14-3 11:00–11:30
Fast Computation of Dirichlet and Neumann Eigenfunctions
Hassell, Andrew
Australian National Univ.

Abstract: Recently, Alex Barnett and I published a fast method, the ‘weight-ed Neumann-to-Dirichlet method’, for rapidly computing eigenfunctions and eigenvalues of the Laplacian on Euclidean domains (Comm. Pure Appl. Math. 67 (2014), 351-407). However, the method, as published, is applicable only to the Dirichlet boundary condition and starshaped domains. In this talk, I describe joint work with Barnett on developing this method to rapidly compute Laplace eigenfunctions for general boundary conditions and domains.

MS-Th-BC-14-4 11:30–12:00
Lower Bounds for the First Eigenvalue of the Vibration Clamped Plate under Compression
Ashbaugh, Mark
Univ. of Missouri

Abstract: We give a sharp lower bound to the fundamental frequency of a clamped vibrating plate under compression in the context of plates of different shapes of fixed area. Mathematically, the problem is that of bounding the first eigenvalue of a certain 4th-order partial differential operator with leading term the bi-Laplacian from below by a positive constant over the domain’s area squared. We give a Rayleigh-Faber-Krahn-type result for this problem. (Joint with Benguria and Mahadevan.)

MS-Th-BC-15 10:00–12:00 213B
Recent Trends in Homogenization of Partial Differential Equations
Organizer: Damlaman, Alain
UFEC
Organizer: Donato, Patrizia
Univ. of Rouen

Abstract: The mathematical theory of homogenization studies the asymptotic behavior of problems with small parameters describing for example, heterogeneities (oscillating coefficients) or the geometry of domains (size of holes in porous media). The classical tools that we discuss are the multiple scale method, Tartar’s oscillating test functions method, the two-scales convergence.

We describe here an alternative, the periodic unfolding. Applications will be discussed as in particular, homogenization in perforated domains.

MS-Th-BC-15-1 10:00–10:30
General Methods in Homogenization. Application to Perforated Domains
Cioranescu, Doina
Univ. Pierre et Marie Curie, Laboratoire J.L. Lions

Abstract: The mathematical theory of homogenization studies the asymptotic behavior of problems with small parameters describing for example, heterogeneities (oscillating coefficients) or the geometry of domains (size of holes in porous media). The classical tools that we discuss are the multiple scale method, Tartar’s oscillating test functions method, the two-scales convergence.

We describe here an alternative, the periodic unfolding. Applications will be discussed as in particular, homogenization in perforated domains.

MS-Th-BC-15-2 10:30–11:00
Homogenization of Parabolic Problems via the Periodic Unfolding Method
Yang, Zhanzheng
South-Central Univ. for Nationalities

Abstract: This talk will survey some recent progress for the homogenization and correctors of a parabolic problem with imperfect interfaces. Perfect interfaces are modeled by a boundary conditions where the jump of the solution across the interface is proportional to the flux (which itself does not exhibit a jump).

MS-Th-BC-15-3 11:00–11:30
Asymptotic Analysis of the Approximate Control for A Class of Parabolic Equations with Interfacial Contact Resistance
Jose, Editha
Univ. of the Philippines Los Banos
Donato, Patrizia
Univ. of Rouen

Abstract: We study the asymptotic behavior of the approximate control for a class of parabolic equations with periodic rapidly oscillating coefficients in composites with a periodic interfacial resistance. We first prove the approximate controllability of the problem as well as the homogenized one, which is a coupled system P.D.E.-O.D.E. Then we show that the control and the corresponding solution of the periodic problem converge respectively to the control and to the solution of the homogenized problem.

MS-Th-BC-15-4 11:30–12:00
Effective Properties of Suspensions and Fluid Emulsions
Vernescu, Bogdan
Worcester Polytechnic Inst.

Abstract: We study suspensions of rigid particles in a Newtonian fluid, and of fluid emulsions of deformable droplets, in the presence of surface discontinuities. The macroscopic effects of the velocity slip on the particles’ surfaces in suspensions, and the effects of the droplets’ surface tension in emulsions are derived.

MS-Th-BC-16 10:00–12:00 205A
Lie Symmetries, Solutions and Conservation laws of nonlinear differential equations - Part III of III
For Part 1, see MS-We-D-16
For Part 2, see MS-We-E-16
Organizer: Khakie, Chaady Masood
North-West Univ., Mafikeng Campus
Organizer: Zhang, Lijun
Zhejiang Sci-Tech Univ.

Abstract: This mini-symposium is devoted to all research areas that are related to nonlinear differential equations and their applications in science and engineering. The main focus of this mini-symposium is on the Lie symmetry analysis, conservation laws and their applications to ordinary and partial differential equations. These differential equations could originate from mathematical models of diverse disciplines such as architecture, chemical kinetics, civil engineering, ecology, economics, engineering, fluid mechanics, biology and finance. Other approaches in finding exact solutions to nonlinear differential equations will also be discussed. This includes, but not limited to, asymptotic analysis methodologies, bifurcation theory, inverse scattering transform techniques, the Hirota method, the Adomian decomposition method, and others.

MS-Th-BC-16-1 10:00–10:30
Lie Group Classification of A Generalized Coupled (2+1)-dimensional Hyperbolic System
Motbibi, Dimpho
North-West Univ.

Abstract: We carry out Lie group classification of a generalized coupled (2+1)-dimensional hyperbolic system. Several cases arise for which the Principal Lie algebra extends. Group-invariant solutions will be presented for some cases.

MS-Th-BC-16-2 10:30–11:00
Traveling Wave Solutions of Higher-order Wave Equations
Zhang, Lijun
Zhejiang Sci-Tech Univ.

Abstract: We investigate the exact traveling wave solutions of the fifth-order Kaup-Kuperschmidt equation. The bifurcation and exact solutions of a general first-order nonlinear equation are investigated. With the help of Maple and using the bifurcation and exact solutions of two derived subequations, we obtain two families of solitary wave solutions and two families of periodic wave solutions of the KK equation.

CP-Th-BC-16-3 11:00–11:20
An Improved Square Formulation for Schubert Calculus
Hein, Nickolas
Univ. of Nebraska at Kearney
Sottle, Frank
Texas A&M Univ.

Abstract: Formulating a Schubert problem as the solutions to a system of equations in either Pluecker space or in the local coordinates of a Schubert cell typically involves more equations than variables. Using reduction to the diagonal, we previously gave a formulation for Schubert calculus that involved the same number of variables as equations (a square formulation). We give a d&##46256;erent square formulation which involves fewer equations and variables. The idea behind our formulation is that partial desingularizations of Schubert varieties have simple descriptions.

CP-Th-BC-16-4 11:20–11:40
The Stokes and Navier-Stokes Equations with Non Standard Boundary Conditions
SELOULA, Nour
Univ. of Caen

Abstract: We consider the stationary and the non stationary Stokes equations with nonstandard boundary conditions where the pressure and the tangential velocity are imposed. We prove the existence and uniqueness of weak, strong and very weak solutions. We give a variational of the Stokes system with these boundary conditions, in the case where the compatibility condition is not verified. We also study the non linear Navier stokes problem.

CP-Th-BC-16-5 11:40–12:00
An Effective High-order Stereo-modeling Method for Solving Wave Equations
Li, Jinghuang
China Univ. of Mining & Tech. (Beijing)
Yang, Dinghui
Tsinghua Univ.
Yang, Lei
China Univ. of Mining & Tech.

Abstract: In this study, we develop a new finite difference method, which use not only displacement but also its gradients, to solve the acoustic and elastic wave equations for seismic modeling to meet the high demand today. The analyses of this 12th order stereo-modeling (12-STEM) method including the theoretical error, stability condition and numerical dispersion relation are given.
Abstract:
We study semigeostrophic system with general convex initial data. The results show that the maximum error of the phase velocity is only about 3% for 12-STEM, whereas it's about 15% for 12-LWC. Under the condition of no visible numerical dispersion, the computational speed of 12-STEM is roughly 8 times faster than that of 12-LWC. However, 12-STEM requires only about 38% of the storage space for the 12-LWC for comparable reliability.

Singular limits in mathematical physics - Part II of V
For Part 1, see MS-WE-E-17
For Part 3, see MS-Th-D-17
For Part 4, see MS-Th-E-17
For Part 5, see MS-Fr-D-17
Organizer: Cheng, Bin
Univ. of Surrey
Organizer: Secchi, Paolo
Univ. of Brescia
Organizer: Ju, Qiangchang
Inst. of Applied Physics & Computational Mathematics (IAPCM)
Organizer: Jiang, Ning
Tsinghua Univ., Beijing

Abstract: This mini-symposium will address recent advances in analytical and numerical studies of singular limits of multiscale physical models as certain parameters approach zero or infinity. It shall cover such areas as incompressible and fast rotating limits in fluid dynamics, hydrodynamical systems of complex fluid and kinetic models, and relaxations. The singular nature of these models makes it challenging to rigorously justify and quantify their limits and to numerically simulate them in a way consistent with theory. Novel techniques and results in partial differential equations, stochastic differential equations and numerical analysis will be discussed.

Singular Limits of Smooth Solutions of Evolutionary PDEs and Their Numerical Analysis
Schochet, Steve
Tel Aviv Univ.

Abstract: After reviewing the theory of singular limits of smooth solutions of evolutionary partial differential equations both for the standard case in which the large terms have constant-coefficients and for some equations having variable-coefficient large terms, an analysis of certain numerical schemes for singular limits will be presented that is analogous to the corresponding PDE theory. The analysis has so far be done for certain finite-difference schemes but some preliminary results are available for finite-volume schemes.

The Singular Limits for the Full Navier-Stokes-Poisson System
Ju, Qiangchang
Inst. of Applied Physics & Computational Mathematics (IAPCM)

Abstract: We shall report the recent results of the quasi-neutral limit of the full Navier-Stokes-Poisson system for both strong solution and weak solutions. In particular, The effect of large temperature variations will be discussed.

Toward A Justification of Variational Asymptotics for Multiscale Systems with Strong Gyroscopic Forcing
Oliver, Marcel
Jacobs Univ.

Abstract: In systems with strong gyroscopic forces, approximate equations for the dynamics on a slow manifold can be found via variational asymptotic normal form theory. We explain the method, using the non-relativistic limit of the nonlinear Klein-Gordon equation as an example, and prove a shadowing result for this particular case.

Solutions for Semigeostrophic System with General Initial Data
Feldman, Mikhail
Univ. of Wisconsin-Madison

Abstract: We study semigeostrophic system with general convex initial data in physical space, which includes the case when the dual-space solutions are singular measures. To accommodate general initial data, we introduce a notion of relaxed renormalized Lagrangian solutions. We show weak stability and existence of solutions. The renormalization property ensures the return from physical to dual space: as consequences we get conservation of energy and a weak time-regularity of solutions. Joint work with A. Tudorascu.

Recent Advances in Stochastic Approximation for Uncertainty Quantification: Analysis and Computation - Part II of II
For Part 1, see MS-WE-E-18
Organizer: Archibald, Rick
Oak Ridge National Laboratory
Organizer: Webster, Clayton
Oak Ridge National Laboratory
Organizer: Zhang, Guannan
Oak Ridge National Laboratory

Abstract: This mini-symposium focuses on the fundamental problem of how to accurately approximate solutions of both forward and inverse complex systems with random inputs. Predicting the behavior of complex phenomena relies on constructing solutions in terms of high dimensional spaces, particularly in the case when the input data are affected by large amounts of uncertainties. The resulting explosion in computational effort is a symptom of the curse of dimensionality. This mini-symposium aims at exploring recent advances in high-dimensional approximation, sparse polynomial approximation, multilevel methods, model calibration and data-driven reduced order modeling.

A Stochastic Collocation Approach for Multi-Fidelity Model Classes
Narayan, Akl
Univ. of Massachusetts Dartmouth
Xiu, Dongbin
Univ. of Utah

Abstract: We present a novel algorithm for robustly incorporating inexpensive low-fidelity models and data into expensive high-fidelity simulations. Our approach maintains high-fidelity model accuracy while requiring only low-fidelity computational effort. The method is non-intrusive and extensible, effectively working with black-box simulation tools. Our procedure can address multi-physics situations, missing parameters, and an arbitrary numbers of model with varying degrees of fidelity.

Analysis of Quasi-optimal Polynomial Approximations for High-dimensional Parameterized PDEs
Webster, Clayton
Oak Ridge National Laboratory
Zhang, Guannan
Oak Ridge National Laboratory

Abstract: In this talk, we present a generalized methodology for analyzing the convergence of quasi-optimal polynomial and interpolation approximations, applicable to a wide class of parameterized PDEs with both deterministic and stochastic inputs. Such quasi-optimal methods construct an index set that corresponds to the “best M-terms,” based on sharp estimates of the polynomial coefficients. Computational evidence complements the theory and shows the advantage of our generalized methodology compared to previously developed estimates.

Starting from Measurements: An Integrated UQ Cycle with Adaptive Sparse Grids
Pflueger, Dirk
Univ. of Stuttgart

Abstract: We consider non-intrusive stochastic collocation for uncertainty quantification as our applications prevent us from changes in the underlying simulation code. We propose spatially adaptive sparse grids for both density estimation and stochastic collocation. With their help, the numerical discretization is still possible in higher-dimensional settings. This allows us to start with data that is provided by measurements and to combine the estimated densities with the simulation’s surrogate without introducing additional sampling or approximation errors.
### MS-Th-BC-19: 10:00–10:30

**Organizer:** Cheng, Juan Inst. of Applied Physics & Computational Mathematics

**Abstract:** This mini-symposium aims at bringing women mathematicians to share recent progress and to inspire new ideas in applied mathematics. Talks may address modeling, theoretical and computational aspects of numerical methods, as well as various applications arising from biomedical problems, fluid dynamics, electromagnetism, rarefied gas dynamics, and constrained optimal control problems, etc. Besides the scientific aspects, the fourth part of this mini-symposium is a career panel session, which is to create a platform for women mathematicians at different stages with different career paths to network, to exchange experiences and advice in career advancement, and to discuss challenges and strategies for a successful career.

#### MS-Th-BC-19-1
**Construction of Explicit Numerical Methods for the Vlasov-Maxwell Equations with Poisson Structure**

**Yajuan, Sun** Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

**Abstract:** By defining a non-canonical Poisson structure, the Vlasov-Maxwell equation is written in a Hamiltonian form. We use the particle-in-cell (PIC) method to compute the Vlasov-Maxwell equation. By using this method, the individual particles in six-dimensional phase space are tracked in self-consistent electromagnetic fields sampled on Eulerian grid. In this talk, we prove that with the PIC method the semi-discretized system is still Hamiltonian with the discrete Poisson structure. By splitting the Hamiltonian function of the semi-discretized system, we present the explicit numerical methods which can preserve the Poisson structure of the Vlasov-Maxwell equations.

#### MS-Th-BC-19-2

**Superconvergence and Superconvergent Filtering for Semi-Lagrangian Discontinuous Galerkin Schemes**

**Ryan, Jennifer** Univ. of East Anglia

**Seal, David** Michigan State Univ.

**Abstract:** In this work, we show that the application of Smoothness-Increasing Accuracy Conserving (SIAC) filters to a non-standard, semi-Lagrangian discontinuous Galerkin time stepping method improves the order from k+1 to 2k+1. This extension requires analyzing the underlying projection operators tied to the SLDG scheme. We show that we do indeed increase the order of the smoothness of the post-processed approximation.

#### MS-Th-BC-19-3

**Spectral Method for Optimal Control Problems Governed by PDEs with State Constraints**

**Chen, Yanping** South China Normal University

**Abstract:** In our researches, the control problems with state (control-state) constraints are approximated by Galerkin spectral method. The optimality conditions are constructed, and a priori and a posteriori error estimates are derived. Moreover, numerical tests confirm the theoretical analysis, and indicate the proposed method in our work is competitive for computing these control problems.

#### MS-Th-BC-19-4

**High-order Methods for High-performance Simulations**

**MIN, MISUN** Argonne National Laboratory

**Abstract:** I will present recent algebraic developments for solving electromagnetic systems based on classical and quantum mechanical modeling approaches. Studies include scalable algorithms for quantum absorption analysis and electron transport for plasmonics and quantum systems and photovoltaics. These efforts include high-order numerical discretizations, involving the design of accurate transparent boundary operators and efficient preconditioners, and scalable algorithms and large-scale simulations with hybrid programming for advanced computing architecture.

### MS-Th-BC-20: 10:00–10:30

**Organizer:** Sun, Jiguang Michigan Technological Univ.

**Organizer:** Cakoni, Fioralba Univ. of Delaware

**Abstract:** This mini-symposium will bring top researchers from America, Europe, and Asia to present the recent advances of the theory, computation, and applications of transmission eigenvalues. It will also be a great chance for these researchers to exchange new ideas and discuss the future development for the transmission eigenvalue problem.

#### MS-Th-BC-20-1

**On the Eigenvalue Density Theorems in Interior Transmission Problem and Its Applications**

**Chen, Lung-Hui** National Chung Cheng Univ.

**Abstract:** Starting with the interior transmission condition on the boundary of the perturbation, we will demonstrate how to apply Cartwright-Polya-Levinson theory to obtain its indicator function. By this indicator function, we can describe the eigenvalue density in interior transmission problem. Conversely, the eigenvalue density determines the indicator function. When perturbing the indicator function, we obtain the information on the index of refraction. As an application, we examine the thermoacoustic tomography.

#### CP-Th-BC-20-2

**Interaction of Water Waves with A Pair of Semi-infinite Elastic Plates over Undulating Bed Topography**

**Samantaray, Sudhanshu Shekhar** Divine Residential College, Nagargar Biswal, Trilochan Vivekananda Inst. of Tech., Bhubaneswar

**Martha, Subash Chandra** Indian Inst. Of Tech. ROPAR

**Abstract:** Interaction of water waves with floating structures have been investigated assuming linear theory in the literature of the last few decades. In this present paper, the interaction of water waves with a pair of semi-infinite elastic plates, separated by a gap of finite width, floating horizontally over the bottom bed which has small undulation, is investigated. Employing perturbation analysis, the boundary value problem under consideration is solved. The first order reflection and transmission coefficients are obtained in terms of integrals involving the shape function representing the bottom undulation and the solution of the scattering problem necessitating elastic plate which is floating over the flat bed. For sinusoidal undulation of the bottom, the numerical values of these coefficients are obtained and depicted graphically.

#### CP-Th-BC-20-3

**Detecting Highly Cyclic Structure with Complex Eigenpairs**

**Klymko, Christine** Lawrence Livermore National Laboratory

**Sanders, Geoffrey** LLNL

**Abstract:** Highly 3- and 4- cyclic subgraph topologies are detectable via calculation of eigenvectors associated with certain complex eigenvalues of Markov propagators. We characterize this phenomenon theoretically to understand the capabilities and limitations for utilizing eigenvectors in this venture. We provide algorithms for approximating these eigenvectors and give numerical results, both for software that utilizes complex arithmetic and software that is limited to real arithmetic. Additionally, we discuss the application of these techniques to motif detection.

#### CP-Th-BC-20-4

**Least-squares Spectral Element Methods for 3D Elliptic and Stokes Eigenvalue Problems**

**Husain, Akhlaq** LNM Inst. of Information Tech. Jaipur

**Abstract:** In this talk we discuss how to solve elliptic and Stokes eigenvalue problems on three dimensional polyhedral domains using least squares h8722;spectral element methods. We obtain exponential rate of convergence for approximate eigenvalues as well as the eigenfunctions when the domains are smooth. The computational results confirm the theoretical estimates and effectiveness of the method in dealing with eigenvalue problems. The results presented here are valid for multiple or clustered eigenvalues also.
Minisymposium on discontinuous Galerkin method: recent development and applications - Part V of VIII

For Part 1, see MS-Tu-D-21
For Part 2, see MS-Tu-E-21
For Part 3, see MS-We-D-21
For Part 4, see MS-We-E-21
For Part 6, see MS-Th-D-21
For Part 7, see MS-Th-E-21
For Part 8, see MS-Fr-D-21

Organizer: Xu, Yan [Univ. of Sci. & Tech. of China]
Organizer: Shu, Chi-Wang [Brown Univ.]

Abstract: Over the last few years, discontinuous Galerkin (DG) methods have found their way into the mainstream of computational sciences and are now being successfully applied in almost all areas of natural sciences and engineering. The aim of this minisymposium is to present the most recent developments in the design and theoretical analysis of DG methods, and to discuss relevant issues related to the practical implementation and applications of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

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MS-Th-BC-21 10:00–12:00 309B
Some Recent Development of Superconvergence Study of Discontinuous Galerkin Methods

Zhimin, Zhang [Beijing Computational Sci. Research Center, & Wayne State Univ.]

Abstract: Superconvergence phenomenon is well understood for the h-version finite element method and researchers in this field have accumulated a vast literature during the past 40 years. However, the relevant study for the discontinuous Galerkin method is far from complete. In this talk, we summarize some recent development on superconvergence study for discontinuous Galerkin methods. In addition, some current issues and un-solved problems will also be addressed.

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MS-Th-BC-21-1 10:00–10:30
Superconvergent Hybridizable Discontinuous Galerkin Method for Third-order Equations

Chen, Yanlai [Univ. of Massachusetts Dartmouth]

Abstract: We design and analyze the first hybridizable discontinuous Galerkin methods for stationary, third-order linear equations in one-space dimension. 13 methods will be analyzed in a unified setting. They all provide superconvergent approximations to the exact solution and its derivatives. We also prove that their numerical traces converge at the nodes with order at least 2k+1 allowing an element-by-element post-processing for more accurate solutions. This is joint work with Bo Dong (UMassD) and Bernardo Cockburn (UMN).

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MS-Th-BC-21-2 10:30–11:00
Superaccuracy, Superconvergence and Postprocessing of the DG Solutions of Hyperbolic Equations

Krivodonova, Lilia [Univ. of Waterloo]

Abstract: We discuss a connection between super accuracy in wave number approximation, spatial superconvergence at the roots of Radu polynomials and postprocessing techniques. We show that superconvergence and super-accuracy are related to the same subdiagonal Pade approximants. Further, postprocessing is possible due to a particular structure of the spatial error and recovers the superaccuracy of the method. While these concepts have been discussed before, we will present a theory that ties these three phenomena together.

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MS-Th-BC-21-3 11:00–11:30
HDG Methods for Diffusion: Superconvergence by M-decompositions

Fu, Guosheng [Univ. of Minnesota]

Abstract: We introduce the concept of an M-decomposition and show how to use it to systematically construct hybridizable discontinuous Galerkin and mixed methods for steady-state diffusion methods with superconvergence properties on unstructured meshes.

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MS-Th-BC-22 10:00–12:00 206A
Recent development and applications of weighted essential non-oscillatory methods - Part I of V

For Part 2, see MS-Th-D-22
For Part 3, see MS-Th-E-22
For Part 4, see MS-Fr-D-22
For Part 5, see MS-Fr-E-22

Organizer: Qiu, Jianxian [Xiamen Univ.]
Organizer: Shu, Chi-Wang [Brown Univ.]

Abstract: The spectrum covered by the minisymposium ranges from recent development, analysis, implementation and applications, for the weighted essential non-oscillatory (WENO) methods. The WENO methods provide a practical effective framework to solve out many nonlinear wave-dominated problems with discontinuities or sharp gradient regions, which play an important role arising in many applications of computational fluid dynamics, computational astrophysics, computational plasma physics, semiconductor device simulations, among others. Devising robust, accurate and efficient WENO methods for solving these problems is of considerable importance and, as expected, has attracted the interest of many researchers and practitioners. This minisymposium serves as a good forum for researchers to exchange ideas and to promote this active and important research direction.

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MS-Th-BC-22-1 10:00–10:30
WENO Schemes: Survey and Recent Developments

Shu, Chi-Wang [Brown Univ.]

Abstract: We give a short survey of WENO schemes and then review some of their recent developments, including a simple WENO limiter for DG and CPR schemes, finite difference WENO schemes with positivity-preserving limiter for correlated random walk with density-dependent turning rates, WENO compact schemes, and free-stream preserving finite difference WENO schemes on curvilinear meshes.

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MS-Th-BC-22-2 10:30–11:00
On the Maximum Principle Preserving Flux Limiters with Application to High Order Conservative Schemes

Xu, Zhengfu [Michigan Technological Univ.]

Abstract: In this presentation, we will discuss the maximum principle preserving flux limiters for the algorithm design, accuracy analysis to their applications to high order conservative schemes, such as finite difference/finite volume WENO, discontinuous Galerkin methods. We will also discuss the generalization to positivity preserving high order finite difference WENO scheme solving compressible Euler equations.

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MS-Th-BC-22-3 11:00–11:30
Positivity-preserving High Order Schemes for Conservation Laws

Zhang, Xiangxiong [Purdue Univ.]

Abstract: We will discuss the construction of arbitrarily high order accurate DG and WENO schemes which satisfy a strict maximum principle for nonlinear scalar conservation laws, passive convection in compressible flows, and preserve positivity of density and pressure for compressible Euler equations in gas dynamics. The main difficulty is how to enforce the positivity without destroying the high order accuracy and the local conservation, which was unknown previously regarding higher than second order accuracy.

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MS-Th-BC-22-4 11:30–12:00
High Order Positivity-preserving Lagrangian Schemes for Multi-material Compressible Flow

Cheng, Juan [Inst. of Applied Physics & Computational Mathematics]

Abstract: In this talk, we will present our recent work on the design of high order positivity-preserving Lagrangian schemes. We construct a class of uniformly high order accurate conservative Lagrangian schemes which preserve positivity of physically positive variables such as density and internal energy in the simulation of compressible multi-material flows with general equations of state. One- and two-dimensional numerical tests for the positivity-preserving Lagrangian schemes are provided to demonstrate the effectiveness of the method.
PDEs that are more generally described as abstract DAEs or PDAEs and that require sophisticated methods for their numerical and analytical treatment. Our speakers reflect the broad application area of constrained PDEs and discuss difficulties in the application side and recent advances in the analysis and the numerical approximation. The talks cover general theoretical aspects of PDEs with applications in the modelling of elastodynamics, flow networks, and fluid dynamics as well as specific issues that come with time integration of DAEs.

MS-Th-BC-23-1 10:00–10:30
Numerical Analysis of Numerical Methods for Neutral Delay Differential Algebraic Equations
Tian, Hongjiong
Shanghai Normal Univ.

Abstract: This talk is concerned with numerical stability of general linear methods for a system of linear neutral delay differential-algebraic equations. A sufficient and necessary condition for asymptotic stability of general linear methods solving such systems is derived. Based on this main result, we further investigate the asymptotic stability of linear multistep methods, Runge-Kutta methods, and block theta-methods, respectively. Numerical experiments confirm our theoretical result.

MS-Th-BC-23-2 10:30–11:00
Modeling and Numerical Analysis of PDAEs Describing Flow Networks
Tischendorf, Caren
Humboldt Univ. of Berlin

Abstract: The simulation of flow networks as electric circuits, water and gas supplying networks leads to partial differential algebraic system equations (PDAEs). Such systems contain partial differential equations of elliptic-parabolic/hyperbolic type and/or ordinary differential equations coupled with constraints. We present some common structures of such PDAEs caused by the network topology. We demonstrate that the stability of numerical schemes is highly influenced the constraints and present some suitable discretizations for certain prototype PDAEs.

MS-Th-BC-23-3 11:00–11:30
Operator DAEs with Noise Arising in Fluid Dynamics
Mena, Hermann
Univ. of Innsbruck
Altmann, Robert
TU Berlin
Levajkovic, Tijana
Department of Mathematics, Univ. of Innsbruck

Abstract: We consider an abstract formulation of a constrained PDE of semi-explicit structure (PDAE) with consistent initial value and noise. This PDAE appears in fluid dynamics, e.g., Stokes equation. We apply the polynomial chaos expansion methodology and deal with the arising infinite dimensional triangular system of deterministic equations. Because of the differential-algebraic structure, the system is very sensitive to perturbations in the constraint equation. Thus, we consider for the analysis a regularized version of the system.

MS-Th-BC-24 10:00–12:00
Combinatorial Issues in Sparse Matrix Computation
Organizer: Ng, Esmond
Lawrence Berkeley National Laboratory
Organizer: Duff, Iain
STFC Rutherford Appleton Laboratory

Abstract: Sparse matrix computation is rich in combinatorial problems. Reordering for sparsity preservation in matrix factorization is one such problem. Partitioning for parallel matrix factorization is another. In this minisymposium, we feature some recent work on the combinatorial aspect of sparse matrix computation. Some of the talks will focus on algorithmic development, while others will investigate more theoretical issues.

MS-Th-BC-24-1 10:00–10:30
Towards A Recursive Graph Bipartitioning Algorithm for Well Balanced Domain Decomposition
Casadei, Astrid
Inria
Pierre, RAMES
Bordeaux Univ. & Inria
Roman, Jean
Inria

Abstract: In the context of hybrid sparse linear solvers based on domain decomposition and Schur complement approaches, getting a domain decomposition tool leading to a good balancing of both the internal node set size and the interface node set size is a critical point for parallel computation. We propose several variations of the existing algorithms in the multilevel Scotch partitioner and we illustrate the improved results on a collection of graphs coming from numerical scientific applications.

MS-Th-BC-24-2 10:30–11:00
Experiments With A Nested Dissection Code
Ashcraft, Cleve
Livermore Software Tech. Corporation
Duff, Iain
STFC Rutherford Appleton Laboratory
Scott, Jennifer
STFC

Thorne, Sue
STFC

Abstract: We study the constituent parts of dissection orderings including algorithms based on the Ford-Fulkerson algorithm for network flows. We show the power and limitations of such methods for refining the cut sets. We also compare single and multilevel approaches. We will illustrate our algorithms and compare them with MeTiS orderings by runs on both model problems and realistic test cases.

MS-Th-BC-24-3 11:00–11:30
Recent Progress on the Minimum Local Fill Ordering Heuristic
Ng, Esmond
Lawrence Berkeley National Laboratory
Peyton, Barry
Dalton State College

Abstract: The minimum local fill (MLF) heuristic computes a fill-reducing permutation for sparse Cholesky factorization. It is generally believed that MLF is very expensive and produces marginally better permutations than the well-known minimum degree (MD) heuristic. Recently we have introduced implementations of MLF that are effective in reducing fill but are not too costly when compared with MD. In this talk, we will describe further enhancements that result in more efficient implementations of the MLF heuristic.

MS-Th-BC-24-4 11:30–12:00
Hypergraph Models to Reorder Sparse Matrices into Special Forms for Efficient Matrix Computations
Aynanat, Cevdet
Bilkent Univ.

Abstract: Efficient processing of many scientific applications that involve repeated sparse matrix computations requires reordering rows/columns of these matrices into special forms. These applications involve parallel sparse iterative solvers, and parallel and cache-efficient computation of sparse kernel operations such as sparse matrix-vector multiplication, sparse matrix-matrix multiplication, etc. This talk discusses various hypergraph-partitioning-based models proposed to reorder sparse matrices and shows how the objectives and constraints of these models encode the optimization of the underlying application.

MS-Th-BC-25 10:00–12:00
Numerical Methods for Stochastic PDE and Uncertainty Quantification - Part IV

For Part 1, see MS-Tu-E-25
For Part 2, see MS-We-D-25
For Part 3, see MS-We-E-25

Organizer: ZHOU, TAO
AMSS, the Chinese Acad. of Sci.
Organizer: Yu, Xijun
Inst. of Applied Physics & Computational Mathematics
Organizer: Xi, Dongbin
Univ. of Utah

Abstract: Efficient solution strategy for stochastic partial differential equations (SPDE) has been a classical topic, as many physical phenomena are inherently random. The topic has received an increasing amount of attention in recent years, driven by the need for uncertainty quantification (UQ). In UQ, even deterministic systems need to be modeled as random because of the uncertainty in the system inputs. Stochastic problems become more challenging to solve, as they often reside in high dimensional random space. The purpose of this mini-symposium is to gather researchers from mathematics and computer science and engineering to interchange the latest advances in simulation techniques for SPDE and UQ. The focus will be on efficient algorithms for practical systems, particularly those arising from multidisciplinary problems.
We study the problem faced by an economic agent trying to find an optimal strategy for the joint management of her consumption from a basket of K goods that may become unavailable for consumption from some random time \( \tau \), onwards, and her investment portfolio in a financial market model comprised of one risk-free security and an arbitrary number of risky securities driven by a multidimensional Brownian motion. We apply previous abstract results on stochastic optimal control problem with multiple random time horizons to obtain a sequence of dynamic programming principles and the corresponding Hamilton-Jacobi-Bellman equations. We then proceed with a numerical study of the value function and corresponding optimal strategies for the problem under consideration in the case of discounted constant relative risk aversion utility functions (CRRA).

A Backward Dual Representation for the Quantile Hedging of Bermudan Options

BOUVERET, GERALDINE
IMPERIAL COLLEGE LONDON

Abstract: We study the problem of hedging a claim of Bermudan style with a given probability \( p \) within a Markovian complete financial market. More precisely, we want to characterize the minimal initial value \( v(.,p) \) of an hedging portfolio for which we can find a financial strategy such that, with a probability \( p \), it remains above the exercise value of the Bermudan option at any possible exercise date. This problem is referred to as a stochastic target and quantile hedging problem and is an extension to [1] and [2]. Using stochastic target and duality arguments, we derive a backward algorithm for the Fenchel transform of the pricing function. We provide numerical illustrations.

to discuss recent advances on the decoupling methods for multi-physics and multi-scale problems with their applications.

**MS-Th-BC-27-1** 10:00–10:30

**Partitioned Two-step Second-order Method for Magnetohydrodynamics in Els"asser Variables**

Trenchea, Catalin  
Univ. of Pittsburgh

Abstract: We propose a partitioned, two step, second-order method for magnetohydrodynamics in Els"asser variables, which treats implicitly the subproblem terms and explicitly the coupling terms. The stability analysis shows that the method is unconditionally stable for the magnetic Prandtl number in the interval (0,5,2). In a large number of laboratory simulations, the magnetic Prandtl number is taken to be unity. The algorithm is shown to be long-time stable, and the finite element error analysis is presented with a numerical test supporting the theory.

**MS-Th-BC-27-2** 10:30–11:00

**Multiscale Weak Galerkin Methods**

Ye, Xi  
Univ. of Arkansas at Little Rock

Abstract: Multiscale weak Galerkin finite element methods will be introduced in the presentation. The Weak Galerkin method is an extension of the standard Galerkin finite element method where classical derivatives were substituted by weakly defined derivatives on functions with discontinuity. It has the flexibility of employing discontinuous elements and shares the simple formulations of continuous finite element methods at the same time. There is a natural connection between weak Galerkin finite element methods and multiscale methods.

**MS-Th-BC-27-3** 11:00–11:30

**A Surrogate Bayesian Inference Approach with Application to Large Eddy Simulation Turbulence Models**

Webster, Clayton  
Oak Ridge National Laboratory
Tran, Hoang  
Oak Ridge National Laboratory
Zhang, Guannan  
Oak Ridge National Laboratory

Abstract: In this effort, we developed an adaptive hierarchical sparse-grid (AHSG) surrogate modeling approach to Bayesian inference of large eddy simulation (LES) models, which, through a numerical demonstration of the Smagorinsky turbulence model of two-dimensional flow around a cylinder at sub-critical Reynolds number, is proven to significantly reduce the number of costly LES executions without losing much accuracy in the posterior probability estimation.

**MS-Th-BC-27-4** 11:30–12:00

**A Dual–mixed Finite Element Method for the Brinkman Problem**

Neilan, Michael  
Univ. of Pittsburgh

Abstract: In this talk, we develop a dual mixed finite element method for the Brinkman problem. In this approach, the velocity and the deviatoric part of the velocity gradient are approximated by discontinuous piecewise polynomials, and the total stress tensor is approximated by standard divergence-conforming finite element elements. Existence, uniqueness and error estimates are discussed, and numerical experiments are given.

**MS-Th-BC-28** 10:00–12:05

**Numerical Analysis for Forward-Backward Stochastic Differential Equations and Related Problems - Part II of II**

For Part 1, see MS-We-E-28

Organizer: Zhao, Weidong  
Shandong Univ.
Organizer: ZHOU, TAO  
AMSS, the Chinese Acad. of Sci.

Abstract: Backward stochastic differential equations (BSDE’s) were first introduced by J.M. Bismut in 1973 and generalized to the nonlinear form by Pardoux and Peng in 1990. Since then, BSDEs and coupled FBSDEs have been widely studied and used in connection with partial differential equations, stochastic optimal control theory, nonlinear filtering and mathematical finance. The numerical analysis of FBSDEs is more complicated than that of classical SDEs, so that there are many interesting and challenging open problems. The mini-symposium aims at exploring efforts related to numerical analysis for F-BSDEs and related problems such as SPDEs, nonlocal diffusions, nonlinear filtering, stochastic optimal control, mathematical finance, etc.

**MS-Th-BC-28-1** 10:00–10:25

**High Order Numerical Schemes for the Coupled FBSDEs with Applications to Stochastic Optimal Control**

Zhao, Weidong  
Shandong Univ.
ZHOU, TAO  
AMSS, the Chinese Acad. of Sci.

Abstract: In this talk, we will introduce accurate numerical methods for solving coupled nonlinear forward backward stochastic differential equations with applications in solving fully nonlinear second-order parabolic partial differential equations and stochastic optimal control problems.

**MS-Th-BC-28-2** 10:25–10:50

**Error Estimate of the Crank-Nicolson Scheme for Solving the Decoupled FBSDEs**

Li, Yang  
Univ. of Shanghai for Sci. & Tech.
Zhao, Weidong  
Shandong Univ.

Abstract: In this talk, by the theory of the multiple Malliavin calculus, we will introduce Crank-Nicolson scheme for solving decoupled forward-backward stochastic differential equations, and give the rigorous proof of second-order convergence rate of the scheme.

**MS-Th-BC-28-3** 10:50–11:15

**Efficient Numerical Methods for Forward Forward Doubly Stochastic Differential Equations and Their Applications to Nonlinear Filtering Problems**

Cao, Yanzhao  
Auburn Univ.

Abstract: Nonlinear filtering problems arise in many application fields such as financial mathematics, signal processing, target tracking, and biological sciences. As a class of stochastic computing problems, high dimensionality and low regularity are the bottlenecks of solving nonlinear filtering problems. In this talk, we present a class high order numerical methods for nonlinear filtering problems through construction of high order methods for forward backward doubly stochastic differential equations.

**MS-Th-BC-28-4** 11:15–11:40

**Numerical Approximation of Switching Problems**

Chassagneux, Jean-francois  
Imperial College London

Abstract: We use the representation of Switching Problems as obliquely reflected BSDEs to obtain a numerical approximation of the solution. We thus focus on the discretization of the obliquely reflected BSDEs. By proving a stability result for the Euler scheme associated to the BSDEs, we are able to obtain convergence result in the case where the driver of the BSDEs depends on . This is a joint work with A. Richou.

**MS-Th-BC-28-5** 11:40–12:05

**Fourier Cosine Expansions for Backward Stochastic Differential Equations in Finance**

Oosterlee, Cornelis  
CWI -center for mathematics & computer Sci.

Abstract: In this presentation we will explain how Fourier cosine expansions can be used to solve BSDEs originating from finance. By solving BSDEs, we can find the solution of a time-dependent PDE by means of the computation of conditional expectations. We have developed a Fourier technique to deal with BSDEs efficiently called the BCOS method ("BSDE COS method"), based on a time-stepping procedure. The resulting discrete schemes have a close connection to fundamental solutions of PDEs, and their Fourier transforms, and also to the characteristic function, which is the Fourier transform of the probability density function, well-known in probability theory. We will solve BSDEs appearing in finance with second-order accuracy in time.

**MS-Th-BC-29** 10:00–12:00

**Numerical Homogenization and Multiscale Model Reduction Methods - Part I of V**

For Part 2, see MS-Th-D-29
For Part 3, see MS-Th-E-29
For Part 4, see MS-Fr-D-29
For Part 5, see MS-Fr-E-29

Organizer: Zhang, Lei  
Shanghai Jiao Tong Univ.
Organizer: Peterseim, Daniel  
Universität Bonn
Organizer: Jiang, Lijian  
Hunan Univ.
Organizer: Chung, Eric  
The Chinese Univ. of Hong Kong

Abstract: Problems that transcend a variety of strongly coupled time and length scales are ubiquitous in modern science and engineering such as physics, biology, and materials. Those multiscale problems pose major mathematical challenges in terms of analysis, modeling and simulation. At the same time, advances in the development of multiscale mathematical methods coupled with continually increasing computing power have provided scientists with the unprecedented opportunity to study complex behavior and model systems over a wide range of scales. This minisymposium is aimed at presenting the state-of-the-art in multiscale modeling, simulation and analysis for the applications in science and engineering. It will focus on the developments and challenges in numerical multiscale methods and multiscale model reduction methods. The lectures will cover the following subjects: - Numerical homogenization methods, e.g., Generalized FEM, MsFEM, FEM-HMM, DG methods, Partition of Unity methods, multiscale domain decomposition etc. - Multiscale model reduction method-
Multiscale Approximations for Mixed Finite Element Methods

Peterseim, Daniel
Universität Bonn

Abstract: We introduce a new Petrov-Galerkin multiscale method for the numerical approximation of the Helmholtz equation with large wave number $k$ in bounded domains. The discrete spaces are generated from standard mesh-based finite elements by local subscale corrections in the spirit of numerical homogenization. If the mesh size $H$ and the oversampling parameter $I$ are such that $Hk$ and $\log(k)/I$ fall below some generic constants, the method is stable and accurate; pollution effects are eliminated.

Fast Multiscale Gaussian Wavepacket Transforms and Multiscale Gaussian Beams for Wave Equations

Qian, Jianliang
Michigan State Univ.

Abstract: We develop new multiscale Gaussian beam methods for initial boundary value problems of wave equations in the high frequency regime. The starting tools are fast multiscale Gaussian wavepacket transforms and Gaussian beams. 2-D and 3-D examples demonstrate the performance of the new method.

Multi-scale Methods for Elliptic Equations with Highly Oscillatory Periodic Diffusion Coefficients and Stochastic Potentials

Jing, Wenjia
Univ. of Chicago

Abstract: We study the limiting distribution of the random part of the homogenization error of elliptic equations with highly oscillatory periodic diffusion coefficients and highly oscillatory random potentials. We characterize this distribution theoretically, and then study finite element based multi-scale methods for such equations, and emphasize their performances not only in capturing the homogenization limit, but also in capturing this limiting fluctuations.

Multiscale Approximations for Mixed Finite Element Methods

Henning, Patrick
Univ. of Muenster

Abstract: We propose and analyze a mixed finite element method for solving elliptic multiscale problems. The method is based on a localized orthogonal decomposition (LOD) of Raviart-Thomas finite element spaces. It requires to solve local problems in small patches. These computations can be perfectly parallelized and are cheap to perform. Using these local results, we construct a low dimensional “generalized” mixed finite element space for solving the original saddle point problem in an efficient way.

Numerical approaches in optimization with PDE constraints: recent progress and future challenges - Part III of VII

For Part 1, see MS-We-D-31
For Part 2, see MS-We-E-31
For Part 3, see MS-We-D-30
For Part 4, see MS-We-F-30
For Part 5, see MS-We-E-30
For Part 6, see MS-We-D-30
For Part 7, see MS-We-F-30

Organizer: Yan, Ningning
Chinese Acad. of Sci.
Organizer: Hinze, Michael
Universität Hamburg

Abstract: The numerical treatment of optimization problems with PDE constraints is a very active field of mathematical research with great importance for many practical applications. To achieve further progress in this field of research, the development of tailored discretization techniques, adaptive approaches, and model order reduction methods has to be intertwined with the design of structure exploiting optimization algorithms in function space. This minisymposium covers mathematical research in PDE constrained optimization ranging from numerical analysis and adaptive concepts over algorithm design to the tailored treatment of optimization applications with PDE constraints. It thereby forms a platform and fair for the exchange of ideas among young researchers and leading experts in the field, and for fostering and extending international collaborations between research groups in the field.

Analysis and Optimal Control of A Gradient Enhanced Damage Model

Susu, Livia
TU Dortmund
Meyer, Christian
TU Dortmund

Abstract: The talk is concerned with a damage model including two damage variables, a local and a non-local one, which are coupled through a penalty term in the free energy functional. After introducing the precise model, we prove existence and uniqueness for the viscous regularization thereof. Moreover, we rigorously study the limit for penalization parameter tending to infinity. It turns out that in the limit both damage variables coincide and satisfy a classical viscous damage.

Reduced-order Control Design for the Monodomain Equations

Breiten, Tobias
Karl-Franzens-Universität Graz
Kunisch, Karl
Univ. of Graz

Abstract: The monodomain equations represent a reasonably accurate model for the electric potential of the human heart. The PDE-ODE structure of the linearized model leads to a system that is not null controllable but that can still be stabilized by finite dimensional controllers. This allows for constructing the controller based on model reduction techniques. While the reduced model is obtained from the linearized system, it is shown that it locally stabilizes the nonlinear system as well.

Computational Optimal Control of the Current Profile Evolution in Fusion Plasma

Xu, Chao
Zhejiang Univ.

Abstract: The central task of current profile control during the ramp-up phase of a tokamak discharge is to find the actuator trajectories that are necessary to achieve certain desired current profile at some time between the end of the ramp-up phase and early stage of the flat top phase. We solve open loop optimal control problems with respect to the magnetic diffusion PDE models the dynamics of the poloidal magnetic flux profile of fusion plasma in tokamaks.

Liquidity Adjusted Futures Pricing Model

Zhang, Yongmin
Univ. of Nottingham Ningbo China

Abstract: This paper proposes a new model introducing liquidity risk factor into the futures pricing model. Empirically, we find that the liquidity adjusted futures pricing model is more accurate than the classical model and the improvement rate is around 30%. More importantly, unlike the existing model, our model can be applied in both spot price predictions and futures price predictions purely based on historical market information. The model does an impressive work since all prediction errors are less than 1.6%, which is well below the historical oil return volatility. As a result, the model is likely useful in studies of asset pricing with liquidity risk but also has price forecasting research implications. We also discover a coupling effect of liquidity and maturity through a theoretical study on solutions of partial differential equations with various inputs of liquidity levels and maturities. Our two dimensional PDE models can be extended to solve American type derivative products with liquidity adjustment.

Integration, Approximation and Discrepancy - Part III of III

For Part 1, see MS-We-D-31
For Part 2, see MS-We-E-31

Organizer: Ulbrich, Mario
Johannes Kepler Univ.
Organizer: Gnewuch, Michael
Christian-Albrechts-Universität zu Kiel

Abstract: Numerical methods for high dimensional integration and approximation play a crucial role in a number of applications. This session brings together experts from the areas of integration, approximation, discrepancy theory, information-based complexity, potential theory, and partial differential equations (PDE) to discuss numerical methods for these types of problems. In this context, well distributed point sets are important. The generation of good point sets for various problems as well as bounds for their discrepancy and integration error will be covered in the minisymposium. Particular emphasis is given to the dependence of the results on the dimension. Approximation of functions is intimately related with the integration problem and the proposed minisymposium should stimulate the exchange between both communities.

Fully Discrete Needlet Approximation on the Sphere

Wang, Yuguang
Univ. of New South Wales

Abstract: Spherical needlets provide a multiscale decomposition of real square integrable functions on the unit sphere. The original spherical needlet decomposition has its coefficients defined by inner product integrals. We use an additional quadrature rule to construct a fully discrete version of the original
needlet approximation and prove the convergence error for smooth spherical functions. The theory is illustrated numerically by the approximation for a function of known smoothness, using symmetric spherical designs.

**MS-Th-BC-31-2**

**Best Restriction Approximation of Sobolev Classes by Entire Functions of Exponential Type**

Ling, Bo

Xiyan Univ.

Abstract: We consider the best restriction approximation of some generalized Sobolev classes using entire function of exponential type, as well as the relative average width of these classes, and obtain some asymptotic results.

**MS-Th-BC-31-3**

**Construction of Low-discrepancy Sequence According to An Unnormalized Density**

Zhu, Houying

The Univ. of New South Wales

Dick, Josef

The Univ. of New South Wales

Abstract: Generating samples from a probability distribution is a common problem occurring in mathematics, statistics and computer science. For an unnormalized target distribution, we propose sampling methods based on optimization when direct simulation is not possible or expensive. We are interested in the discrepancy properties of point sets constructed this way. It can be shown that these points have the correct distribution and small discrepancy. This is a joint work with Josef Dick.

**MS-Th-BC-31-4**

**The Sharp Jackson Inequality for L^2**

Approximation on the Cylinder

Gu, Yi

Yunnan Univ.

Abstract: We consider Jackson inequality in L^2([B^d × T, W_2^{s,p}(x)]) where the weight function W_2^{s,p}(x) is defined on the ball B^d and related to reflection group, and obtain the sharp Jackson inequality.

**MS-Th-BC-32**

**Structured-mesh methods for interface problems. - Part IV of VIII**

For Part 1, see MS-Tu-E-32

For Part 2, see MS-We-D-32

For Part 3, see MS-We-E-32

For Part 5, see MS-Th-D-32

For Part 6, see MS-Th-E-32

For Part 7, see MS-Fr-D-32

For Part 8, see MS-Fr-E-32

Organizer: Chen, Huanzhen

College of Mathematical Sci. Shandong Normal Univ.

Organizer: He, Xiaoming

Missouri Univ. of Sci. & Tech.

Organizer: KWAK, Do Young

Korea Advanced Inst. of Sci. & Tech.

Organizer: Zhang, Xu

Purdue Univ.

Abstract: In many real world applications it is more convenient or efficient to utilize structured meshes for solving different types of interface problems. Since the structured meshes may not fit the non-trivial interfaces, special methods need to be developed to deal with the difficulties arising from the interface problems in order to solve them on these meshes. Therefore, great efforts have been made for solving interface problems and tracing the moving interfaces based on structured meshes in the past decades. This mini-symposium intends to create a forum for researchers from different fields to discuss recent advances on the structured-mesh numerical methods for interface problems and their applications.

**MS-Th-BC-32-1**

**Adaptive Finite Element Algorithms for Structured-mesh Methods for Interface Problems**

Zhang, Shun

City Univ. of Hong Kong

Abstract: In this talk, we will talk about a posteriori error estimates and adaptive algorithms for structured-mesh methods for interface problems. For interface problems, immersed finite elements can handle the un-alignment of interface and computational grids well. On the other hand, such problems often have low regularity near the intersections of interfaces, which need adaptive refinements to handle. We will discuss algorithms combining these two features.

**MS-Th-BC-32-2**

**Finite Element Method for Stokes Interface Problem**

SANCHEZ-URIBE, MANUEL

Brown Univ.

Guzman, Johnny

Brown Univ.

Abstract: We present higher-order piecewise continuous finite element methods for solving the Stokes interface problem in two dimensions. We develop the method based on corrections added to the standard Stokes variational formulation, allowing us to implement and analyze a variety of finite element spaces. We prove optimal error estimates of the method on general quasi-uniform and shape regular meshes in maximum norms.

**MS-Th-BC-32-3**

**Computation of the Schroedinger Equation in the semiclassical regime on unbounded domain**

Jiwei, Zhang

Beijing Computational Sci. Research Center

YANG, XU

Univ. of California, Santa Barbara

Abstract: The study of this paper is two-fold: (1) local absorbing boundary conditions (ABCs) are generalized to compute the Schrödinger equation on unbounded domain; then (2) a new asymptotic method based on the frozen Gaussian approximation. The ABCs are dealt that all effects of the Gaussian functions which contribute to the outgoing waves will be eliminated by stopping Hamiltonian flow of their centers when they get out of the domain of interest.

**MS-Th-BC-32-4**

**Immersed Finite Element Methods for Interface Problems**

Lin, Tao

Mathematics

He, Xiaoming

Missouri Univ. of Sci. & Tech.

Abstract: This is a brief introduction to immersed finite element (IFE) methods which can use interface-independent (Cartesian) meshes to solve interface problems even for interfaces with non-trivial geometries. Starting with basic ideas of IFE methods, we will discuss fundamental analysis for IFE methods, highlighting some essential differences between FE and IFE methods. We will then illustrate features of IFE methods with applications. We will conclude with a list of future research topics for IFE methods.

**MS-Th-BC-33**

**Mathematical Modelling, Analysis and Computation for Bose-Einstein condensation - Part III of III**

For Part 1, see MS-We-D-33

For Part 2, see MS-We-E-33

Organizer: Wang, Hanquan

Yunnan Univ. of Finance & Economics

Abstract: Recently, modeling and simulation of Bose-Einstein condensates (BEC) at zero temperature are one of most interesting research topics in physics as well as applied mathematics. At such low temperature, different kinds of BEC can be modeled by the famous Gross-Pitaevskii equation (GPE) or coupled GPEs or nonlocal GPE(s). How to analyze and solve the GPE(s) for understanding the physics of BEC is interested by mathematicians and physicists. In this minisymposium, we aim to discuss the mathematical properties of these nonlinear Schrödinger type models, find solutions to those models both analytically and numerically, do numerical analysis for efficient numerical methods, and show their applications into simulation of BEC and related physics. This minisymposium with be helpful to design efficient numerical methods for nonlinear Schrödinger type equation. It can also be helpful for applied mathematician to share their latest research work with physicists who are working on research of BEC and related physics.

**MS-Th-BC-33-1**

**On Multichannel Solutions of Nonlinear Schrödinger Equations: Algorithm, Analysis and Numerical Explorations**

Zhao, Xiaofei

National Univ. of Singapore

Abstract: We apply the method of modulation equations to numerically solve the NLS with multichannel dynamics, given by a trapped localized state and radiation. This approach employs the modulation theory of Soffer-Weinstein, which gives a system of ODE’s coupled to the radiation term, which is valid for all times. We comment on the differences of this method from the well-known method of collective coordinates.

**MS-Th-BC-33-2**

**Numerical and Asymptotic Results for Modified GP Equation**

Ruan, Xinran

National Univ. of Singapore

Abstract: The Gross-Pitaevskii (GP) equation plays a central role in the understanding of BEC. The two-body nonlinear term is parameterized by the s-wave scattering length. However, higher order corrections are needed for better approximations in some cases. With the correction, we get the modified GP model: \(i\partial_t \psi = -\frac{1}{2} \Delta \psi + V(x) \psi + |\psi|^4 \psi - \Delta (|\psi|^2) \psi\). In my talk, I will discuss some numerical and asymptotic results for the model. Two special kinds of potentials are considered. I will also study the dimension reduction problem.

**CP-Th-BC-33-3**

**Bifurcation Diagrams of Positive Solutions of A Prescribed Mean Curvature Problem**

11:00–11:20
Abstract: We study global bifurcation diagrams and exact multiplicity of positive solutions for the one-dimensional prescribed mean curvature problem arising in Microelectromechanical systems (MEMS).

Simulations of Particle Structuring Driven by Electric Fields
Hu, Yi
Vlahovska, Petia
Miksis, Michael
Northwestern Univ.
Brown Univ.
Northwestern Univ.

Abstract: Recent experiments (Ouriemi & Vlahovska, 2014) show intriguing surface patterns when a uniform electric field is applied to a droplet covered with colloidal particles. Depending on the particle properties and the electrical field intensity, particles organize into an equatorial belt, pole-to-pole chains, or dynamic vortices. Here we present simulations of the collective particle dynamics, which account for electrohydrodynamic flow and dipole-dipole interactions. Our results provide insight into the various particle assemblies observed in the experiments.

Advances in optimal experimental design
Organizer: Hu, Xin
Organizer: Long, Yuan
Organizer: Marzouk, Youssef
Organizer: TEMPONE, RAUL
KING ABDULLAH Univ. OF Sci. & Tech.
Massachusetts Inst. of Tech.
Massachusetts Inst. of Tech.

Abstract: The challenge of optimal information gathering-for the purpose of inference, prediction, design, or control-pervades fields ranging from geophysics to chemical engineering and beyond. These questions can be formalized through the framework of optimal experimental design. Yet extending classical design methodologies to tackle problems of greater scale and dynamic, or stochastic, complexity, and to find optimal sequential designs, requires new algorithms and formulations. This minisymposium will gather a wide variety of approaches focusing on design for large-scale inverse problems and non-linear models, design in the presence of model error, and the approximation and optimization of information metrics. Relevant techniques include surrogate modeling, model reduction, sparse quadrature, asymptotic approximations, PDE-constrained optimization, stochastic optimization, and approximate dynamic programming. We invite contributions focused on methodology and motivated by engineering and science applications.

Computational Methods for Parameter Estimation and Optimal Experimental Design
Chung, Matthias
Krueger, Justin
Virginia Tech
Virginia Tech

Abstract: Experimentalists face the dilemma of choosing between the accuracy and costs of an experiment. Optimization methods form the basic computational tools to address fundamental questions of optimal experimental design. Driven by its application, optimal experimental design leads to challenging Bayes risk minimization problems. We address challenges such as ill-posedness of the parameter estimation problem and large scales of ODE systems. We present a design framework for dynamical systems and illustrate its performance on biological models.

Optimal Sequential Experimental Design Using Dynamic Programming and Transport Maps
Huan, Xin
Marzouk, Youssef
Massachusetts Inst. of Tech.
Massachusetts Inst. of Tech.

Abstract: How to select a sequence of experiments that maximizes value of information? Optimization methods form the basis of computational tools to address fundamental questions of optimal experimental design. Driven by its application, optimal experimental design leads to challenging Bayes risk minimization problems. We address challenges such as ill-posedness of the parameter estimation problem and large scales of ODE systems. We present a design framework for dynamical systems and illustrate its performance on biological models.

Scalable Methods for Optimal Experimental Design and Optimal Control for Systems Governed by PDEs with Uncertain Parameters
Alexanderian, Allen
The Univ. of Texas at Austin

Abstract: We formulate an A-optimal experimental design criterion for infinite-dimensional nonlinear Bayesian inverse problems. Our method aims to minimize the average variance of a Gaussian approximation to posterior law of inversion parameters by solving a bi-level PDE-constrained optimization problem. I will also discuss risk-averse optimization under uncertainty with application to optimal control of PDEs with uncertain parameter fields. We use numerical results for a porous medium flow problem with uncertain permeability to illustrate the methods.

Fast Bayesian Optimal Experimental Design and Its Applications
Long, Quan
King Abdullah Univ. of Sci. & Tech.

Abstract: We analyze Laplace method in the context of optimal Bayesian experimental design and extend this method from the classical scenario, where a single dominant mode of the parameters can be completely determined by the experiment, to the scenarios where a non-informative parametric manifold exists. While Laplace method requires a concentration of measure, multi-level Monte Carlo method can be used to tackle the problem when there is a lack of measure concentration.
Boundary and interior layers: analysis and simulations - Part II of II

MS-Th-BC-37-2 10:30–11:00
Verifying the analysis and simulations - Part II of II

Jie, Chen Beijing Inst. of Tech.
Ma, Liqiu Beijing Inst. of Tech.
Jie, Chen Beijing Inst. of Tech.

Abstract: Cellular automata can imitate complex discrete model just through repeating simple action. In particular, for the dissemination and diffusion problem of many physical phenomena such as fluid flows, semiconductor device simulation or in financial models etc. The mini-symposium will be concerned with in cases of where the solution contains deep gradients exhibiting the boundary layers or interior layers. For such problems, standard discretization methods such as a Galerkin finite element method or classical finite difference methods yield inaccurate oscillatory solutions. These layers are characterized by rapid transitions in the solution, and thus are very difficult to capture the solutions accurately without using a large number of unknowns or using fitted meshes in the layer regions. The aim of this mini-symposium is to exchange ideas and explore novel techniques for resolving the boundary or interior layers while simulating the non-smooth model problems.

Some DG Methods for Singularly Perturbed Volterra Integro-Differential Equations

Xie, Ziqing Hunan Normal Univ.

Abstract: To our knowledge, there are much less works on the uniform convergence of numerical methods for singularly perturbed Volterra integro-differential equations (VIDES) compared with those on singularly perturbed differential equations. In this talk, some DG methods are implemented for solving singularly perturbed Volterra VIDES. Some interesting phenomena are observed from our numerical experiments and then verified theoretically. More importantly, combined with some local grid-refinement strategies, the uniform convergence or super-convergence of our approaches are rigorously established.

A Numerical Far Field Boundary Condition for Anisotropic Laplace Operators

Wang, Wei-Cheng Department of Mathematics, National TsingHua Univ.

Abstract: The report aims to present some recent theoretical progresses in several brunches of complex systems analysis and some further applications: 1) Study of haze generation and diffusion with cellular automata method; 2) Event-trigger control for systems with saturation nonlinearity; 3) Accurate identification under set-valued data and adaptive control of set-valued systems; 4) Stochastic event systems seeking for discrete-time linear systems.

The Simulation of Haze Generation and Diffusion Within Beijing Based on Cellular Automata

Deng, Fang Beijing Inst. of Tech.
Ma, Liqiu Beijing Inst. of Tech.
Jie, Chen Beijing Inst. of Tech.

Abstract: Cellular automata can imitate complex discrete model just through repeating simple action. In particular, for the dissemination and diffusion problem of many physical phenomena such as fluid flows, semiconductor device simulation or in financial models etc. The mini-symposium will be concerned with in cases of where the solution contains deep gradients exhibiting the boundary layers or interior layers. For such problems, standard discretization methods such as a Galerkin finite element method or classical finite difference methods yield inaccurate oscillatory solutions. These layers are characterized by rapid transitions in the solution, and thus are very difficult to capture the solutions accurately without using a large number of unknowns or using fitted meshes in the layer regions. The aim of this mini-symposium is to exchange ideas and explore novel techniques for resolving the boundary or interior layers while simulating the non-smooth model problems.
Zuo, Zhiqiang  
Tianjin Univ.

Abstract: This talk discusses the event-triggered control for systems in the presence of saturation nonlinearities. The state/output feedback controllers and the anti-windup scheme for saturated systems using event-triggered strategy under different trigger conditions are presented. It is shown that the domain of attraction has close relationship to trigger conditions and there is a tradeoff between the size of domain of attraction and the communication burden. Some future research directions are finally discussed.

MS-Th-BC-38-3 11:00–11:30
Identification and Adaptive Control under Set-Valued Data
Zhao, Yanlong  
Acad. of Mathmatics & Sys. Sci., CAS

Abstract: This talk introduces the accurate identification and control under set-valued data, which is a type of inaccurate data emerged with the development of industrialization, informatization and biological techniques. The main difficulty is that the classic methods don’t work since the information of set-valued observation is only whether the measurement is in some sets. This talk contains a series of work on the identification and adaptive control of set-valued systems.

MS-Th-BC-39 10:00–12:00 302B
Extremum Seeking and its Applications
Organizer: Liu, Shijun  
Sichuan Univ.

Abstract: Extremum seeking (ES) is a real-time non-model based optimization approach and also a method of adaptive control. In recent years, many great progresses have been made in both theoretical development of extremum seeking and its engineering applications. The minisymposium aims to present recent advances in the ES, including 1) fast extremum seeking in dynamic systems; 2) improvement of extremum seeking control; 3) source seeking scheme via discrete-time extremum seeking; 4) applications of extremum seeking in non-cooperative games.

MS-Th-BC-39-1 10:00–10:30
Fast Extremum Seeking in Dynamic Systems
Manzie, Christopher  
Univ. of Melbourne

Abstract: In this presentation, extensions to extremum seeking that enable faster convergence to the steady state optimum performance of dynamic systems will be developed. Partial system information, which is reasonable in the context of most engineering applications, will be used to lessen the time scale separation requirements of the components of traditional extremum schemes. The theoretical results will be supported by simulation and application examples.

MS-Th-BC-39-2 10:30–11:00
The Removal of Time-scale Separation in Extremum-seeking Control
Guay, Martin  
Queen’s Univ.

Abstract: In this talk, we will discuss a new approach to address the removal of time-scale separation in the design of extremum-seeking controllers for unknown non-linear dynamical systems. A proportional integral extremum seeking controller design approach is proposed to minimize the impacts of time-separation on the transient performance of control systems. The application of the proportional-integral approach to feedback stabilization and observer design will be discussed.

MS-Th-BC-39-3 11:00–11:30
Multi-agent Source Seeking via Discrete-time Extremum-seeking Control
Ying, Tan  
The University of Melbourne

Abstract: Recent developments in extremum seeking theory have established a general framework for the methodology, although the specific implementations, particularly in the context of multi-agent systems, have not been demonstrated. In this work, a group of sensor-enabled vehicles is used in the context of the extremum seeking problem using both local and global optimization algorithms to locate the extremum of an unknown scalar field distribution.

MS-Th-BC-39-4 11:30–12:00
Discrete-time Stochastic Extremum Seeking and Its Applications
Liu, Shu-Jun  
Sichuan Univ.

Abstract: We employ our recently developed discrete-time stochastic averaging theorems and stochastic extremum seeking to iteratively optimize open-loop control sequences for unknown but reachable discrete-time linear systems with a scalar input and without known system dimension, for a cost that is quadratic in the measurable output and the input.

MS-Th-BC-40 10:00–12:30 303A
Modeling, Analysis, and Control for Distributed Parameter Systems
Organizer: Yao, Pengfei  
AMSS, Chinese Acad. of Sci.

Abstract: Distributed parameter systems are systems whose state space is infinite-dimensional. Modeling, analysis, and control of distributed parameter systems are theoretically challenging and technically important in real-world applications. The minisymposium aims to present the state-of-the-art progress in modeling, analysis, and control of several distributed parameter systems, including 1) modeling for cavititation of membrane shells; 2) boundary proportional and integral control/regularization of a fluid flow system governed by hyperbolic partial differential equations; 3) periodicity and regularity principle for conservative evolutionary partial differential Equations; 4) dissipativity of switched systems using multiple storage functions.
Maximum Regularity Principle will be proposed to understand where those “hidden regularities” come from and how to use them.

**MS-Th-BC-41**

**Advanced Control Theory of Complex Systems**

Organizer: TCCT Technical Committee on Control Theory, CAA

Abstract: Complex systems are systems formed out of many components whose behavior is emergent, which is, the behavior of the systems cannot be simply inferred from the behavior of their components. The complex nature makes the advanced control of the systems theoretically challenging and technically important in latest control research. The minisymposium aim to reveal the recent progress in advanced control research of several classes of complex systems, including 1) study of equilibrium state control theory; 2) examination for big data in industrial processes analysis and its applications; 3) analysis for uncertain negative-imaginary systems and its applications; 4) a control-theoretic study of iteratively solving nonlinear equations.

**Equilibrium State Control Theory**

Wang, Qinglin
Beijing Inst. of Tech.

Abstract: The Equilibrium State Control Theory is a novel control method for control systems, which considers that the indirect control to state and output can be realized when the movement of equilibrium state is controlled. This idea gives new solutions for the state-space, and also can be applied in the feedback linearization for the nonlinear time-varying systems. It provides a new point of view for the control systems design.

**Fault Detection Using Knowledge**

Yingwei, Zhang
Northeastern Univ

Abstract: In this paper, a new fault diagnosis method for industrial process is proposed. Knowledge learning is proposed to build the mathematical model and train the offline data. For process monitoring and fault detection, experience is quite important. In this paper, few experience data is used to be labeled data by experts for extracting knowledge, and online process data can be monitored by using the knowledge.

**Analysis of Uncertain Negative-imaginary Systems and Its Applications**

Song, Zhuoyue
Beijing Inst. of Tech

Abstract: Negative-imaginary systems have important engineering applications, for example, in lightly damped flexible structures with collocated position sensors and force actuators. In this talk, robustness analysis and controller synthesis methods for uncertain negative-imaginary systems are explored. Some preliminary results about engineering applications of negative-imaginary systems will also be discussed.

**A Control-theoretic Study of the Iterative Solutions to Nonlinear Equations**

Yang, Ying
Ding, Steven
Univ. of Duisburg Essen

Abstract: In this talk, the fixed point iteration and Newton’s methods for iteratively solving nonlinear equations, and the Runge-Kutta methods for solving nonlinear ordinary differential equations are studied in the control theoretical framework. This work is mainly motivated by the increasing demands on the reliability of integrating the fast converging iterative solutions of nonlinear equations into the embedded control systems.

**Cooperative Control and Multi-Agent Systems III**

Organizer: TCCT Technical Committee on Control Theory, CAA

Abstract: Recent advances in sensing, communication and computation technologies have enabled a group of agents, such as robots, to communicate or sense their relative information and to perform tasks in a collaborative fashion. The past few years witnessed rapidly-growing research in cooperative control technology. Multi-agent system (MAS) is a computerized system composed of multiple interacting intelligent agents within an environment. Multi-agent systems can be used to solve problems that are difficult or impossible for an individual agent or a monolithic system to solve. The aim of this minisymposium is to share novel approaches and innovative applications of cooperative control and MAS, including: 1) vector space structure of finite games; 2) constrained consensus problem in the presence of communication delays; 3) price analysis of anarchy via smooth games; 4) connectivity preservation control of multiple Euler-lagrange Systems.
problems involving uncertain parameters. The parameters are assumed to be contained in a given uncertainty set. We propose approximations of the robust counterpart based on linear or quadratic models which leads to a tractable problem. We show applications to the robust optimization of a permanent magnet synchronous motor geometry and to the robust geometry optimization of load-carrying structures governed by the elastodynamic wave equation.

**Limited Memory Steepest Descent Methods for Large-Scale Optimization**

**Abstract:** We present a limited memory steepest descent method for solving large-scale optimization problems. Building off of well-known Barzilai-Borwein methods and a recently proposed enhancement by Fletcher, our approach is specifically designed to handle challenges that arise when a problem instance may be nonconvex. We also show enhancements of our approach for solving constrained problems within a sequential linearly constrained framework.

**A Slightly Changed ADMM for Three Block Separable Convex Optimization**

**Abstract:** Alternating directions method of multipliers (ADMM) is recognized as a powerful approach for the structured convex optimization with two separable operators. When ADMM is extended directly to a three-block separable convex minimization model, it was recently shown that the convergence is not guaranteed. This talk will give a slightly changed ADMM for solving multi-block separable convex optimization. We show the contraction property, prove the global convergence and establish the worst-case convergence rate of the method.

**On the Computational Power of Constant-Depth Exact Quantum Circuits**

**Abstract:** We show that constant-depth polynomial-size exact quantum circuits with unbounded fan-out gates, called $\mathcal{QNC}_0^0$ circuits, are powerful. More concretely, we first show that there exists a $\mathcal{QNC}_0^0$ circuit for the OR function. This is an affirmative answer to the question of Hoyer and Spalek. Then, we show that, under a plausible assumption, there exists a classically hard problem that is solvable by a $\mathcal{QNC}_0^0$ circuit with gates for the quantum Fourier transform.

**Strong Monogamy of Quantum Entanglement for Multi-party Quantum Systems**

**Abstract:** We introduce quantum information science and technology as a new multidisciplinary research field among mathematics, physics, computer science and engineering. This minisymposium focuses on the research field, in particular quantum computational algorithms, quantum cryptography, quantum information theory and entanglement theory. In this minisymposium, we introduce quantum information science and technology and their related mathematical problems to industrial and applied mathematicians, and present some of recent research results about quantum computation, entanglement theory and quantum information theory.

**Concentrated Information of Tripartite Quantum States**

**Abstract:** We introduce the concentrated information of tripartite quantum states. For three parties Alice, Bob, and Charlie, it is defined as the maximal mutual information achievable between Alice and Charlie via local operations and classical communication performed by Charlie and Bob. The gap between classical and quantum concentrated information is proven to be an operational figure of merit for a state merging protocol involving shared mixed states and no distributed entanglement. We derive upper and lower bounds on the concentrated information, and obtain a closed expression for arbitrary pure tripartite states in the asymptotic setting. We show that distillable entanglement, entanglement of assistance, and quantum discord can all be expressed in terms of the concentrated information, revealing the fundamental role of this concept in quantum information theory. (Joint work with Alexander Streltsov and Gerardo Adesso.)
assuming the TV regularization to be a prior and taking the statistical distribution of the covariance matrix in each resolution element into account, the variational model for PoSAR covariance data speckle suppression, named WisTV-C, is derived from the maximum a posteriori estimate. A similar variational model for PoSAR coherency data speckle reduction, named WisTV-T, is also obtained. As far as we know, this is the first variational model for the whole PoSAR covariance or coherency matrix data despeckling. Since the models are non-convex, a convex relaxation iterative algorithm is designed to solve the variational problem, based on the variable splitting and alternating minimization techniques. Experimental results on both simulated and real PoSAR data demonstrate that the proposed approach notably removes speckles in the extended uniform areas and, meanwhile, better preserves the spatial resolution, the details such as edges and point scatterers, and the polarimetric scattering characteristics, compared with other methods. This is a joint work with X Nie and H Qiao.

**MS-Th-BC-46**

10:00–12:00 306B

**Inverse Problems for Image Reconstruction and Processing - Part III of IV**

For Part 1, see MS-We-D-46

For Part 2, see MS-We-E-46

For Part 4, see MS-Th-D-46

**Organizer:** Wei, Suhua  Inst. of Applied Physics & Computational Mathematics

**Chen, Raymond**  The Chinese Univ. of Hong Kong

**Wei, Suhua**  Inst. of Applied Physics & Computational Mathematics

**Nikolova, Mila**  CMLA, CNRS - ENS Cachan

**Tai, Xue-Cheng**  Department of Mathematics, Univ. of Bergen

**Abstract:** Many image reconstruction tasks amount to solve ill-posed inverse problems. Indeed, measurement devices typically cannot record all the information needed to recover the sought-after object; furthermore, the operators that model these devices are seldom accurate and data are corrupted by various perturbations. A common approach to find an approximate to the unknown object is regularization. The key points are the correct choices of the data fidelity term and the regularization term, as well as the trade-off between these terms. This is a challenging problem since the optimal solutions of the whole functional should correctly reflect the knowledge on the data-production process and the priors on the unknown object. The optimal solutions usually cannot be computed explicitly and iterative schemes are used. This symposium focuses on imaging inverse problems mathematical models, numerical algorithms, theoretical analysis and various applications, especially, applied to CT reconstruction and some processing techniques for images.

**MS-Th-BC-46-1**

10:00–10:30

**High-order Total Variation Regularization Approach for Axially Symmetric Object Tomography from a Single Radiograph**

**Chen, Ke**  Univ. of Liverpool

**Williams, Bryan**  Univ. of Liverpool

**Zhang, Jianping**  Univ. of Liverpool

**Abstract:** We first discuss how to impose positivity constraint in the variational total variation model for restoration of images with noise and blur, highlighting our new method of implicitly imposing the constraint. Then, to simultaneously restore both the image and the kernel, we present our blind deconvolution work where positivity is crucial and such models will not work otherwise. Finally, I show some work on fractional order derivatives and their advantage of work where positivity is crucial and such models will not work otherwise. Finally, I show some work on fractional order derivatives and their advantage of work where positivity is crucial and such models will not work otherwise.

**MS-Th-BC-46-2**

10:30–11:00

**On Some Refined Variational Models for Restoration of Blurred Images**

**Suhr, Sebastian**  Univ. of Muenster

**Abstract:** We tackle the reconstruction problem of density images from indirect measurements with a novel variational approach: By implementing an appropriate modelling of the mass-conserving density transformation in the reconstruction process we obtain the first building block of our variational method. Suitable regularization for images with edges (total variation) and for reasonable deformations (hyperelastic) without self folding completes the functional. We focus on obtaining analytical results and conclude the talk with applications to cardiac PET.

**MS-Th-BC-46-4**

11:30–12:00

**Tomography from Few Projections: Weak Guarantees and Applications**

**Pietro, Stefania**  Univ. of Heidelberg

Abstract: We investigate conditions for unique signal recovery based on sparse and cosparse signal models from few tomographic projections. Although certain industrial tomographic sensors do not fulfill typical Compressed Sensing conditions, we show that the transition from non-recovery to recovery is sharp for specific sparse images. The signal class covered by both sparse and cosparse models seems broad enough to cover relevant industrial applications of non-standard tomography, like particle image velocimetry and contactless quality inspection.

**MS-Th-BC-47**

10:00–12:00 108

**Numerical methods for compressible multi-phase flows - Part IV of VI**

For Part 1, see MS-We-D-46

For Part 2, see MS-We-E-46

For Part 3, see MS-Th-E-46

**Organizer:** Wei, Suhua  Inst. of Applied Physics & Computational Mathematics

**Chen, Yibing**  Beijing Inst. of Applied Physics & Computational Mathematics

**Organizer:** Tiegang, Liu  Beijing Computational Sci. Research Center

**Organizer:** Sussman, Mark  Florida State Univ.

**Organizer:** Wang, Shuanghu  Institute of Applied Physics & Computational Mathematics

**Abstract:** Compressible multi-phase flows appear in many natural phenomena, and are very important in many applications, including space science, aerospace engineering, energy, homeland security, etc. Numerical calculation is a key for understanding many related problems. More and more numerical methods are being developed and improved. In this mini-symposium, novel numerical methods will be presented to show the progress in the area of compressible multi-phase flows, including interface capturing/tracking methods, phase change calculations, mixing methods, fluid-structure interaction methods, multi-physics calculations, adaptive mesh refinement, and high performance computing.

**MS-Th-BC-47-1**

10:00–10:30

**A Conservative Front-tracking Method on General Quadrangular Grids**

**Mao, De-kang**  Shanghai Univ.

**Abstract:** We have developed a front-tracking method for compressible fluid (described by the Euler system), which is within the ALE framework, runs on general quadrangular grids, and is based on the conservation properties of the fluids. The method allows the interface to cut grid cells, and inside the cut cells the locations of the interface segments are computed using the conservation properties of the fluids. Numerical results show that the method can simulate interfaces with large deformation.

**MS-Th-BC-47-2**

10:30–11:00

**High-orderADER Schemes for Compressible Multiphase Flows. Eleuterio Toro**

**Toro, Eleuterio**  Univ. of Trento

**Abstract:** We first review some typical mathematical models for compressible multiphase flows and point out some mathematical and numerical difficulties, such as hyperbolicity and conservation. We then put forward approaches for designing first-order monotone (for the scalar case) schemes based on the centred, the Godunov and the flux vector splitting approaches. Finally, on the basis of these ideas we propose high-order schemes with boundedness-preserving characteristics.

**MS-Th-BC-47-3**

11:00–11:30

**A Kinetic Scheme for Compressible Multi-phase Flows**

**Chen, Yibing**  Beijing Inst. of applied physics & computational mathematics

**Liu, Na**  Inst. of applied physics & computational mathematics

**Abstract:** An kinetic scheme is developed to solve the Baer-Nunziato model.
of compressible two-phase flows. Based on the kinetic theory, the conserva-
tive flux function of the model were split by the movement of micro-particles. A
well-balance condition is then introduced to determined the numerical scheme
of non-conservative terms. Thus both the conservative and nonconservative
terms were discreted in the same manner. A number of numerical results
show the robustness and good resolution of the new scheme.

MS-Th-BC-48 10:00–12:00 212B
Regularization methods for biomedical image analysis on manifolds - Part I of II
For Part 2, see MS-Th-D-48
Organizer: Chen, Chong Chinese Acad. of Sci.
Organizer: Dong, Guozhi Univ. of Vienna
Abstract: Inverse problems of functions defined on manifolds and Image anal-
ysis with data on surfaces are emerging topics, while the biomedical image
and many other biological data analysis provide one the main sources of these
problems. This minisymposium will be devoted to recent advances of regu-
larization methods and the related topics, with respect to biomedical image
analysis in the context of a manifold domain. The aim is to provide a platform
for researchers and scientists for exchanging ideas and developing new research
topics. It is supposed to contain two sections, and speakers consist of
both leading experts and young researchers.

A New Framework for the Statistical Analysis of Geometric-functional Dataset-
s’ Variability.
Charon, Nicolas Johns Hopkins Univ.
Abstract: In this talk, we will be interested in the problem of statistical analysis
and classification on populations of functional shapes, i.e geometrical shapes
that carry additional scalar signal. The main difficulty is to model and estimate
joint variations in shape and signal together. For that purpose, we propose a
mathematical and numerical framework to estimate atlases on such datasets
and simple tools to analyze resulting inter-subject variability among a popula-
tion.

A Multi-scale Geometric Flow Method for Molecular Structure Reconstruction
Chen, Chong Chinese Acad. of Sci.
Abstract: The aim of this study was to further upgrade both the computational
efficiency and accuracy of the L2-gradient flow method. In a finite-dimensional
space spanned by the radial basis functions, a minimization problem, com-
bined a fourth-order geometric flow with an energy decreasing constraint, is
solved by a bi-gradient method. The experimental results showed that the
proposed method yields more desirable results.

Parameter Estimation of An Adapted Mean-curvature Flow Model of Shape Evolution
Lefevere, Julien Aix-Marseille Universite
Abstract: This work has been initiated through the visual analogy between the early
cortical folding process and the smoothing of a brain surface by mean
curvature flow. We introduce a new geometric flow with one-parameter and
propose an efficient optimization strategy for parameter estimation involving
an energy depending only on volume and total area of the closed surface. Our
model is trained on brain data and reveals promising predictions for develop-
mental neuroscience.

Computational Evolving Manifolds in Biomedical Image Analysis
Mikula, Karol Slovak Univ. of Tech., Bratislava
Abstract: We present Lagrangean and Eulerian evolving manifold models and
computational approaches used for 3D and 4D image segmentation, 3D point
cloud surface reconstruction and 4D cell tracking with application in biomed-
ical image analysis and developmental biology.

Mathematical Theory of System and Control III: controllability and estimation of
partial differential equations, and stochastic dynamic programming
Organizer: Tang, Shanjian Fudan Univ.
Organizer: Zhang, Xu Sichuan Univ.
Abstract: The minisymposium concerns control of partial differential equa-
tions, analysis of stochastic systems and a population dynamic model. It is
one of the series of minisymposia on the mathematical theory of systems and
control.

Exact Controllability of Networks of Nonlinear Strings and Beams
Leugering, Guenter Univ. Erlangen-Nuremberg
Abstract: We consider networks of nonlinear strings and Timoshenko beam-
s as well as Cosserat networks. We provide the modeling, the analysis of
equilibrium solutions and show that the models can be reformulated in the
framework of the theory of Tatsien Li. We then provide local and global-
controllability results and also consider observability problems. This is joint
work with Tatsien Li and Quilong Gu.

On the Controllability of Viscous Fluid Equations with Non-constant Density.
Evedoza, Sylvain Institut de Mathematiques. de Toulouse
Abstract: In this talk, I will report on recent works on the local exact control-
lability to trajectories of viscous fluids when the density is assumed to be non-
constant. This includes in particular the case of compressible Navier-Stokes
equations or density dependent incompressible Navier-Stokes equations. In
both cases, the main trick is to develop Carleman estimates adapted to the
parabolic equation satisfied by the velocity field and to the transport equation
satisfied by the density.

A Primal-Dual Method for Stochastic Dynamic Programming
Chen, Nan The Chinese Univ. of Hong Kong
Abstract: We use the information relaxation technique to develop a primal-
dual iterative approach to solve stochastic dynamic programming problems.
In each iteration, we obtain confidence intervals for the optimal value so that
we can assess the quality of the currently used policy. We show the method
will converge to the true value in finite number of iterations.

Lp Theory for Linear Backward Stochastic Partial Differential Equations with
VMO Coefficients
Zhang, Fu Fudan Univ.
Abstract: Backward SPDEs arise in many applications of probability theory
and stochastic processes. The lack of the solution’s regularity brings huge
difficulty to study the property of the BSPDE. We study the Lp theory of the
solution to the BSPDE with measurable coefficients. The dual method, by
which Du, Qiu, and Tang [2012, AMO] study the Lp theory in the case that the
coefficients of the equation are Lipschitz continuous, could not be applied
here. We use the Green function representation of the linear BSPDE and
the technique of sharp function, to study the BSPDE directly, obtain a partial
Lp (≥ 2) estimate in the VMO coefficients case.

Mathematical and Numerical Aspects of Electronic Structure Theory - Part I of V
For Part 2, see MS-Th-D-50
For Part 3, see MS-Th-E-50
For Part 4, see MS-Fr-D-50
For Part 5, see MS-Fr-E-50
Organizer: Lin, Lin Univ. of California at Berkeley
Organizer: Lu, Jianfeng Duke Univ.
Abstract: Electronic structure theory and first principle calculations are among
the most challenging and computationally demanding science and engineer-
ning problems. This minisymposium aims at presenting and discussing new
developments of mathematical analysis, and numerical methods for achiev-
ing ever higher level of accuracy and efficiency in electronic structure the-
ory. This includes ground state and excited state density functional theory
calculations, wavefunction methods, together with some of their applications
in computational materials science and quantum chemistry. We propose to
bring together experts on electronic structure theory, which include not only
mathematicians, but also physicists working actively in the field.

Large-scale Real-space Electronic Structure Calculations
Gavini, Vikram Univ. of Michigan
Abstract: This talk presents the development of a real space approach to per-
form efficient large-scale Kohn-Sham density functional theory calculations
using an adaptive higher-order spectral finite-element discretization. Further,
the development of a sub-quadratic scaling subspace projection method that
treats both metallic and insulating systems in a single framework, and is appli-
cable to both pseudopotential and all-electron calculations, will be presented.
Corsetti, Fabiano  
CIC nanoGUNE

Abstract: The Electronic Structure Library (ESL) is a new initiative to create an online repository of software for use within electronic structure codes. One of the aims of the ESL is to give members of the community access to a diverse range of Kohn-Sham eigensolvers, in the form of fully functioning libraries. We focus on the libOMM library implementing the orbital minimization method, and discuss its efficiency for codes using a basis of finite-range atomic orbitals.

**Numerical Approaches for Solving the Optimal Transport Problem in the Strong-interaction Limit of Density Functional Theory**

Mendl, Christian  
Stanford Univ.

Abstract: For strongly interacting electronic systems, the Kohn-Sham formulation of density-functional theory leads to an optimal transport problem with Coulomb cost function. In this framework of "strictly correlated electrons" (SCE), we explore numerical approaches for solving the optimal transport problem based on finite-element discretizations of the electron density.

**Sparse Correction for Coupled Cluster Calculations**

Yang, Chao  
Lawrence Berkeley National Laboratory

Abstract: The coupled-cluster method is a highly accurate wavefunction method solving a many-body Schrödinger’s equation. However, its computational complexity scales as $O(N^4)$, where $N$ is the number of electrons. In this talk, we discuss a technique for reducing the cost of coupled-cluster calculation by exploiting the sparsity of the correction tensor in an inexact Newton method for solving the coupled-cluster nonlinear equation.

**Dynamics and information coding in neuronal systems - Part I of II**

For Part 2, see MS-Th-D-51

Organizer: Zhou, Douglas  
Shanghai Jiao Tong Univ.

Abstract: Computational neuroscience has experienced explosive growth over last two decades. It has helped to explain or even predict many neurological phenomena in experiment over scales ranging from molecular, single cellular to neuronal circuits. As more realism is incorporated into these models, novel dynamical features often arise which further enrich our understanding of the brain. This minisymposium explores this theme by discussing recent work in the modeling of both individual neuron dynamics and network topology, focusing upon implications on network behavior and information coding. The speakers will draw particular attention to new mathematical approaches in explaining sensory processing and information propagation.

**Subthreshold Oscillations, Multiple Delays, and Rhythms in the Olfactory System**

Karamchandani, Avinash  
Northwestern Univ.
Graham, James  
Northwestern Univ.
Meng, Hongyu  
Northwestern Univ., ESAM
Riecke, Hermann  
Northwestern Univ.

Abstract: Olfactory processing in the brain exhibits a number of rhythms, which signify enhanced coherence among many neurons. While the faster gamma rhythm is generated within the olfactory bulb, the slower beta rhythm which signify enhanced coherence among many neurons. While the faster gamma rhythm is generated within the olfactory bulb, the slower beta rhythm which signify enhanced coherence among many neurons. While the faster gamma rhythm is generated within the olfactory bulb, the slower beta rhythm which signify enhanced coherence among many neurons. While the faster gamma rhythm is generated within the olfactory bulb, the slower beta rhythm.

**Kinetic Monte Carlo Simulations of Multicellular Aggregate Self-Assembly in Biobfication**

Sun, Yi  
Univ. of South Carolina
Wang, Qi  
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: We present a 3D lattice model to study self-assembly of multicellular aggregates by using kinetic Monte Carlo (KMC) simulations. This model is developed to describe and predict the time evolution of postprinting structure formation during tissue or organ maturation in a novel biobfication technology—bioprinting. Here we simulate the self-assembly and the cell sorting processes within the aggregates of different geometries including vascular networks, which can involve a large number of cells of multiple types.

**A Stochastic Multiscale Model That Explains the Segregation of Axonal Microtubules and Neurofilaments in Neurological Diseases**

Xue, Chuan  
Ohio State Univ.

Abstract: The shape and function of an axon is dependent on its cytoskeleton, including microtubules, neurofilaments and actin. Neurofilaments accumulate abnormally in axons in many neurological disorders. An early event of such accumulation is a striking radial segregation of microtubules and neurofilaments. This segregation phenomenon has been observed for over 30 years now, but the underlying mechanism is still poorly understood. We present a stochastic multiscale model that explains these phenomena and generates testable predictions.

**Stochastic Dynamical Descriptions of Living Processes and Nonequilibrium Thermodynamics and Steady-State Cycle Kinetics**

Qian, Hong  
Univ. of Washington, Applied Mathematics

Abstract: Nonequilibrium thermodynamics (NET) concerns with transport processes. On a mesoscopic level and in terms of statistical descriptions of dynamics, various transport phenomena can all be quantitatively described in terms of a single entity: the flux that transports probabilities following Chapman-Kolmogorov equation. This explains why mesoscopic stochastic NET attains a universal formulation and appears as a branch of applied prob-
ability in its abstract form. We introduce this new theory through simple ex-
ample from biochemistry.

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<th>MS-Th-BC-52-4</th>
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<tr>
<td>Simulated Evolution on Fitness Landscape Constructed by Constraint Satisfaction Problems</td>
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<tr>
<td>Hu, Yucheng</td>
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<td>Tsinghua Univ.</td>
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**Abstract:** The complex structures of all proteins in nature are outcomes of random walk driven by mutation and selection. Reconstructing the fitness landscape from experimental measurements is difficult. Alternatively, in this paper we turn the popular Sudoku game into an artificial fitness landscape and use it as a model system to study sequence evolution under constraints. Insights gained from this prototype-protein may help us understand the complex evolutionary process of tightly folded proteins.

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<tr>
<th>MS-Th-BC-53</th>
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<tr>
<td>Modeling in Finance beyond classical paradigms</td>
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<td>Organizer: Ludkovski, Mike</td>
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<td>Organizer: Teichmann, Josef</td>
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<td>Organizer: Cuchiero, Christa</td>
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**Abstract:** Not only the value chain of certain products, but also other production factors, emission contents, income distribution have to be distribut-
ed correspondingly at a global perspective. We are facing with challenges in how to look at the global economy, thus it is very important to understand how GVCs work, how they affect the economic performance, how the economies benefit from GVCs, and so on. In this special session, we would like to answer some of the questions from several perspectives, including global value chain, and domestic and regional income inequality in China; Processing trade, heterogeneous techn-
ologies, and the structure of China’s DPN CGE model; emissions consider-
ing regional and firm heterogeneity in global value chains, trade-off between economic growth and quality.

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<th>MS-Th-BC-54-1</th>
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<tr>
<td>Processing trade, heterogeneous technologies, and the structure of China’s DPN CGE model</td>
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<td>Pel, Jianxu</td>
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<td>Yang, Cuihong</td>
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**Abstract:** China’s dual trade regime is featured by heterogeneous produc-
tion technologies. Processing trade uses higher proportion of imported goods in production composite; Whereas, production for normal exports and other domestic uses absorbs relatively smaller share of imported intermediates in the production recipe. One of the consequences is that, production technolo-
gies exhibit distinct heterogeneity, which is in line with heterogeneous firms’ theory. This paper constructs a DPN CGE model and its potential applications are discussed.

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<th>MS-Th-BC-54-2</th>
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<tr>
<td>Trade-off between Economic Growth Speed and Efficiency</td>
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<td>Fan, Jin</td>
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**Abstract:** We propose a new accounting framework to quantify the respec-
tive contributions of processing exports and ordinary exports to the regional income inequality from a value chain perspective. This is based on a newly developed Chinese interregional input-output table, which separates the pro-
cessing exports from the other products at regional level.

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<th>MS-Th-BC-54-3</th>
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<tr>
<td>Globalization and Regional Inequality Within China: A Domestic Value Chain Analysis</td>
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<td>Duan, Yuwan</td>
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**Abstract:** We propose a new accounting framework to quantify the respec-
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<th>MS-Th-BC-54-4</th>
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<tr>
<td>Spillover Effects of TTIP on BRICS Economies: A Dynamic GVC-Based CGE Model</td>
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<td>Cai, Songfeng</td>
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**Abstract:** A new unified approach that allows to strengthen the original results and establishes a novel connection with the Skorokhod embedding problem.

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<th>MS-Th-BC-54-5</th>
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<td>New advances in model order reduction: methods, algorithms, and applications - Part II of II</td>
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<td>For Part I, see MS-We-E-55</td>
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**Abstract:** This minisymposium intends to bring together new progress in different aspects of model order reduction (MOR): methods, algorithms and applications. The topics include various MOR methods: interpolatory method, reduced basis method, POD, for various complex systems: linear, nonlin-
ear, parametric, and for various applications: flow control, population balance sys-
tem, neutral delayed system, chromatography, uncertainty quantification, electromagnetics, vibro-acoustics systems, coupled systems. The speakers are quite international and have senior research experiences in MOR.
MS-Th-BC-55-1 10:00–10:30
Using Model Order Reduction for Computing Fast Frequency Sweeps of Vibro-acoustic Systems Described by Indirect Boundary Element Models
Lefteriu, Sandra
Ecole des Mines de Douai
Beriot, Hadrien
Siemens Industry Software
Souza Lenzi, Marcos
Universidade Federal do Para

Abstract: The matrices arising from boundary element discretizations of the Helmholtz equation are fully populated and their calculation is demanding, particularly for industrial applications. We propose a two-step algorithm for computing frequency sweeps with fine increments of vibro-acoustic systems. First, matrices are computed only at a few master frequencies, the rest being interpolated after an appropriate scaling. Second, we extrapolate the response by using derivative information and constructing Pade approximants via Well-Conditioned Asymptotic Waveform Evaluation (WCAWE).

MS-Th-BC-55-2 10:30–11:00
Interpolatory Model Reduction for Flow Control
Gugercin, Serkan
Virginia Tech
Borggaard, Jeff
Virginia Tech

Abstract: In this talk, we propose an interpolation framework for model reduction and describe a well studied flow control problem that requires model reduction of a large scale system of differential algebraic equations. We show that interpolatory model reduction produces a feedback control strategy that matches the structure of much more expensive control design methodologies.

MS-Th-BC-55-3 11:00–11:30
Circuit Model for Electromagnetics via the Reduced-Basis Method
De La Rubia, Valentin
Università Politecnica de Madrid

Abstract: In this work, the electromagnetic behaviour in microwave devices is described in terms of circuit theory. A transversal coupling matrix gathering all electromagnetic phenomena within a frequency band is found. As a result, further insight from the microwave point of view arises. A Finite Element Method approach is carried out for the electromagnetic analysis and a reliable reduced-order model for fast frequency sweep is proposed via the Reduced-Basis Method.

MS-Th-BC-55-4 11:30–12:00
Model Order Reduction for Uncertainty Quantification in Inverse and Risk Analysis
Chen, Peng
ETH Zurich (Swiss Federal Inst. of Tech. in Zurich)
Rozza, Gianluigi
SISSA, International School for Advanced Studies
Quarteroni, Alfio
EPFL

Abstract: We present some new advances of the development of model order reduction (MOR) techniques in the field of uncertainty quantification (UQ), in particular for inverse problems and risk analysis. We develop a goal-oriented MOR technique with effective a posteriori error estimation in order to choose the most representative reduced basis functions. The proposed technique for large computational reduction are demonstrated by two examples, Bayesian inversion for heat conduction and risk analysis for crack propagation.

MS-Th-BC-56 10:00–12:00
Fractional Partial Differential Equations II - Part IV of IV
MS-Th-BC-56-1 10:00–10:30
A Fast Gradient Projection Method for A Constrained Fractional Optimal Control
Du, Ning
Shandong Univ.
Wang, Hong
Univ. of South Carolina

Abstract: Fractional control problem introduces significantly increased computational complexity and storage requirement than the corresponding classical control problem due to the nonlocal nature of fractional differential operators. We develop a fast gradient projection method which greatly reduce the computational cost and memory requirement for a pointwise constrained optimal control problem governed by a time-dependent space-fractional diffusion equation. Numerical experiments show the utility of the method.

MS-Th-BC-56-2 10:30–11:00
Valuation of American Option under A Fractional Diffusion Model
Guo, Xu
Hong Kong Baptist Univ.

Abstract: We concentrate on the analytical study of American options under a particular exp-Lévy jump diffusion model, namely CGMYe model. The decomposition formula of the American option and the integral equation of the optimal-exercise boundary are derived. Moreover, an analytical approximation formula is obtained for the option value, which is valid for both short and long maturities. Numerical simulations are also provided for the European options and the optimal-exercise boundary for American options.

MS-Th-BC-56-3 11:00–11:30
A Fast Numerical Method for Space-fractional PDEs on A General Convex Domain
Jia, Jinhong
School of Mathematics, Shandong Univ.

Abstract: Because of the nonlocal property of fractional differential operators, the numerical methods for FPDEs often generate dense coefficient matrices, which often requires computational work of $O(N^3)$ to invert per time step and memory of $O(N^2)$. We develop a fast numerical method for space-fractional diffusion equations on a general convex domain, which have computational cost of $O(N \log^4 N)$ per time step and memory of $O(N)$, while retaining the same accuracy and approximation property of the underlying numerical methods.

MS-Th-BC-56-4 11:30–12:00
A High-accuracy Preserving Spectral Galerkin Method for Space-fractional Partial Differential Equations
Zhang, Xuhao
Shandong Univ.

Abstract: Fractional diffusion equations were shown to provide an adequate and accurate description of transport processes exhibiting anomalous behavior. We developed a high-accuracy preserving spectral Galerkin method for the Dirichlet boundary-value problem of one-sided variable-coefficient conservative fractional diffusion equations. Numerical experiments substantiate the theoretical analysis and show that the method exhibits an exponential convergence provided the diffusivity coefficient and the right-hand side term have the desired regularity.

MS-Th-BC-57 10:00–12:00
Modeling, Applications, Numerical Methods, and Mathematical Analysis of Fractional Partial Differential Equations I - Part I of V
For Part 2, see MS-Th-D-57
For Part 3, see MS-Th-E-57
For Part 4, see MS-Th-F-57
For Part 5, see MS-Th-G-57
Organizer: Wang, Hong
Univ. of South Carolina
Organizer: Karniadakis, George
Brown Univ.

Abstract: Fractional Partial Differential Equations (FPDEs) are emerging as a new powerful tool for modeling many difficult complex systems, i.e., systems with overlapping microscopic and macroscopic scales or systems with long-range memory and long-range spatial interactions. They offer a new way of accessing the mesoscale using the continuum formulation and hence extending the continuum description for multiscale modeling of viscoelastic materials, control of autonomous vehicles, transitional and turbulent flows, wave propagation in porous media, electric transmission lines, and speech signals. FPDEs raise modeling, computational, mathematical, and numerical difficulties that have not been encountered in the context of integer-order partial differential equations. The aim of this minisymposium is to cover the recent development in mathematical and numerical analysis, computational algorithms, and applications in the context of FPDEs and related nonlocal problems.

MS-Th-BC-57-1 10:00–10:30
Physical Implications of Fractional Diffusion Models
Hilfer, R
Univ. Stuttgart

Abstract: Fractional Bochner-Lévy-Riesz diffusion arises from ordinary diffusion by replacing the Laplacian with a noninteger power of itself. Bochner-
Levy-Riesz diffusion as a mathematical model leads to nonlocal boundary value problems. As a model for physical transport processes it seems to predict phenomena that have yet to be observed in experiment.

**Abstract:**
FPDEs provide very powerful alternatives to integer-order PDEs. Recent Developments of Fast Numerical Methods and Associated Analysis of Fractional PDEs with Optimal Memory Requirement and Almost Linear Computational Complexity. We will report our recent progress in the associated mathematical and numerical analysis.

**Abstract:**
A fourth-order alternating direction method is derived for the approximation of the Riesz space fractional nonlinear reaction-diffusion model. Stability and convergence of this method are proved. Finally, some numerical examples are given to support our theoretical analysis and these numerical techniques are employed to simulate a two-dimensional fractional Fitzhugh-Nagumo model.

**Abstract:**
In this paper, a novel fourth-order alternating direction method is proposed for modeling anomalous transport and long-range interactions. However, F-PDEs involve complex and singular integral operators. Consequently, corresponding numerical methods generate dense stiffness matrices, for which direct solvers require O(N²) memory and O(N³) complexity for a problem of size N. This renders three-dimensional FPDE simulations computationally intractable. Furthermore, FPDEs with smooth coefficients may generate solutions with strongly local singularity and poor regularity. We go over the recent advances in the development of accurate and efficient numerical methods for FPDEs with optimal memory requirement and almost linear computational complexity. We will report our recent progress in the associated mathematical and numerical analysis.

**Abstract:**
The origin of topology optimization is the relaxation by homogenization – the problem of an optimal layout of two isotropic materials of fixed amount to achieve given aims. Here minimization of the compliance plays a crucial role. Admitting void as a material one paves the way towards the shape forming theory. Alternatively, in the Free Material Design (FMD) all components of Hooke tensor are design variables. The stress-based FMD is a method of a simultaneous material and shape design. Our aim is to gather experts in the field to analyze links between these methods and develop rigorous results on topology optimization.

**Abstract:**
A new computational framework for structural topology optimization based on the concept of moving morphable components is proposed. Optimal structural topology is obtained by optimizing the layout of morphable structural components. The approach can combine both the advantages of explicit and implicit geometry descriptions for topology optimization. It also has the great potential to reduce the computational burden associated with topology optimization substantially. Some representative examples are presented to illustrate its effectiveness.

**Abstract:**
We study the shape optimization of a conductor in a stationary heat conduction problem, which leads to minimization of a functional of linear growth among divergence-free vector fields satisfying a given boundary data. Hence, minimizers are measures, not functions. Exploiting the fact that the above question may be reduced to the least gradient problem simplifies a detailed analysis of solutions. Our consideration is confined to specific cases, like the three point sources problems.
Abstract: The rotating disk reaction vessel has a long standing use in the oil and gas industry to help characterize rock samples while drilling. One of the dominant chemical reactions in this sector is the carbonate system which is also seen in many systems in nature. By including the mathematics of this reaction with the dissolution mechanism, a way of understanding and possibly eliminating the the limitations of the rotating disk method is provided.

Enhanced Training in the Mathematical Sciences: the GSMM Camp
Kramer, Peter Rensselaer Polytechnic Inst.
Abstract: The Graduate Student Mathematical Modeling (GSMM) Camp is an annual week-long meeting. At the Camp, graduate students work together in teams, with the guidance of faculty mentors, on interdisciplinary problems inspired by industrial applications. The program promotes a broad range of problem-solving skills, and provides the students with a valuable educational and career-enhancing experience outside of the traditional academic setting. The talk will focus on the organization, sample problems and outcomes of the Camp.

The Year of Light in Industrial Mathematics: Case Studies from MPI
Moore, Richard New Jersey Inst. of Tech.
Abstract: We consider a difficult combinatorial optimization problem arising from the operation of a system for testing electronic circuit boards (ECB). Because of its difficulty, we first split the problem into a covering subproblem and a sequencing subproblem. We demonstrate that the solution of these two sub-problems yields much better plans than those currently used. We conclude by giving a complete model of the test planning problem.

Robust Control for A Class of Uncertain Dynamical Systems
Rathinasamy, Sakhivel Sri Ramakrishna Inst. of Tech.
Abstract: This paper addresses the problem of robust sampled-data H∞-control for a class of uncertain dynamical systems (Mechanical system) with uncertainty. By constructing a proper Lyapunov functional involving the lower and upper bounds of the delay, a new set of sufficient conditions are obtained in terms of linear matrix inequalities (LMIs) for the existence of H∞-control law which ensures the robust stabilization of the uncertain dynamical systems about its equilibrium point for all norm bounded parameter uncertainties. Finally, a numerical example with simulation result is provided to illustrate the applicability and effectiveness of the proposed sampled-data control law.

INTEGRABLE VARIABLE DISSIPATION DYNAMICAL SYSTEMS AND SOME APPLICATIONS
Shamolin, Maxim V. Lomonosov Moscow State Univ.
Abstract: This activity is a survey of integrable cases in dynamics of a lower- and multi-dimensional rigid body under the action of a nonconservative force field. We review both new results and results obtained earlier. Problems examined are described by dynamical systems with so-called variable dissipation with zero mean. As exhibits we research dynamical equations of motion arising in studying the plane and spatial dynamics of a rigid body interacting with a medium and also a possible generalization of the obtained methods for studying to general systems arising in qualitative theory of ordinary differential equations, in theory of dynamical systems, and also in oscillation theory.

Numerical Null Controllability of Fractional Dynamical Systems
Govindaraj, Venkatesan Indian Inst. of Space Sci. & Tech.
Abstract: Many systems are better characterized using a non-integer order dynamic model based on fractional calculus. The fractional order integration and differentiation represent a rapidly growing field both in theory and in applications to real world problems. Controllability is one of the fundamental concepts in control theory which means that it is possible to steer a dynamical system from an arbitrary initial state to arbitrary final state using a set of admissible controls. Specifically this paper considers the problem of steering the state of a linear time invariant fractional dynamical systems to the origin when the control used is minimum energy admissible control. Sufficient conditions are given for the null controllability of nonlinear fractional dynamical systems. Moreover numerical aspects of the problem are discussed.

Numerical Null Controllability of Fractional Dynamical Systems
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The author is grateful to the Russian Foundation of Fundamental Investigations for support of research.

Tripoli Polynomials and its Accompanying Differential Equations
Ratemi, Wajdi Univ. of Tripoli
Abstract: This paper introduces Tripoli polynomials that generate Waterloo
Abstract: Blind Image Deconvolution Through Bezoutians
T-antipalindromic and T-alternating matrix polynomials of any degree. 
Illustrated by numerical experiments. Similar estimates are also obtained for T-palindromic eigenvalue backward error. The tightness of these bounds are 
illustrated by lab and experimental results with synthetically blurred images are included to demonstrate the effectiveness of our approach.

Computing Symmetric Positive Definite Solutions of Three Types of Nonlinear Matrix Equations
Bagherpour, Negin Sharif Univ. of Tech. 
Mahdavi-Amiri, Nezam Sharif Univ. of Tech.

Abstract: Nonlinear matrix equations arise in many practical contexts related to control theory, dynamical programming and finite element methods for solving some partial differential equations. In most of these applications, it is desired to compute a symmetric and positive definite solution. Here, we propose new iterative algorithms for solving three different types of nonlinear matrix equations. We have recently proposed a new algorithm for solving positive definite total least squares problems (poster submission 56). Making use of an iterative process for inverse of a matrix, we convert the nonlinear matrix equation to an iterative linear one, and, in every iteration, we apply our recent algorithm to solve the linear subproblem and update the newly defined variables and the matrix inverse terms using appropriate formulas. Our proposed algorithms have a number of useful features including lower computing times and error values compared to existing methods.

A Kinetic Ising Model and the Spectra of Some Jacobi Matrices
Fonseca, Carlos Kuwait Univ.

Abstract: One-dimensional statistical physics models play a fundamental role in understanding the dynamics of complex systems in a variety of fields, from chemistry and physics, to social sciences, biology, and neuroscience. Due to their simplicity, they are amenable to exact solutions that can lead to generalizations in higher dimensions. In 1963, R. Glauber solved exactly a one-dimensional spin model, known in literature as the kinetic ising chain, KISC, that led to many applications and two-temperature generalizations. In this talk we consider a case of temperature distributions, extracting information regarding the physical properties of the system from the spectrum analysis of matrix certain Jacobi matrix. We also analyze the eigenvalues of some perturbed Jacobi matrices. The results contain as particular cases the known spectra of several classes of tridiagonal matrices studied recently. This is a joint work with S. Kouachi, D.A. Mazilu, and I. Mazilu.

Estimates for the Structured Eigenvalue Backward Error of Any T-palindromic Matrix Polynomial
Sharma, Punit Indian Inst. of Tech. Guwahati

Abstract: We study the backward error of approximate eigenvalues of T-palindromic polynomials of higher degree with respect to structure preserving perturbation. We derive a lower bound for the eigenvalue backward error of any T-palindromic polynomial with respect to structure preserving perturbation, which is also an upper bound for the backward error with respect to arbitrary perturbation. We also give a choice of vectors to obtain a upper bound for T-palindromic eigenvalue backward error. The tightness of these bounds are illustrated by numerical experiments. Similar estimates are also obtained for T-antipalindromic and T-alternating matrix polynomials of any degree.

Blind Image Deconvolution Through Bezoutians
Belhaj, Skander Manouba Univ. (ISAMM) 
Diaz-Toca, Gema Univ. of Murcia

Abstract: In this paper, we introduce a fast algorithm for computing the univariate GCD of several polynomials (not pairwise) based on the generalized Bezout matrix by using Barnett's method. This novel approach is devoted to presenting an algorithm that permits to solve the problem of blind image deconvolution by computing greatest common divisors (GCD) of several polynomials. Specifically, we design a specialized algorithm for computing the GCD of bivariate polynomials of blurred images which correspond to z-transforms to recover the original image. All algorithms have been implemented in Matlab and experimental results with synthetically blurred images are included to illustrate the effectiveness of our approach.

Formulation of A New Field of Spherical Trigonometric and Its Application to One-dimensional Statistical Physics Models
Chair: Pirzada, Shariefuddin Univ. of Kashmir

Abstract: Nonlinear matrix equations arise in many practical contexts related to control theory, dynamical programming and finite element methods for solving some partial differential equations. In most of these applications, it is desired to compute a symmetric and positive definite solution. Here, we propose new iterative algorithms for solving three different types of nonlinear matrix equations. We have recently proposed a new algorithm for solving positive definite total least squares problems (poster submission 56). Making use of an iterative process for inverse of a matrix, we convert the nonlinear matrix equation to an iterative linear one, and, in every iteration, we apply our recent algorithm to solve the linear subproblem and update the newly defined variables and the matrix inverse terms using appropriate formulas. Our proposed algorithms have a number of useful features including lower computing times and error values compared to existing methods.
ITERATIVE ALGORITHM FOR ZEROS OF BOUNDED M-ACCRETIVE NON-LINEAR OPERATORS

DJITTE, Ngalla
Gaston Berger Univ.

Abstract: An iteration process is proved to converge strongly to a solution of the equation $Ax = 0$ where $A$ is a bounded $m$-accretive operator on $L_p$, $1 < p \leq 2$. The ideas of the iteration process are applied to approximate fixed points of uniformly continuous pseudocontractive maps.

Graphs with Non-concurrent Longest Cycles in Lattices

Shabbir, Ayesha
Univ. College of Engineering, Sci. & Tech., Lahore Leads Univ., Lahore, Pakistan

Abstract: In 1966 T. Gallai asked whether connected graphs with empty intersection of their longest path do or do not exist. After examples of such graphs were found, the question was extended to graphs of higher connectivity, and to cycles instead of paths. Examples being again found, for connectivity up to 3, the question has been asked whether there exist such graphs in geometric lattices. And, response was again positive. Here we are presenting examples of graphs embeddable in the (infinite) triangular, square and hexagonal lattices, and (finite) lattices defined on surfaces in which any pair of vertices is missed by some longest cycle.

Wavelet Multiplicity Function on Local Fields of Positive Characteristics

SHUKLA, NIRAJ KUMAR
INDIAN Inst. Of Tech. INDORE

Abstract: The concept of shift-invariant spaces and multiresolution analysis are extensively studied in Euclidean spaces. In this article we extend the theory of shift-invariant spaces to the context of local fields of positive characteristics having non-archimedean metric and show that the concepts of range function, multiplicity function and spectral function are also valid analogous to the Euclidean case. As a consequence of this generalization we make a connection between the dimension function and the multiplicity function associated to an orthonormal wavelet. Further, we prove that the wavelet multiplicity function satisfies a consistency equation. This is a joint work with S.C. Maury.

Nonlinear Stability in Generalized Photogravitational Restricted Three Body Problem

Ishwar, Bhol
BRA Bihar Univ., Muzaffarpur

Abstract: We have discussed the nonlinear stability of triangular equilibrium points in generalized photogravitational restricted three body problem. The problem is generalized in the sense that both primaries are taken as oblate spheroid. We have applied Arnold’s theorem to examine the condition of nonlinearity. We have found three critical mass ratios where this theorem fails. The stability condition is different from classical case due to radiation and oblateness of the primaries.

Evaluation of Vertical Transmission and Vaccination Impacts Concerning Hepatitis B Disease in a Pygmy Group in the East of Cameroon.

Yannick, Kouakep Tchapchit Jean
Univ. of Ngaoundere

Abstract: We formulate an age-structured model for HBV including the vertical transmission and a vaccination strategy and study their impacts on stability of equilibria (disease free equilibrium and endemic equilibrium). An application is done on a set of data for a #&171;Baka#187; pygmy group in the East of Cameroon. We see numerically also the fact that ignoring the vertical transmission and vaccination doesn’t lead to a good approximation of reality.

Fixed Point Results and its Applied Aspects in Generalized Metric Spaces

Jha, Kanhaiya
Kathmandu Univ.

Abstract: The fixed point theory as a part of non-linear analysis, is a study of function equation in metric or non-metric setting. The classical Banach contraction principle in metric space is one of the fundamental results in metric space with wide applications. The main purpose of this presentation is to discuss some developments of generalized classical metric sub-spaces in functional analysis with applications to other disciplines.

Solutions of Nonlinear Volterra Integro-Differential Equations for Generalized Contraction Mappings

NASHINE, HEMANT KUMAR
Amity School of Applied Sci., Amity Univ.

Abstract: We propose coincidence and common fixed point results for a quadruple of self-mappings satisfying compatibility and subsequentially continuity (alternately subcompatibility and reciprocally continuity) in metric space. X, under a generalized $\phi$-contractive condition. An example and an application, for the solution of certain nonlinear Volterra integro-differential equations, are given to illustrate the usability of the obtained results.

How Far Zooplankton’s Selectivity Affects Plankton Dynamics and Bloom Phenomenon: A Mathematical Study

Bairagi, Nandadulal
Jadavpur Univ.

Abstract: Harmful Algal Bloom (HAB) is a global problem in marine biology. HABs have adverse effects on fisheries, tourism, ecosystem and environment. Several studies have shown that a number of phytoplankton species (called toxic producing phytoplankton or TPP) have the ability to produce toxic substances and the others have not (called non toxic phytoplankton or NTP). These toxin producing phytoplankton are some times less preferred or avoided by herbivorous zooplankton. Therefore, it may be interesting to observe the plankton dynamics with zooplankton’s preference or selectivity. The objective of our study will be to propose a mathematical model that incorporates zooplankton’s selectivity on NTP over TPP and observe how far this selectivity plays role on plankton dynamics and blooms.

Far Field Behavior to Study Planar Shock Waves in Radiative Magnetogasdynamics

Yadav, Sanjay
Indian Inst. Of Tech. Roorkee

Abstract: In this paper, an asymptotic equation is derived which describes the far-field behavior of the governing system of partial differential equations for a one dimensional planar symmetric flow in radiative magnetogasdynamics. This evolution equation is viscous Burger’s equation. A Lie group of transformations method is used to obtain the solution of this evolution equation. This method is based on the differential equation being invariant under a family of transformations depending on a small parameter. The invariant transformation allows one to obtain an arbitrary differential equation, or reduces the order of partial differential equation.

Two-step Iteration Process for Numerical Solution of 2D Nonlinear Equations with Arbitrary BC

Trufimov, Vyacheslav
Lomonosov Moscow State Univ.

Abstract: We have discussed the nonlinear stability of triangular equilibrium points in generalized photogravitational restricted three body problem. The problem is generalized in the sense that both primaries are taken as oblate spheroid. We have applied Arnold’s theorem to examine the condition of nonlinearity. We have found three critical mass ratios where this theorem fails. The stability condition is different from classical case due to radiation and oblateness of the primaries.
Denisov, Anton
Lomonosov Moscow State Univ.
Abstract: We propose two-step iteration process for numerical solution of the 2D nonlinear problems with arbitrary BC. In opposite to the split-step method, our method allows us to realize a conservatism property of finite-difference scheme as well as its asymptotic stability. In current report we demonstrate efficiency of the proposed iteration method by considering two problems. First one is a femtosecond laser pulse propagation in semiconductor under the action of an external electric field. This process is described by the set of 2D non-stationary partial differential equations concerning the concentration of both free electrons and ionized donors, and potential of electric field, and its intensity. The second problem is nonlinear propagation of 2D laser beam, which is described by nonlinear Schrodinger equation with artificial BC. Proposed iteration process can be easy generalized for the numerical solution of the multi-dimensional nonlinear problems.

CP-Th-BC-66-2 10:20–10:40
Hemi-slant Submanifolds as Warped Products in A Nearly Kaehler Manifold
Khan, Kamran
Aligarh Muslim Univ., Aligarh
Abstract: Warped product manifolds provide a natural frame work for time dependent mechanical system and have applications in Physics. The studies on warped product manifolds with extrinsic geometric point of view intensified those common to the two input operators. We prove that the problem is well-posed iteration process can be easy generalized for the numerical solution of the multi-dimensional nonlinear problems.

CP-Th-BC-66-3 10:40–11:00
Scale-Bridging Massively Parallel Molecular Simulation with Lst Lmdyn
Horsch, Martin Thomas
Univ. of Kaiserslautern
Langenbach, Kai
Univ. of Kaiserslautern
Benreuter, Martin
High Performance Computing Center Stuttgart
Glass, Colin
High Performance Computing Center Stuttgart
Eckhardt, Wolfgang
Technical Univ. Munich
Neumann, Philipp
Technical Univ. Munich
Bungartz, Hans-Joachim
Technical Univ. Munich
Eckelsbach, Stefan
Univ. of Paderborn
Vrabec, Jadran
Univ. of Paderborn
Hasse, Hans
Univ. of Kaiserslautern
Abstract: Molecular modelling and simulation has become a powerful tool which can be applied to many physical processes and properties of fluids on the molecular level. A shift in the accessible length and time scales due to massively parallel high-performance computing has greatly increased its potential. The novel molecular dynamics code lmdyn, which scales excellently on up to 146 000 cores, is presented, highlighting the emergence of computational molecular engineering as a discipline.

CP-Th-BC-66-4 11:00–11:20
Conservative Discrete Velocity Method for Non-equilibrium Flows
Zhang, Yonghao
Univ. of Strathclyde
Abstract: Rapid advances have been made for micro/nano-fluidic technology, which demands computationally efficient design simulation tools that can capture non-equilibrium flow phenomena. Our recent development of conservative discrete velocity method for modelling gas flows beyond the Navier-Stokes hydrodynamics will be discussed. With a moderate discrete velocity set, we find our model can accurately recover steady and transient solutions of the kinetic equation in the slip-flow and early transition regimes.

EM-Th-D-01 13:30–15:30
EM-Th-D-01-3 13:30–14:00
Output-sensitive Algorithms for Sunset and Sparse Polynomial Multiplication
Arnold, Andrew
Univ. of Waterloo
Abstract: We consider the complexity of multiplying two univariate polynomial given by their sparse representations. A product of sparse polynomials may have up to quadratically many terms compared to the inputs, but possibly as few as a constant number of terms. We present a randomized algorithm that improves on the bit-complexity of sparse multiplication when the number of terms in the product is sufficiently small. As a subroutine we present a fast probabilistic algorithm for subset.

EM-Th-D-01-4 15:00–15:30
Approximate Computation with Differential Polynomials: Approximate GCRDs
Giesbrecht, Mark
Univ. of Waterloo
Abstract: Differential (Ore) type polynomials with approximate polynomial co-efficients are introduced. These provide a useful representation of approximate linear differential operators with a strong algebraic structure, which has been used very successfully in the exact, symbolic, setting. As an extension to this framework, we present an algorithm for the approximate Greatest Common Right Divisor (GCRD) of two approximate differential polynomials. The GCRD is intuitively the linear differential operator whose solutions are common to the two input operators. We prove that the problem is well-defined (i.e., nearest polynomials with GCRD exist), and explore algorithms to compute an approximate GCRD. We work on an appropriately “linearized” differential Sylvester matrix, and extend methods for the approximate GCD of
regular polynomials to this new setting, including SVD-based methods and Newton iteration. This is joint work with PhD student Joseph Haraldson (Waterloo) and Erich Kaltofen (NCSU).

**MS-Th-D-02**

**Special session 2 of Chinese Conference of Complex Networks (CCCN) 2015**

**Organizer:** Lu, Jinhua Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

**Abstract:** sssion contributes as a part of ICIAM 2015 from the Complex networks and system control TC, which involves two 1-hour speakers as the keynote lectures of CCCCN 2015. Two invited speakers are the leading researchers in the involved fields: Prof. Jun-an Lu (Wuhan University) and Prof. Xiang Li (Fudan University). Prof. Jun-an Lu is a full Professor in the School of Mathematics and Statistics, Wuhan University. Prof. Lu received the prestigious National Natural Science Award from the Chinese government in 2008 and First Prize of Natural Science Award from the Ministry of Education of China in 2007. Prof. Xiang Li is a professor in Fudan University. He was the recipient of the IEEE Guillemin - Cauer Best Transactions Paper Award from the IEEE Circuits and Systems Society in 2005, Shanghai Natural Science Award (first class) in 2008, Shanghai Science and Technology Young Talents Award in 2010, the New Century Excellent Talents Program of Chinese Universities from the Ministry of Education, China, in 2009, Shanghai Science and Technology Rising Star in 2005 and 2009, and other awards and honors.

**MS-Th-D-03**

**Propagation Phenomena of Reaction-Diffusion Models in Biology - Part I of IV**

**For Part 2, see MS-Th-E-03**
**For Part 3, see MS-Fr-D-03**
**For Part 4, see MS-Fr-E-03**

**Organizer:** Li, Wan-Tong Lanzhou Univ.
**Organizer:** Ruan, Shiguang Unv. of Miami

**Abstract:** With the tide of globalization, biological invasions and pathogen transmission, which in turn can affect ecosystem or threaten public health, become focal points in literature. In mathematical biology, there are many reaction-diffusion models arising from various applications such as animal dispersal, geographic spread of epidemics. To model/illustrate these problems, phenomena and investigate/evaluate the corresponding control strategies, it has been proved that the corresponding propagation modes are very important and useful. This minisymposium focuses on the recent advances of propagation phenomena of different reaction-diffusion models in biology. In particular, the traveling wave solutions, asymptotic spreading, entire solutions, generalized transmission and threshold dynamics with their applications of reaction-diffusion models will be discussed.

**Problem Reduction to Parameter Space**

**MS-Th-D-03-2**

**Asymptotic Behavior of Solutions to Reaction-diffusion Equations with Time-delay**

**Mei, Ming** McGill Univ.

**Abstract:** In this talk, we consider a mono-stable reaction-diffusion equation with time-delay, which represents the population model of single species like Australian blowflies. When the system of equations is non-monotone, it possesses some monotone or non-monotone traveling waves dependent on the time-delay to be small or big. We clarify that, for a certain given initial data, the corresponding solution will converge to a certain monotone or non-monotone traveling wave, where the wave speed can be specified.

**MS-Th-D-03-3**

**Influence of Boundary Conditions on the Qualitative Property of Reaction Diffusion Equations**

**Lou, Bendong** Tongji Univ.

**Abstract:** In this talk we consider reaction diffusion equations with various different boundary conditions. We will study the influence of the boundary conditions on the long time behavior of the solutions. Among others, we present some traveling semi-waves with monotone or non-monotone profiles which characterize the spreading phenomena of a species.

**MS-Th-D-03-4**

**Propagation Direction of Bistable Waves in A Nonlocal Reaction-diffusion Equation**

**Fang, Jian** Harbin Inst. of Tech.

**Abstract:** In this talk, we investigate the speed of traveling waves for a non-local reaction-diffusion equation of bistable type. It turns out that varying the range of symmetric nonlocal interaction may alter the propagation direction of waves.

**MS-Th-D-04**

**Curves and Surfaces in Computer Aided Geometric Design - Part II of III**

**For Part 1, see MS-Th-BC-04**
**For Part 3, see MS-Th-E-04**

**Organizer:** Jia, Xiaohong Chinese Acad. of Sci.
**Organizer:** Cheng, Jin-San Chinese Acad. of Sci.

**Abstract:** This symposium is aimed at bridging between people who are working theoretically on curves and surfaces in algebraic geometry and those who are endeavoring to seek for suitable modeling forms of curves and surfaces in Computer Aided Geometric Design. Therefore, the symposium includes wide-ranging topics on curves and surfaces from classic theory aspects to their applications in modern industry. The forms of curves and surfaces consist of but are not limited to: algebraic curves and surfaces, parametric curves and surfaces including NURBS as well as triangular surface patches.

**MS-Th-D-04-1**

**A Visual and Computational Framework for Evaluating the Effectiveness of Surgery on Infants Born with Craniosynostosis**

**Goldman, Ron** Rice Univ.
**Yuan, Binhang** Rice Univ.
**Khechoyan, David** Baylor College of Medicine

**Abstract:** We provide a computational framework to evaluate the effectiveness of cranial surgery on infants suffering from craniosynostosis. The input consists of a 3D triangle mesh representing the infant's head, captured by a new non-invasive 3DMID imaging system. The computational framework consists of three parts: (i) mesh decimation to simplify the input; (ii) mesh registration to find a correspondence between mesh pairs; (iii) comparison of local mesh features for the same infant before and after surgery.

**MS-Th-D-04-2**

**Between Moving Least-squares and Moving Least-\&\#467;1**

**Levin, David** Tel-Aviv University

**Abstract:** One way of generation smooth approximations using scattered data in high dimension is by the moving least-squares method. We suggest to use an error measure which is between the $\ell_1$ and the $\ell_2$ norms, with the advantages of both. Namely, yielding smooth approximations which are not too sensitive to outliers. A fast iterative method for computing the new approximation is discussed and demonstrated and the approximation error is analysed.

**MS-Th-D-04-3**

**Precise Kinematic and Robotics Motion Planning Using Algebraic Contact Analysis**

**Elber, Gershon** Technion, Israel Inst. of Tech.

**Abstract:** Kinematic and motion analysis has applications and needs in numerous applications. We exploit algebraic tools to map kinematics analysis and configurations space computations to sets of algebraic constraints, only to precisely solve them. A subdivision based solver for (piecewise) polynomial multivariates that we develop is employed to efficiently and robustly resolve these constraints. Results demonstrating all these applications will also be presented.

* In collaboration with Myung-So KIm and Yong Joon Kim.

**MS-Th-D-04-4**

**Problem Reduction to Parameter Space**

**Kim, Myung-So** Seoul National Univ.

**Abstract:** We present a problem reduction scheme for geometric computations to the parameter space of curves and surfaces. Geometric constraints are often represented with low degrees in $x$, $y$, $z$, but with higher degrees in the curve or surface parameters $u$, $v$, $s$, $t$. Thus, we eliminate $x$, $y$, $z$, but still represent them as functions of $u$, $v$, $s$, which reduces the computation of differential geometric properties to an almost triviality.
MS-Th-D-05-5 13:30–15:30
Applied and Industrial Mathematics in Spain - Part II of II
For Part 1, see MS-Th-BC-05

Organizer: Chacon Rebollo, Tomas
Univ. of Sevilla

Abstract: This mini symposium presents an overview of the research in applied and industrial mathematics in Spain. This research has experienced a fast development in the last years, reaching a wide geographical and thematic extension. We present some talks on selected topics with a strong focus on real-world applications: analysis of gears in automotive industry, modeling of shallow water flows, wind turbine modeling and several problems proposed by the industry, solved by finite volume methods. Also, some other talks deal with more basic aspects of applied mathematics: mixed methods in Computational Fluid Dynamics, and reduced order models. This overview is complemented with another mini symposium at ICIAM 2015, that exclusively focuses on the industrial Mathematics in Spain.

► MS-Th-D-05-1 13:30–14:00
Examples of Problems Defined by Enterprises and Institutions and Solved Using Finite Volume Methods

Vazquez-Cendon, Elena
Univ. of Santiago de Compostela

Abstract: In this talk we present problems solved using finite volume methodo-
s. The problems were defined by enterprises and institutions and the mathema-
tical technology developed is the core of scientific publications and soft-
ware. In particular the IBER model (http://iberaula.es/web/index.php) is a
two-dimensional mathematical model for the simulation of free surface flow
in rivers and estuaries.

► MS-Th-D-05-2 14:00–14:30
Stabilized Methods and Inf-sup Conditions

Chacon Rebollo, Tomas
Univ. of Sevilla

Abstract: Stabilized methods provide low-cost solvers for incompressible
flows, making possible the use of equal order interpolation of velocity and
pressure. In this talk we review the different inf-sup conditions that yield the
stability of the pressure discretization, in accordance to each actual kind of
In particular we study the solution of the Primitive Equations of the Ocean by
stabilized methods, in which inf-sup conditions in $L^p$ norms are needed.

► CP-Th-D-05-3 14:30–14:50
Non-parametric Frontier Analysis of the Energy Efficiency of Urban Bus Lines and Vehicles

Lozano, Sebastian
Univ. of Seville
Eguia, Ignacio
Univ. of Seville
Molina, Jose Carlos
Univ. of Seville
Racero, Jesus
Univ. of Seville

Abstract: Data Envelopment Analysis (DEA) has been applied in many ef-
ciciency and benchmarking studies in the transportation sector. In this re-
search, DEA is applied to urban bus lines and vehicles to assess the efficien-
cy of the energy consumption of the different line/vehicle combinations. Since
there are different types of vehicles, specific group frontiers as well as a glob-
al multi-frontier are computed. This allows determining an energy frontier
index associated to each type of vehicle. The proposed approach also allows
the estimation of potential energy savings for each bus line due to inefficient
vehicle maintenance and driving practices and due to inefficient vehicle type
assignment. This energy savings translate immediately into both cost and
emissions reductions. Preliminary results of the application of the proposed
approach to the city of Seville, Spain, are presented.

► CP-Th-D-05-4 14:50–15:10
Elliptic Functions in Simulation of Oil Recovery

Astafev, Vladimir
Samara State Technical Univ.

Abstract: The objective of this paper is to simulate the inflow performance
of multiple vertical wells producing from and injecting into a closed reservoir
of constant thickness under pseudosteady-state conditions. For this case we
represent a closed reservoir as an element of unbounded doubly periodic ar-
ray of wells and use the elliptic Weierstrass functions to describe this inflow
performance. This approach allow us for any shape of reservoirs: •
represent a closed reservoir as an element of unbounded doubly periodic ar-
ray of wells and use the elliptic Weierstrass functions to describe this inflow
performance. 

Signal Denoising Using Local Polynomial Regression Harten's Multiresolution Analysis

Yanez, Dionisio F.
Universidad Catolica de Valencia

Abstract: In recent years, a new family of Harten’s multiresolution schemes
[1,3] based on local polynomial regression has been presented [2] and ap-
plied to signal and image compression. These techniques present different
properties, we analyze the applicability of these schemes to remove noise
to digital signals and images. We use several kernel functions and compare our
results with the results obtained using classical methods as multiresolution
based on piecewise interpolation. Some numerical results are showed. Ref-
ences [1] F. Arandiga and R. Donat. Nonlinear multiscale decompositions:
Arandiga and D. F. Yanez. Cell-average multiresolution based on local polyno-
mial regression. application to image processing. Applied Mathematics and

► MS-Th-D-06-1 13:30–14:00
Diffusion Forecast

Harlim, John
The Pennsylvania State Univ.

Abstract: I will discuss a nonparametric modeling approach for forecasting
stochastic dynamical systems on low-dimensional manifolds. In the limit of
large data, this approach converges to a Galerkin projection of the semigroup
solution of the backward Kolmogorov equation of the underlying dynamics on
a basis adapted to the invariant measure. This approach allows one to quan-
tify the probability distribution of non-trivial dynamical systems with
equation-free modeling.

► MS-Th-D-06-2 14:00–14:30
Predicting the Cloud Patterns of the Madden-Julian Oscillation Through A Low-order Nonlinear Stochastic Model

Chen, Nan
New York Univ.
Giannakis, Dimitrios
New York Univ.

Abstract: We assess the limits of predictability of the large scale cloud patterns
in the boreal winter MJO. NLSA is applied to define two spatial modes with
high intermittency. A 4-D nonlinear stochastic model for the two observed
MJO variables and two hidden variables involving correlated multiplicative
noise defined through energy conserving nonlinear interaction is proposed.
Systematic calibration and prediction experiments show the skillful prediction
and the ensemble spread is an accurate indicator of forecast uncertainty.

► MS-Th-D-06-3 14:30–15:00
Filtering with Noisy Lagrangian Tracers

Tong, Xin
Courant Inst. of Mathematical Sci.
Chen, Nan
New York Univ.

Abstract: An important practical problem is the recovery of a turbulent veloc-
ity field using Lagrangian tracers that move with the fluid flow. Despite the
inherent nonlinearity in measuring noisy Lagrangian tracers, there are exact
closed analytic formulas for the optimal filter. These formulas provide a con-
duction framework for the analysis of filter performance in large tracers number
limit, the demonstration of information barrier type of phenomena, and the
construction of simplified filters using multiscale structures.
Abstract: In this talk I will present some results concerning some harmonic maps into the projective plane that appear as limits of minimizers of the Landau-de Gennes energy functional when the (one) elastic constant goes to zero. This is joint work with Dmitry Golovaty.

MS-Th-D-08-2 14:00–14:30
Chevron Structures in Smectic A Liquid Crystals
Giorgi, Tiziana
New Mexico State Univ.

Abstract: We will present an analysis of the chevron structure, which is formed in a Smectic A liquid crystal under the influence of an applied magnetic field. We will start with a two-dimensional De Gennes free energy functional for Smectic A, and use Gamma-convergence to show that in a suitable regime of fields, a chevron structure is favored by the energy. We will next present analogous results for the more general Chen-Lubensky free energy in a one-dimensional setup. This is joint work with Carlos Garcia-Azpeitia and Sookyung Joo.

MS-Th-D-08-4 15:00–15:30
Dimension Reduction for the Landau-de Gennes Model in Nematic Thin Films

Golovaty, Dmitry
The Unv. of Akron
Montero, Alberto
Pontificia Universidad Catolica de Chile
Sternberg, Peter
Indiana Univ.

Abstract: We use the method of Gamma-convergence to study the behavior of the Landau-de Gennes model for a nematic liquid crystalline film in the limit of vanishing thickness. We assume general weak anchoring conditions on the top and the bottom surfaces of the film and the strong Dirichlet boundary condition on the lateral boundary of the film. We establish a general convergence result and then discuss the limiting problem in several parameter regimes.

MS-Th-D-09 13:30–15:30
Recent advances on computational wave propagation - Part I of II
For Part 2, see MS-Th-E-09

Organizer: Li, Jichun
Univ. of Nevada Las Vegas
Organizer: Huang, Yunqing
Xi'an JiaoTong Univ.
Organizer: Shu, Shi
Xi'an JiaoTong Univ.

Abstract: We present new spectral solvers for time evolution of Partial Differential Equations in general domains. Based on the novel Fourier-Continuation (FC) method for the resolution of the Gibbs phenomenon, these methodologies provide solutions that enable the use of spectral methods, high-performance computing, high-frequency waves, multiscale methods, novel techniques for metamaterials and cloaking simulations). Note: All invited speakers are confirmed.

MS-Th-D-09-1 13:30–14:00
Fast Spectral PDE Solvers for Complex Structures: the Fourier-Continuation Method
Bruno, Oscar
Caltech

Abstract: We present new spectral solvers for time evolution of Partial Differential Equations in general domains. Based on the novel Fourier-Continuation (FC) method for the resolution of the Gibbs phenomenon, these methodologies provide solutions that enable the use of spectral methods, high-performance computing, high-frequency waves, multiscale methods, novel techniques for metamaterials and cloaking simulations. Note: All invited speakers are confirmed.

MS-Th-D-09-2 14:00–14:30
A Class of Uncertainty Quantification Algorithms for Stochastic Wave Scattering
Ganesh, Mahadevan
Colorado School of Mines

Abstract: We present an efficient framework for quantifying uncertainties in...
the propagation of acoustic waves through a stochastic media. Simulation even for a single deterministic configuration is inherently difficult because of the complex media. The stochasticity leads to a larger dimensional model involving spatial variables and additional stochastic variables, and accounting for uncertainty in key parameters of the input probability distributions leads to substantial computational complexity. (This is a collaborative work with Stuart Hawkins.)

**MS-Th-D-09-3** 14:30–15:00
Finite Element Analysis and Modeling of Invisibility Cloaks with Metamaterials
Li, Jichun
Univ. of Nevada Las Vegas
Huang, Yuning
Xiantang Univ.

**Abstract:** Since the pioneering works of Pendry et al and Leonhardt in 2006 (both published in Vol.312 of Science, June 23, 2006), many interesting works on cloaks with metamaterials have been published. In this talk, I’ll give a brief introduction to metamaterials, then I’ll focus on some cloaking models and study them from the mathematical and simulation point of view. Both frequency and time-domain models and simulation results will be presented.

**MS-Th-D-09-4** 15:00–15:30
Hagstrom, Thomas
Southern Methodist Univ.

**Abstract:** As the radiation of energy to the far field is an important feature of most problems in wave theory, accurate and efficient near-field approximate radiation conditions are a necessary component of any comprehensive wave simulation tool. We review the theory and implementation of Complete Radiation Boundary Conditions - optimal methods in the simplest case of homogeneous, isotropic media - and discuss the prospects for extension to general hyperbolic systems and inhomogeneous far fields.

**MS-Th-D-10** 13:30–15:30
Singular Problems and Integral Dynamical Models in Applied Mathematics - Part II of II
For Part I, see MS-Th-B-10

**Organizer:** Sidorov, Denis
Energy Sys. Inst., Russian Acad. of Sci. (SB)

**Abstract:** This mini-symposium concentrates on the theory of singular equations especially applicable to stability, bifurcation and algorithmic analysis of DE/IEs in mechanics and mathematical physics. Mini-symposium addresses the recent results on existence theorems, regularization, and identification, including asymptotic, numerical and group theoretic methods. The employment of such methods in various problems in modern physics, heat-and-power engineering, and mechanics (plasma, aerocelastics, phase transitions, rheology) has given the authors rich possibilities for creativity and application.

**MS-Th-D-10-1** 13:30–14:00
Mathematical Modelling of Nonlinear Dynamics of Heat Transfer in Packed Beds
Sidorov, Denis
Energy Sys. Inst., Russian Acad. of Sci. (SB)

**Abstract:** This talk concentrates on results of development of mathematical theory applicable for non-Newtonian fluid mechanics models studies. It concentrates on non-classical initial-boundary value problems arising in practical models of packed beds.

**MS-Th-D-10-2** 14:00–14:30
On Stable Estimation of the Images Gradient Values
Sidorov, Denis
Energy Sys. Inst., Russian Acad. of Sci. (SB)
Mutfahov, Ilidar
Irkutsk State Technical Univ.

**Abstract:** The abstract scheme of regularisation equations with vector regularisation parameter for linear operator equations is employed for stable estimation of images gradient. The special auxiliary regularising equation which possesses unique solution is used.

**MS-Th-D-10-3** 14:30–15:00
Many Parametric Bifurcation Problem of the Deflection of the Elongated Plate in A Supersonic Gas Flow
Loginov, Boris
Ulyanovsk State Technical Univ.
Badokina, Tatiana
Mordovian State Univ. of N. P. Ogarev

**Abstract:** Bifurcation problem about buckling of strip-plate in supersonic gas flow under compressed/extended boundary stresses is considered. The dependence on bifurcation parameters (Mach number, compression/extension coefficient) and small normal load, expressed through the roots of the characteristic equation for the linearization, allows to give the problem exact solution, to determine the parameters critical manifolds, to construct (first for aeroelasticity problems) Green functions for the linearizations and bifurcating solutions asymptotics by Lyapounov-Schmidt method.

**MS-Th-D-10-4** 15:00–15:30
Andronov-Hopf Bifurcation in Equations with Symmetrizable under Group Symmetry Linearization
Kim-Tyan, Luiza
National Research Technological Univ. (Moscow Inst. of Steel & Alloys)

**Loginov, Boris**
Ulyanovsk State Technical Univ.

**Abstract:** For first order differential equations in Banach spaces with densely defined linear Froudholm operator before the derivative and small parameter in nonlinearity in the linearization Andronov-Hopf bifurcation problem is consid- ered. On the base of the suggested by V.A.Trenogin symmetrizzability notion for the linear operators in Banach spaces sufficient conditions for Lyapounov- Schmid branch system of bifurcation pseudopotentiality types A and B are obtained and at the usage of Conley-Morse index theory the bifurcation existence the- orem is proved.

**MS-Th-D-11** 13:30–15:30
Matrix computations using structures and other innovative techniques - Part I of III
For Part 2, see MS-Th-E-11
For Part 3, see MS-Fr-D-11

**Organizer:** Xia, Jianlin
Purdue Univ.

**Organizer:** Chen, Jie
IBM Thomas J. Watson Research Center

**Abstract:** This mini-symposium is concerned with a wide range of innovative matrix computation techniques, including structures, randomization, splitting preconditioning, etc. The techniques make it feasible to develop new fast and reliable direct or iterative solutions. In particular, certain block or hierarchical structures can be used to obtain effective preconditioners or nearly linear complexity direct solvers for challenging numerical problems. Interesting applications to imaging, PDE/integral equation solutions, optimization, parallel computing, and engineering simulations will also be shown.

**MS-Th-D-11-1** 13:30–14:00
Randomized Algorithms for Numerical Linear Algebra
Gu, Ming
Univ. of California Berkeley

**Abstract:** We discuss a new class of efficient randomized algorithms for spectrum-revealing LU, Cholesky and QR factorizations. Our algorithms are much more efficient than other approaches for low-rank matrix approxima- tion and we develop a new set of approximation error bounds that suggest that our matrix factorizations are also at least as effective as other low-rank approximation methods.

**MS-Th-D-11-2** 14:00–14:30
Linear-Cost Storage and Computation with Kernel Matrices
Chen, Jie
IBM Thomas J. Watson Research Center

**Abstract:** Kernel matrices embrace a rich structure that enables more efficient storage and computation than does a usual n-by-n dense matrix. We present an O(n) data structure for compressing a kernel matrix and O(n) algorithms for various matrix operations, including matrix-vector multiplication, matrix in- version, determinant, and square root calculation. We demonstrate the use of this compressed structure in Gaussian process data analysis and kernel machine learning.

**MS-Th-D-11-3** 14:30–15:00
The Multivariate Eigenvalue Problem
Zhang, LeiHong
Shanghai Univ. of Finance & Economics

**Abstract:** The Multivariate Eigenvalue Problem (MEP), arising from the Maxi- mal Correlation Problem (MCP), is an important model in the canonical corre- lation analysis. In this talk, we shall characterize some distinctive traits of the absolute maximum correlation, and also present several efficient algorithms for MCP-MEP.

**MS-Th-D-11-4** 15:00–15:30
An Efficient Method for Counting the Eigenvalues Inside A Region of the Complex Plane
Yin, Guojian
Shenzhen Inst.s of Advanced Tech., Chinese Acad. of Sci.

**Abstract:** In many applications, the information about the number of eigenval- ues inside a given region is required. In this talk, we give a contour-integral based method for this purpose. The new method is motivated by two im- portant findings. An appealing feature of our method is that it can integrate with recently developed eigensolvers based on contour integrals to determine whether all desired eigenvalues are found by these methods. Numerical ex-
Abstract: In applications of bifurcation theory the situation arises when the finite-dimensional branching equation (BEq) is potential, while the original nonlinear equation haven’t this property. Three articles are devoted to this phenomenon. Here sufficient conditions for BEq potentiality and pseudopotentiality are obtained, particularly under group symmetry conditions, when the bifurcation point has nontrivial stationary subgroup. For stationary and dynamic bifurcations general theorems are proved about the inher-

ance of the group symmetry of original nonlinear equation by the relevant Lyapunov and Schmidt BEqs moving along the trajectory of the branching point, taking into account the presence of stationary subgroup of the branch-

ing point. Theorems on the BEqs reduction (its order lowering) are proved at the action of continuous group symmetry. G-invariant implicit operators the-

orems are proved for stationary and dynamic bifurcation. Simple, but very
techical examples of SO(2) and SH(2) symmetries are considered with the general form of C1-smooth BEq construction on allowed group symmetry.

With the aid of Morse-Conley topological index theory it is proved the bifur-
cation existence theorem for Andronov-Hopf bifurcation. Sufficient condi-
tions for the linearized stability of bifurcating solutions are obtained. The obtained
results are applied to bifurcation problems with E. Schmidt spectrum in the lin-
earization. Three communications are devoted to nonlinear equations, their
solutions stability and bifurcation theory to problems of hydroaeroelasticity .

One of them considers the multiparameter bifurcation problems on the diver-
gence of the elongated plate in supersonic gas flow compressed or extended
by external boundary conditions in the exact statement, that is achieved by the
representation of the bifurcation manifold through the roots of the char-
acteristic equation of the linearized ODE. Here the most difficulties arise at
the analytical proof of the divergence absence. The Fredholm property of
these problems is proved also on the base of the usage of the roots of char-
acteristic equations of the linearization. Lyapunov functions and functionals,
Lyapunov vector-functions techniques is applied to the investigation of so-
lutions stability in two reports to hydroaeroelasticity problems and two articles
on the stabilization of nonlinear systems motions (with digital control and with
aftereffect.)

**MS-Th-D-12-1**
13:30–14:00
Direct Lyapunov Method in the Investigation of the Problems on Stability and
Stabilization of Nonlinear Systems Motions with Aftereffect
Andreyev, Aleksander
Ulyanovsk State Univ.

Abstract: In the report the problems on stability and stabilization of nonlinear
systems with aftereffect is investigated using Lyapunov functionals and non-
stationary control systems. We present the new theorem on asymptotic
stability of zero solution of the system of functional-differential equations with
finite delay. The problem on stabilization of program motion of the mechanical
system with delayed control is solved.

**MS-Th-D-12-2**
14:00–14:30
Method of Lyapunov Vector Functions in the Investigation of the Problems on the
Stabilization of Nonlinear Systems Motions with Digital Control
Peregudova, Olga
Ulyanovsk State Univ.

Abstract: In the report the problem of stabilization of nonlinear time-varying
dynamical systems with digital control is investigated using Lyapunov vector
functions and comparison systems. We present a backstepping design based
on the Euler approximate discrete-time model of a continuous-time plant. As
an example the problem of motion stabilization of the three-wheeled mobile robot
with two degrees of freedom is solved on the basis of a sampling system and
application of backstepping procedure with Lyapunov function.

**MS-Th-D-12-3**
14:30–15:00
Stability of Solutions for One Class of Initial Boundary Value Problems in Hy-
droaeroelasticity
Vel’misov, Petr
Anklyov, Andrey
Ulyanovsk State Technical Univ.

Abstract: The mathematical models in problems about dynamics and stability of
deformable elements at external (flying and submersibles, antenna plant, filters) and internal (flowing channels of different function, wind tunnels, nozzle,
pipes, pipelines, sensors, vibration devices) flows is proposed. The analytical,
numerical analysis and numerical methods of the hydroaeroelasticity problem
solution are presented, and on their basis the dynamics and stability of the
deformable elements at a flow their stream of liquid (gas) are researched.

**MS-Th-D-12-4**
15:00–15:30
Stability Investigation of Fluctuations of Construction Elastic Elements of the
Base of Lyapunov Functionals
Anklyov, Andrey
Vel’misov, Petr
Ulyanovsk State Technical Univ.

Abstract: For the example the mathematical model of the flow channel with
an elastic element on the wall is proposed. The model represents an initial-
boundary value problem for system of the differential equations with partial
derivatives for determination of two unknown functions deformation (deflec-
tion) of a element and velocity potential of liquid in channel. On the basis of
construction of the Lyapunov type mixed functional the sufficient stability
conditions of solutions of this problem are received.

**MS-Th-D-13**
13:30–15:30
Progress in hyperbolic problems and applications - Part III of VI
For Part 1, see MS-We-E-13
For Part 2, see MS-Th-BC-13
For Part 4, see MS-Th-E-13
For Part 5, see MS-Fr-D-13
For Part 6, see MS-Fr-E-13

Organizer: Wang, Yin
Univ. of Oklahoma
Organizer: Tewdall, Allen
City Univ. of New York, College of Staten Island

Abstract: Hyperbolic conservation laws form the basis for the mathematical
modeling of many physical systems, and describe a wide range of wave prop-
gagation and fluid flow phenomena, including shock waves in nonlinear situa-
tions. For one dimensional systems with small data, a well-posedness theory
of entropy weak solutions is well known. Analysis in several space dimension-
s, however, remains an enormous challenge. In this minisymposium, recent
results in the theory and numerical analysis of hyperbolic problems will be
presented. A variety of computational techniques, including finite volume, fi-
nite element, spectral, WENO, and discontinuous Galerkin methods, will be
represented.

**MS-Th-D-13-1**
13:30–14:00
Entropy Stability of Conservative Schemes for Conservation Laws
Li, Jiequan
Beijing Normal Univ.

Abstract: We shall show inherent relations between classical numerical vis-
cosity and entropy dissipation and use them as principles to design high order
schemes for convection-dominated fluid dynamical problems.

**MS-Th-D-13-2**
14:00–14:30
Full Compressible Euler Equations with Damping on Boundar Domains
Zhao, Kun
Tulane Univ.
Pan, Ronghua
Georgia Inst. of Tech.

Abstract: In this talk, the global dynamics of small smooth solutions to initial-
boundary value problems of the full compressible Euler equations with fric-
tional damping, and a reduced system consisting of a porous medium type
equation and a transport equation will be presented. Furthermore, the error
of isentropic approximation for the full Euler equations will be discussed.

**MS-Th-D-13-3**
14:30–15:00
Well Posedness and Optimal Control in Structured Population Models
Colombo, Rinaldo M.
Univ. of Brescia

Abstract: This presentation is focused on initial–boundary value problems for
systems of balance laws inspired by structured population models. First, par-
ticular classes of non-local boundary conditions allow to consider renewal e-

duations on a graph, motivated by instance by juvenile-adult models. In this
setting, various control problems can be stated and solved, examples being
the optimal management of renewable resources or the optimal mating ratio.

**MS-Th-D-13-4**
15:00–15:30
Krylov Implicit Integration Factor WENO Methods for High Dimensional
Convection-diffusion Problems
Zhang, Yong-Tao
Univ. of Notre Dame

Abstract: In this talk, I shall present our recent work on developing efficien-
t Krylov implicit integration factor (IFF) schemes for solving high dimensional
convection-diffusion problems. The hyperbolic part of the problems is dis-
cretized by WENO schemes. We designed several strategies and their com-
binations to deal with the computational challenge arising from high spatial
dimensions, including Krylov subspace approximations and sparse grid tech-
iques. Extensive numerical experiments were performed to show the high

efficiency of the new method comparing with IIF schemes developed in the
literature. This is a joint work with Dong Lu at U. of Notre Dame.
Eigenvales of partial differential operators and their applications - Part III of III
For Part 1, see MS-We-E-14
For Part 2, see MS-Th-BC-14
Organizer: Kao, Chiu-Yen
Organizer: Osting, Braxton
Claremont McKenna College
Univ. of Utah
Abstract: Eigenvalues and eigenfunctions are fundamental to the understanding of the dynamics and properties of solutions to partial differential equations. This minisymposium features the latest progress on numerical and theoretical approaches for solving linear and nonlinear eigenvalue problems, eigenvalue optimization, and their applications in several different and important scientific areas including mechanical vibration, optimal conductivity, photonic crystals, and shape classification and recognition.

Band-Gap Optimization for Two Dimensional Photonic Crystals
Shu, Yu-Chen
Department of Mathematics, National Cheng Kung Univ.
CHANG, CHIEN CHENG
National Taiwan Univ.
Abstract: In this talk, a hybrid optimization method is presented to maximize band gaps for photonic crystals with transverse magnetic and transverse electric waves simultaneously. The method is based on gradient flow and the gradient is computed from the discrete system. Since photonic crystals are usually made by two or more materials with specific shapes, we search optimized the parameters of the shapes. Some optimal configurations for different bands are shown.

Maximization of Laplace-Beltrami Eigenvalues on Closed Riemannian Surfaces
Osting, Braxton
Kao, Chiu-Yen
Lai, Rongjie
Univ. of Utah
Claremont McKenna College
Rensselaer Polytechnic Inst.
Abstract: We consider the dependence of Laplace-Beltrami eigenvalues on the underlying Riemannian surface. Computational methods are proposed for finding the conformal and topological spectra, which are defined by eigenvalue optimization problems of maximizing the k-th eigenvalue as the surface varies within an admissible class. Several properties of optimizers are studied computationally, including uniqueness, symmetry, and eigenvalue multiplicity.

Parallel Generalized Eigenvalue Computation with Hybrid Solvers and Their Benchmark on Supercomputers
Imachi, Hiroto
Hoshi, Takeo
Tottori Univ.
Tottori Univ.
Abstract: New distributed parallel dense solvers for symmetric positive definite generalized eigenvalue problems were constructed as hybrid ones between the three parallel solver libraries of ScALAPACK, ELPA and EigenExa. The strong scaling benchmark was carried out on the K supercomputer and other supercomputers with matrix sizes of \( N = 10^3 \times 10^5 \), and it shows high parallel efficiency. The used matrices are constructed from electronic structure calculation problems and available in our matrix data library (http://www.elses.jp/matrix/).
Stability of Supersonic Contact Discontinuities in Three Dimensional Com-
pressible Steady Flows
Wang, Yuguang
Shanghai Jiaotong Univ.
Abstract: In this talk, we study the stability of contact discontinuities in three
dimensional compressible isentropic steady flows. Both of linear and nonlin-
ear stability shall be studied.

MS-Th-D-17-2 14:00–14:30
The Boundary Layer Problem for 2D Incompressible Flows.
Lopes Filho, Milton
Universidade Federal do Rio de Janeiro
Abstract: In this talk we examine recent results on the vanishing viscosity lim-
it for incompressible 2D flows in domains with boundary, focusing on Kato’s
boundary layer criterion and its consequences.

MS-Th-D-17-3 14:30–15:00
On the Vanishing Shear Viscosity Limit and the Vanishing Resistivity Limit
for One-dimensional Compressible MHD Equations
Zhang, Jianwen
Xiamen Univ.
Abstract: In the first part of this talk, the global well-posedness of strong so-
lutions to an initial-boundary value problem of one-dimensional compressible
heat-conductive MHD equations with constant viscosity, resistivity and heat-
conductivity coefficients is established, and the vanishing shear viscosity limit
is justified. In the second part, the global existence of strong solutions of
an initial-boundary value problem of one-dimensional compressible isentropic
MHD equations with zero resistivity coefficient is proved, and the vanishing
resistivity limit is justified.

MS-Th-D-17-4 15:00–15:30
Incompressible Limit of Navier-Stokes Equations in Bounded Domains
Ou, Yaobin
Renmin Univ. of China
Abstract: In this paper, we study the singular limit of compressible Navier-
Stokes equations in three-dimensional bounded domains as the Mach num-
ber goes to zero. Provided that the initial data are “well-prepared” in the sense
that certain Sobolev norms of temporal derivatives are bounded initially, we
establish the uniform estimates with respect to the Mach number, which gives
the convergence from the compressible Navier-Stokes equations to the in-
compressible Navier-Stokes equations.

MS-Th-D-18 13:30–15:30 209B
Mathematics and Optics - Part I of IV
For Part 2, see MS-Th-E-18
For Part 3, see MS-Fr-D-18
For Part 4, see MS-Fr-E-18
Organizer: Santosa, Fadil
Inst. for Mathematics & its Applications
Zhejiang Univ.
Organizer: Weinstein, Michael
Columbia Univ.
Abstract: The importance of optics and is summarized in the 2013 US Nation-
al Academy of Sciences report “Optics and Photonics: Essential Technology
for Our Nation”. Envisioned technologies which rely on optics include com-
munications, imaging, sensing, and computing. What is clear from the report
is that the Mathematical Sciences is poised to make significant contributions
to the progress in technology. Indeed there is a growing research activity at
the nexus of the Mathematical Sciences and the Optical Sciences. Together
with advances in materials science and nano-structure fabrication, there is a
growing role for mathematical tools, both computational and analytical.
The goal of this minisymposium is to highlight research in the mathematical
sciences that deal with problems arising in optics and photonics. Topics that
will be discussed in the sessions include optics in meta-materials, cloaking,
photonic bandgap structures, design and control of optical devices, plasmon-
ics, and nonlinear phenomena in optics. These topics will be emphasized
during the Institute for Mathematics and its Applications (IMA) annual themat-
ic program “Mathematics and Optics”, 2016-17. The minisymposium is an
invitation to mathematical scientists to participate in the IMA program.

MS-Th-D-18-1 13:30–14:00
New Insights on Cloaking Due to Anomalous Localized Resonance
Thaler, Andrew
Inst. for Mathematics & its Applications
Abstract: We present recent results on cloaking due to anomalous localized
resonance for general charge density distributions. We prove that the power
dissipated in a superlens diverges as certain dissipation parameters in the
superlens tend to zero and when certain charge density distributions are lo-
cated within a critical distance of the superlens. The critical distance strongly
depends on the rate at which the dissipation parameters in the materials sur-
rrounding the superlens tend to zero.

MS-Th-D-18-2 14:00–14:30
Inverse Scattering Spectroscopy for Fast Sizing Metal Nanoparticles
Wave Equations, and investigate a family of L2 stable high order discontinuous
Electromagnetic Field Enhancement for Metallic Nano-gaps to illustrate the application of this approach.

Abstract: We report the use of molecular dynamics to identify from equilibrium thermal fluctuations the hydrodynamic modes in a fluid confined by solid walls, thereby extending the application of the fluctuation-dissipation theorem to yield not only the accurate location of the hydrodynamic boundary at the molecular scale, but also the relevant parameter value(s) for the description of the macroscopic boundary condition. Results on two examples are presented to illustrate the application of this approach.

Electromagnetic Field Enhancement for Metallic Nano-gaps
Lin, Junshan
Department of Mathematics & Statistics, Auburn Univ.
Abstract: Electromagnetic field enhancement and extraordinary optical transmission effect through subwavelength apertures has significant potential applications in biological and chemical sensing, spectroscopy, terahertz semiconductor devices, etc. In this talk, I will present our recent mathematical studies on the field enhancement when an electromagnetic wave passes through a single metallic nano-gap. The ongoing work on the field enhancement of other sub-wavelength metallic structures will also be highlighted.

Eigenvalues Minimization for Biharmonic Equations
Chen, Weitao
Chou, Ching-Shan
Kao, Chi-Yen
Univ. of California, Irvine
The Ohio State Univ.
Claremont McKenna College
Abstract: We propose a numerical method to find the optimal rearrangement of density distribution in order to minimize a specific eigenvalue. We answer the open question about optimal density configurations for clamped rods with minimal second and above eigenvalues numerically.

L2 Stable Discontinuous Galerkin Methods for One-dimensional Two-way Wave Equations
Cheng, Yingda
Li, Fengyan
Chou, Ching-Shan
Xing, Yulong
Michigan State Univ.
Rensselaer Polytechnic Inst.
The Ohio State Univ.
Oak Ridge National Laboratory & Univ. of Tennessee
Abstract: Simulating wave propagation is one of the fundamental problems in scientific computing. In this talk, we consider one-dimensional two-way wave equations, and investigate a family of L2 stable high order discontinuous Galerkin methods, which is defined through a general form of numerical fluxes. For these L2 stable methods, we systematically establish stability (hence energy conservation), error estimates (in both L2 and negative-order norms), and dispersion analysis.

Dispersion Reducing Methods for Edge Discretizations of the Electric Vector Wave Equation
Bokil, Vrushali
Ohio State Univ.
Abstract: We present a technique called M-adaptation, based on the mimetic finite difference method, for minimizing numerical dispersion error in edge discretizations of the time-domain vector wave equation on square meshes. The temporal discretization uses the Leapfrog scheme, and mass-lumping is performed to obtain an explicit time stepping method. We obtain a method that has fourth order accurate numerical dispersion as well as numerical anisotropy. Numerical simulations are provided to illustrate theoretical results.

Energy Conserving Local Discontinuous Galerkin Methods for the Nonlinear Schroedinger Equation with Wave Operator
Xu, Yan
Univ. of Sci. & Tech. of China
Abstract: In this paper, we present a fully discrete scheme by discretizing the space with the local discontinuous Galerkin (LDG) method and the time with the Crank-Nicholson scheme to simulate the multi-dimensional Schrodinger equation with wave operator. The energy conservation is also a crucial property for long time simulations which will be demonstrated in the numerical experiment. The optimal error estimates of the semi-discrete scheme can be obtained for the linear case. Some numerical experiments in...
trategy to overcome the ill-posedness of the problem. Numerical experiments are implemented for the benchmark Marmousi model. The results show the
effectiveness and correctness of the presented inversion method.

**MS-Th-D-20-4 15:00–15:30**

**A Primal Dual Active Set Algorithm for the Nonconvex Sparse Optimization Problems**

Lu, Xiliang  
Wuhan Univ.

Abstract: In this talk, we consider the problem of recovering a sparse signal from noisy measurement data. An algorithm of primal-dual active set strategy for a class of nonconvex sparsity-promoting penalties is proposed. Convergence analysis for some special cases are provided, and numerical examples verifies the efficiency of the given algorithm.

**MS-Th-D-21 13:30–15:30**

Minisymposium on discontinuous Galerkin method: recent development and applications - Part VI of VIII

For Part 1, see MS-Tu-D-21
For Part 2, see MS-Th-E-21
For Part 3, see MS-We-D-21
For Part 4, see MS-We-E-21
For Part 5, see MS-Th-BC-21
For Part 7, see MS-Th-E-21
For Part 8, see MS-Fr-D-21

Organizer: Xu, Yan  
Univ. of Sc. & Tech. of China
Organizer: Shu, Chi-Wang  
Brown Univ.

Abstract: Over the last few years, discontinuous Galerkin (DG) methods have found their way into the mainstream of computational sciences and are now being successfully applied in almost all areas of natural sciences and engineering. The aim of this minisymposium is to present the most recent developments in the design and theoretical analysis of DG methods, and to discuss relevant issues related to the practical implementation and applications of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

**MS-Th-D-21-1 13:30–14:00**

**A Staggered Discontinuous Galerkin Method for the Navier-Stokes Equations**

Chung, Eric  
The Chinese Univ. of Hong Kong

Abstract: We will present a new staggered discontinuous Galerkin method for the Navier-Stokes equations. The method preserves many of properties arising from the PDE. Numerical results are shown. The research is partially supported by CUHK Direct Grant.

**MS-Th-D-21-2 14:00–14:30**

**Third Order Maximum Principle Preserving Discontinuous Galerkin Method for Convection Diffusion Equations on Unstructured Triangular Meshes**

Yan, Jue  
iowa state Univ.

Abstract: In this talk, we show the Direct discontinuous Galerkin method and its variations satisfy the strict maximum principle with third order of accuracy on two dimensional unstructured triangle mesh. Sufficient conditions are given to guarantee the piecewise polynomial solutions bounded above and below by the given constants. Numerical examples are carried out to show the optimal 3rd order of accuracy is maintained with the maximum principle limiter. The positivity of the polynomial solutions are preserved.

**MS-Th-D-21-3 14:30–15:00**

**Well-balanced Discontinuous Galerkin Methods for the Euler Equations under Gravitational Fields**

Xing, Yulong  
Oak Ridge National Laboratory & Univ. of Tennessee

Abstract: Hydrodynamical evolution in a gravitational field arises in many astrophysical problems. Improper treatment of the gravitational force can lead to a solution which oscillates around the equilibrium. In this presentation, we propose a recently developed well-balanced discontinuous Galerkin method for the Euler equations under gravitational fields, which can maintain the hydrostatic equilibrium state exactly. Some numerical tests are performed to verify the well-balanced property, high-order accuracy, and good resolution for smooth and discontinuous solutions.

**MS-Th-D-21-4 15:00–15:30**

**Runge-Kutta Discontinuous Galerkin Method Using WENO Limiters on (un)structured Meshes**

Zhu, Jun  
Nanjing Univ. of Aeronautics & Astronautics

Abstract: In this talk, we generalize some new limiters based on the weight-ed essentially non-oscillatory (WENO) finite volume methodologies for the Runge-Kutta discontinuous Galerkin (RKDG) methods solving nonlinear hyperbolic conservation laws on structured and unstructured meshes. Numerical results for both scalar equations and Euler systems of compressible gas dynamics are provided to illustrate the good performance of these procedures.

**MS-Th-D-22 13:30–15:30**

Recent development and applications of weighted essential non-oscillatory methods - Part II of V

For Part 1, see MS-Th-BC-22
For Part 3, see MS-Th-E-22
For Part 4, see MS-Fr-D-22
For Part 5, see MS-Fr-E-22

Organizer: Qiu, Jianxian  
Xiamen Univ.
Organizer: Shu, Chi-Wang  
Brown Univ.

Abstract: The spectrum covered by the minisymposium ranges from recent development, analysis, implementation and applications, for the weighted essential non-oscillatory (WENO) methods. The WENO methods provide a practical effective framework to solve out many nonlinear wave-dominated problems with discontinuities or sharp gradient regions, which play an important role arising in many applications of computational fluid dynamics, computational astrophysics, computational plasma physics, semiconductor device simulations, among others. Devising robust, accurate and efficient WENO methods for solving these problems is of considerable importance and, as expected, has attracted the interest of many researchers and practitioners. This minisymposium serves as a good forum for researchers to exchange ideas and to promote this active and important research direction.

**MS-Th-D-22-1 13:30–14:00**

**Hermite WENO Schemes for Hyperbolic Conservation Laws**

Qiu, Jianxian  
Xiamen Univ.

Abstract: A class of WENO schemes based on Hermite polynomials, termed HWENO schemes, for solving hyperbolic conservation law is presented. Both the function and its first derivative values are evolved in time and used in the reconstruction, while only the function values are evolved and used in WENO schemes. Comparing with WENO schemes one major advantage of HWENO schemes is its compactness in the reconstruction. Numerical results are presented to show the efficiency of the schemes.

**MS-Th-D-22-2 14:00–14:30**

**A Class of Central Compact Schemes with Spectral-like Resolution**

Zhang, Shuhai  
state key laboratory of aerodynamics

Abstract: In this talk, I will report our recent work of a class of central compact schemes with spectral-like resolution. Combining the technique of Lele’s linear compact scheme and WENO interpolation, we developed a class of central compact scheme including linear and nonlinear scheme. The linear compact scheme has higher order, spectral-like resolution and low dissipation. It is an ideal method for the computation of multi-scale problems, such aeroacoustics. The nonlinear compact scheme has the similar property to compute strong shock wave with WENO scheme. While, the resolution for short wave is much higher than that of WENO scheme.

**MS-Th-D-22-3 14:30–15:00**

**Hybridization of Weighted Essentially Non-oscillatory Finite Difference Scheme for Conservation Law**

Don, Wai Sun  
Ocean Univ. of China/Brown Univ.
Gao, Zhen  
Ocean Univ. of China
Li, Peng  
Beijing Inst. of Tech.

Abstract: I will discuss some recent development of hybridization of high order nonlinear WENO FD scheme and classical linear scheme(finite differences, compact) and non-classical scheme (spectral, Fourier conjugation) scheme, together with high order shock sensors (multi-resolution, Fourier conjugate) to demonstrate the smoothness of a solution of hyperbolic conservation laws. The pros and cons of the various schemes in terms of accuracy and efficiency and some critical issues will be discussed and illustrated with examples.

**MS-Th-D-22-4 15:00–15:30**

**Hybrid WENO Schemes with Different Indicators on Curvilinear Grids**

Li, Gang  
Qingdao Univ.

Abstract: In [J. Comput. Phys. 229 (2010) 8105-8129], we studied hybrid weighted essentially non-oscillatory (WENO) schemes with different indicators for hyperbolic conservation laws on uniform grids for Cartesian domains. In this presentation, we extend the schemes to solve two-dimensional systems of hyperbolic conservation laws on curvilinear grids for non-Cartesian domains. Our goal is to obtain similar advantageous properties as those of the hybrid WENO schemes on uniform grids for Cartesian domains. Extensive numerical results for the Euler equations of gas dynamics as well as the shel-
low water equations all strongly support that the hybrid WENO schemes with discontinuity indicators on curvilinear grids can also save considerably computational cost in contrast to the pure WENO schemes. They also maintain the essentially non-oscillatory property for general solutions with discontinuities and keep the sharp shock transition.

### Abstract

PDE based eigenvalue problems arise from electronic structure calculations, band structure calculations in photonic crystals and dynamics of electromagnetic fields. This minisymposium brings together researchers working on PDE-based eigenvalue problems from areas of mathematical modeling and analysis, numerical analysis, high-performance computing and applications. This minisymposium features the latest progress on developing adaptive discretizations, stable nonlinear iterations and fast algebraic solvers, code designing and high performance computing on modern computer systems.

**MS-Th-D-23**

**13:30–14:00**

**Low-rank Tensor Methods for High-dimensional Eigenvalue Problems**

**Kressner, Daniel**

EPFL

**Abstract:** This talk is concerned with eigenvalue problems that feature extremely large matrices with Kronecker structure. Such problems arise, for example, from the discretization of high-dimensional PDE eigenvalue problems on tensorized domains or from the simulation of stochastic automata network systems. We discuss optimization based methods for achieving low-rank approximations to the solution of such problems and present new a priori approximation results.

**MS-Th-D-23-2**

**14:00–14:30**

**Eigendecompositions and Fast Eigensolvers for Three Dimensional Maxwell’s Equations**

**Lin, Wen-Wei**

National Chiao Tung Univ.

**Abstract:** This talk focuses on discrete double/single-curl operators in Maxwell’s equations for 3D photonic crystals, chiral and pseudochiral complex media with face centered cubic lattices. We derive an eigendecomposition of degenerate coe\(\&\#64259;\)cient matrices and apply it to project the associated GEVP to a SEVP which can be solved by the inverse Lanczos method. We propose efficient matrix-vector multiplication schemes on FFT due to the eigendecomposition to sign\(\&\#64257;\)antly reduce the computational cost and develop fast eigensolvers.

**MS-Th-D-23-3**

**14:30–15:00**

**Eigenvector Problem in Electron Excitation**

**Yang, Chao**

Lawrence Berkeley National Laboratory

**Abstract:** Single-electron excitation can be described by a nonlinear eigenvalue known as the Dyson’s equation in which the Hamiltonian operator is a function of the eigenvalue to be determined. We will describe the nonlinear structure of the eigenvalue problem and examine numerical methods for solving this type of problem. We will examine the Bethe-Salpeter eigenvalue problem that describe the collective excitation of an electron-hole pair.

**MS-Th-D-23-4**

**15:00–15:30**

**Analysis and Computation for Ground States in Degenerate Quantum Gas**

**Bao, Weizhu**

National Univ. of Singapore

**Cai, Yongyong**

Beijing Computational Sci. Research Center

**Abstract:** The ground state in degenerate quantum gas is defined as the minimizer of the energy functional under a constraint, which is an infinity dimensional nonconvex minimization problem. In this talk, we will discuss the existence and uniqueness as well as non-existence of the ground state under different parameter regimes; present asymptotic approximations in some limiting parameter regimes; and propose some efficient and accurate numerical methods for computing the ground states.

**MS-Th-D-24**

**13:30–15:30**

**Computational Electromagnetism and Its Engineering Applications - Part I of IV**

**For Part 2, see MS-Th-E-24**

**For Part 3, see MS-Fr-D-24**

**For Part 4, see MS-Fr-E-24**

**Organizer:** Duan, Huoyuan

Collaborative Innovation Centre of Mathematics, School of Mathematics & Statistics, Wuhan Univ., Wuhan 430072, China

**Organizer:** Zheng, Weiyong

Chinese Acad. of Sci.

**Abstract:** In recent years, there arises a surge of numerical studies for electromagnetic problems in complex engineering systems, such as large power transformers, electrical machinery, magnetic fusion, etc. The mathematical models turn out to be nonlinear, multiscale, strongly singular, and coupled with multiple physical fields. It brings new challenges to researchers from both mathematical and engineering communities in developing practical mathematical models and effective and efficient numerical methods and solvers. This mini-symposium seeks to bring together researchers in both computational mathematics and electromagnetic engineering that involve the mathematical modeling, analysis, computation, and experimental validation for electromagnetic problems. The main theme will be focused on new efficient numerical methods and fast solvers for Maxwell’s equations and magnetohydrodynamic equations and will address their extensive applications to engineering problems. It will promote exchange of ideas and recent developments on mathematical modeling, numerical discretization, solvers and engineering practices of computational electromagnetism.

**MS-Th-D-24-1**

**13:30–14:00**

**A Consistent, Conforming and Genuinely Nodal-continuous Finite Element Method for 3D Time-harmonic Maxwell Equations with Singular Solution and Singular Data**

**Duan, Huoyuan**

Collaborative Innovation Centre of Mathematics, School of Mathematics & Statistics, Wuhan Univ., Wuhan 430072, China

**Abstract:** This paper has explored a weak form of the 3D time-harmonic Maxwell equations, and by mimicking this weak form we have developed a new finite element method by employing \(H^1\)-conforming nodal-continuous elements. The method is coercive, equivalence to the \(H^1(\Omega)\)-norm, resulting in a symmetric, positive definite algebraic linear system, together with a \(O(h^{-2})\) condition number. The quasi-optimal error estimate has been established, leading to a convergence in the \(H^1(\Omega)\)-norm.

**MS-Th-D-24-2**

**14:00–14:30**

**A First Order System Least Squares Method for the Helmholtz Equation**

**Qiu, Weifeng**

City Univ. of Hong Kong

**Chen, Huangxin**

Xiamen Univ.

**Abstract:** We present a first order system least squares (FOSLS) method for the Helmholtz equation at high wave number \(k\), which always deatures Hermitian positive definite algebraic system. By utilizing a non-trivial solution decomposition to the dual FOSLS problem, we give error analysis to the FOSLS method where the dependence on \(h, k\) is given explicitly. The L2 norm error of the scalar solution is shown to be quasi optimal under reasonable assumption.

**MS-Th-D-24-3**

**14:30–15:00**

**Analysis of Transient Electromagnetic Scattering from Three-Dimensional Cavities**

**Li, Peijun**

Purdue Univ.

**Abstract:** This talk is concerned with the mathematical analysis of the time-domain Maxwell equations in a three-dimensional cavity. An exact transparent boundary condition is developed to reformulate the open cavity scattering problem in an unbounded domain equivalently into an initial-boundary value problem in a bounded domain. The well-posedness and stability are studied for the reduced problem. Moreover, an a priori estimate is established for the electric field with a minimum regularity requirement for the data.

**MS-Th-D-24-4**

**15:00–15:30**

**Nonconforming Finite Element Method for Wave Propagation in Metamaterials**

**Yao, Changhui**

School of mathematics & statistics

Wuhan 430072, China

**Abstract:** Nonconforming mixed finite element method is proposed to simulate wave propagation in metamaterials. The error estimate of the semi-discrete scheme is given by convergence order \(O(h)\), which is less than 40 percent of the computational costs comparing with the same effect by using Nédélec-Raviart element. A Crank-Nicolson full discrete scheme is also presented with...
O(\tau^2 + h) by traditional discrete formula. Numerical examples of 2D TE, TM cases and a famous re-focusing phenomena are shown.

**MS-Th-D-25** 13:30–15:30 210A

Emerging PDEs: Analysis and Computation - Part I of IV

For Part 2, see MS-Th-E-25

For Part 3, see MS-Fr-D-25

For Part 4, see MS-Fr-E-25

Organizer: Chen, Zhiming

AMSS, Chinese Acad. of Sci.

Organizer: Nochetto, Ricardo

Univ. of Maryland

Organizer: Zhang, Chensong

Acad. of mathematics & Sys. Sci.

Abstract: Novel models in science and engineering are governed by nonlinear integro-differential equations with increasing complexity which demand innovative techniques in both analysis and computation, such as adaptivity, fast methods and preconditioning, and structure preserving algorithms. Areas of special interest include complex fluids and new materials, electromagnetism, and wave propagation, uncertainty quantification, and fractional PDEs, among others.

This minisymposium intends to gather about 16 world experts and young researchers in analysis and computation of PDE to discuss the most recent progress in this exciting field as well as future directions for research.

**MS-Th-D-25-1** 13:30–14:00

A Finite Element Method for Liquid Crystals with Variable Degree of Orientation

Walker, Shawn

Louisiana State Univ.

Nochetto, Ricardo

Univ. of Maryland

Zhang, Wujun

Univ. of Maryland, College Park

Abstract: We present a finite element method (FEM) for computing equilibrium configurations of liquid crystals with variable degree of orientation. The model consists of a Frank-like energy with an additional "s" parameter that allows for line defects with finite energy, but leads to a degenerate elliptic equation for the director field. Our FEM uses a special discrete form of the energy that does not require regularization, and allows us to obtain a stable (gradient flow) scheme.

**MS-Th-D-25-2** 14:00–14:30

Numerical Methods for Large Bending Problems

Bartels, Sören

Univ. of Freiburg

Abstract: Thin elastic bilayer structures arise in various modern applications, e.g., in the fabrication of nanotubes or microgrippers. The mathematical modeling leads to a nonlinear fourth order problem with nonlinear pointwise constraint. We prove the convergence of a finite element discretization within the framework of Γ-convergence and discuss the convergence of an iterative solution method.

**MS-Th-D-25-3** 14:30–15:00

Quasi-interpolants and Local Projections in Isogeometric Analysis

BUFFA, Annalisa

IMATI “E. Magenes”, CNR

Garau, Eduardo M.

Instituto de Matematica Aplicada del Litoral (CONICET-UNL) & Facultad de Ingeniería nº305; a Quilà305;tica (UNL), Argentina

Giannelli, Carlotta

Dipartimento di Matematica, Università di Pavia

Sangalli, Giancarlo

INdAM c/o Univ. of Florence

Abstract: The analysis of the error for isogeometric methods is based on the construction of suitable projection operators onto the space of splines or their generalisations as NURBS, T-splines or hierarchical splines. In this talk, I will review the general theory of quasi interpolates proposed by Lee, Lyche, and Morken in 2000, and design a class of quasi-interpolation operators that can be proved stable in relevant Sobolev spaces and under minimal assumptions on the underlying mesh.

**MS-Th-D-25-4** 15:00–15:30

Asymptotically Compatible Schemes for Parametrized Variational Problems

Du, Qiang

Columbia Univ.

Tian, Xiaochuan

Columbia Univ.

Abstract: We present the recently developed abstract framework of asymptotically compatible (AC) schemes for robust discretizations of a family of parametrized problems. We discuss a few of its applications, including the characterization of AC schemes for nonlocal diffusion and peridynamic models and their local PDE limits, and the development of a nonconforming discontinuous finite element approximation for nonlocal models.

**MS-Th-D-26** 13:30–15:30 110

Functional Itô calculus and Path-dependent Partial Differential Equations

Organizer: CONT, Rama

Imperial College London

Abstract: The Functional Itô calculus is a non-anticipative functional calculus which extends the Itô calculus to path-dependent functionals of stochastic processes. This recently developed approach has led to new results on the representation of martingales as stochastic integrals, the derivation of Feynman-Kac formulae for path-dependent functionals and a new class of functional equations known as “path-dependent PDEs”, which extends the classical Kolmogorov equations to the non-Markovian case. With interesting connections to the theory of backward stochastic differential equations.

This MiniSymposium presents recent research on Functional Itô calculus and path-dependent PDEs and their applications to stochastic control and simulation of stochastic processes.

**MS-Th-D-26-1** 13:30–14:00

Weak Solutions for Path-dependent Kolmogorov Equations

CONT, Rama

Imperial College London

Abstract: Path-dependent Kolmogorov equations naturally arise as the extension of the classical backward Kolmogorov equations to the case of non-Markovian stochastic processes. We introduce a notion of Sobolev-type weak solution for linear and semilinear path-dependent PDEs and show that this notion of weak solution has a natural connection to (backward) stochastic differential equation. In particular, given a reference semimartingale X, any square-integrable (sub)martingale in the filtration of X is characterized as a weak (sub)solution of the path-dependent Kolmogorov equation corresponding to X.

**MS-Th-D-26-2** 14:00–14:30

Viscosity Solutions of Obstacle Problems for Fully Nonlinear Path-dependent PDEs

Ekren, Ibrahim

ETH Zurich

Abstract: In this talk, we adapt the definition of viscosity solutions to the obstacle problem for fully nonlinear path-dependent PDEs with data uniformly continuous in $(t, \omega)$, and generator Lipschitz continuous in $(y, z, \gamma)$.

. We prove that our definition of viscosity solutions is consistent with the classical solutions, and satisfy a stability result. We show that the value functional defined via the second order reflected backward stochastic differential equation is the unique viscosity solution of the variational inequalities.

**MS-Th-D-26-3** 14:30–15:00

Pathwise Itô Calculus for Rough Paths and Applications

Zhang, Jianfeng

Univ. of Southern California

Abstract: The functional Itô calculus has been very successful in many applications, particularly in viscosity theory for backward path dependent PDEs. In this talk we extend the theory to pathwise Itô calculus, in the rough path framework with possibly non-geometric rough paths. This is appropriate for forward problems. Some applications on (forward) stochastic PDEs will also be discussed.

**MS-Th-D-26-4** 15:00–15:30

Weak Approximation of Martingale Representations

Lu, Yi

Univ. Paris 6

Abstract: We present a systematic method for computing explicit approximations to martingale representations for a large class of Brownian functionals. The approximations are based on a notion of pathwise functional derivative and yield a consistent estimator for the integrand in the martingale representation formula for any square-integrable functional of the solution of an SDE with path-dependent coefficients. Explicit convergence rates are derived for functionals which are Lipschitz-continuous in the supremum norm. The approximation and the proof of its convergence are based on the Functional Itô calculus, and require neither the Markov property, nor any differentiability conditions on the coefficients of the stochastic differential equations involved.
Abstract: We shall address the problem of stabilizing systems coupling the incompressible Navier-Stokes equations with the Lamé system of linear elasticity. The control is a distributed control acting only in the elasticity equation, localized in a neighborhood of the fluid-structure interface. For regular initial data, small enough, we prove the existence of $L^2$ controls stabilizing the coupled system with an arbitrarily prescribed exponential decay rate. This is a joint work with M. Vanniniathan.

**MS-Th-D-28-3** 14:30–15:00
Control of PDE Models Involving Memory Terms
Zuazua, Enrique
BCAM & Ikerbasque

Abstract: We analyse controllability issues for PDE models involving memory terms. We show that, if the support of the control does not move in time, the memory of the system cannot be controlled. We then prove that, if the control moves covering eventually the whole domain, the memory term is also controllable. We use a decoupling argument allowing to write the memory PDE as the superposition of the PDE with an ODE or transport equation.

**MS-Th-D-28-4** 15:00–15:30
Random Attractor for Globally Modified Non-autonomous 3D Navier-Stokes Equations with Memory Effects and Stochastic Perturbations
Chen, Zhang
Shandong Univ.
LIN, Wei
Fudan Univ.

Abstract: In this talk, globally modified non-autonomous 3D Navier-Stokes equations with memory effects and noise perturbations will be discussed. This stochastic equations may produce a infinite dimensional random dynamical system in the space of $C_{ loc}^1$, and theoretical results show that random attractor for this random dynamical system is upper semicontinuous with respect to noise intensity parameter and modified parameter.

**MS-Th-D-28** 13:30–15:30
Numerical Homogenization and Multiscale Model Reduction Methods - Part II of V
For Part 1, see MS-Th-BC-28
For Part 2, see MS-We-D-28
For Part 3, see MS-Th-E-28
For Part 4, see MS-Fr-D-28
For Part 5, see MS-Fr-E-28

Organizer: Peterseim, Daniel
Universität Bonn
Organizer: Zhang, Wei
Shanghai Jiao Tong Univ.
Organizer: Peterseim, Daniel
Universität Bonn
Organizer: Zhang, Wei
Shanghai Jiao Tong Univ.
Organizer: Peterseim, Daniel
Universität Bonn

Abstract: Problems that transcend a variety of strongly coupled time and length scales are ubiquitous in modern science and engineering such as physics, biology, and materials. Those multiscale problems pose major mathematical challenges in terms of analysis, modeling and simulation. At the same time, advances in the development of multiscale mathematical methods coupled with continually increasing computing power have provided scientists with the unprecedented opportunity to study complex behavior and model systems over a wide range of scales. This minisymposium is aimed at presenting the state-of-the-art in multiscale modeling, simulation and analysis for the applications in science and engineering. It will focus on the developments and challenges in numerical multiscale methods and multiscale model reduction methods. The lectures will cover the following subjects: - Numerical homogenization methods, e.g. Generalized FEM, MsFEM, FEM-HMM, DG methods, Partition of Unity methods, multiscale domain decomposition etc. - Multiscale model reduction methods for stochastic systems, such as stochastic PDEs and random materials. - Multiscale methods for problems arising in composite materials and heterogeneous porous media. - Multiscale methods for eigenvalue problems, high frequency waves, and multiscale hyperbolic PDEs. - Multiscale modeling in various applications such as reservoir performance prediction, bio-motility, chemical vapor infiltration, etc.

**MS-Th-D-28-1** 13:30–14:00
Finite Element Heterogeneous Multiscale Method (FE-HMM) for the Helmholtz Equation in Various Complex Materials
Stohrer, Christian
POEMS team, ENSTA ParisTech

Abstract: We present a numerical homogenization method for the Helmholtz Equation using the FE-HMM framework. We first consider composite materials where the wave speed oscillates rapidly on a microscopic length scale, but is uniformly bounded from above and below. We prove convergence of our approximation to the solution of the effective equation which describes the macroscopic behaviour. Afterwards, we apply our scheme to perforated
MS-Th-D-29-2 14:00–14:30
**Computation of Eigenvalues Using Multiscale Techniques**
Målqvist, Axel
Univ. of Gothenburg

**Abstract:** We consider numerical approximation of linear and non-linear eigenvalue problems, using the Localized Orthogonal Decomposition (LOD) technique. In this approach a low dimensional generalized finite element space is constructed, by solving localized (in space) independent linear stationary problems. The eigenvalue problem is then solved in the computed low dimensional space at a greatly reduced computational cost.

MS-Th-D-29-3 14:30–15:00
**Multiscale Model Reduction for Reservoir Performance Predictions**
Wu, Xiaohui
ExxonMobil Upstream Research Company

**Abstract:** Model reduction is a key component in a data-driven and/or decision-driven, integrated reservoir modeling and simulation workflow for reliable reservoir performance predictions. An overview of different model reduction approaches, their practical motivations, challenges, and recent progress is presented. Large scale application of existing model reduction techniques in practical workflows still faces many challenges, from theoretical analysis, to numerical algorithms, and computing infrastructures. A few of these challenges are highlighted in this talk.

MS-Th-D-29-4 15:00–15:30
**A Posteriori Error Estimation for Multiscale Computations Based on MsFEM**
Leung, Frederick
ENPC

**Abstract:** The Multiscale Finite Element Method (MsFEM) is a Finite Element type approach for multiscale PDEs, where the basis functions used to generate the approximation space are precomputed and are specifically adapted to the problem at hand. A priori bounds on the numerical error have been established for several variants of the MsFEM approach. In this work, we introduce a guaranteed and fully computable a posteriori error estimate. Joint work with L. Chomao.

MS-Th-D-30 13:30–15:30 VIP2-2
**Numerical approaches in optimization with PDE constraints: recent progress and future challenges - Part IV of VII**
For Part 1, see MS-We-D-30 For Part 2, see MS-We-E-30 For Part 3, see MS-Th-BC-30 For Part 4, see MS-Th-E-30 For Part 5, see MS-Fr-D-30 For Part 6, see MS-Fr-E-30

**Organizer:** Yan, Ningning
Chinese Acad. of Sci.

**Organizer:** Hinze, Michael
Universität Hamburg

**Abstract:** The numerical treatment of optimization problems with PDE constraints is a very active field of mathematical research with great importance for many practical applications. To achieve further progress in this field of research, the development of tailored discretization techniques, adaptive approaches, and model order reduction methods has to be intertwined with the design of structure exploiting optimization algorithms in function space. This minisymposium covers mathematical research in PDE constrained optimization ranging from numerical analysis and adaptive concepts over algorithm design to the tailored treatment of optimization applications with PDE constraints. It thereby forms a platform and fair for the exchange of ideas among young researchers and leading experts in the field, and for fostering and extending international collaborations between research groups in the field.

**MS-Th-D-30-1 13:30–14:00**
**Finite Difference for Pricing American Lookback Options**
Zhang, Tie
northeastern Univ.

**Abstract:** We are concerned with the pricing of lookback options with American type constraints. An implicit difference scheme is constructed and analyzed. We show that the difference solution is uniquely existent and unconditionally stable, and it converges uniformly to the viscosity solution of the continuous problem. Furthermore, an $O(\Delta t + h^2)$-order error estimate is derived in the discrete $L^\infty$-norm provided that the continuous problem is sufficiently regular.

**MS-Th-D-30-2 14:00–14:30**
**Finite Element Approximation of Time Fractional Optimal Control Problems**
Zhou, Zhongjie
Shandong Normal Univ.

**Gong, Wei**
Chinese Acad. of Sci.

**Abstract:** This talk will address Galerkin finite element approximation of optimal control problem governed by time fractional diffusion equations. Piecewise linear polynomials are used to approximate the state, while the control is discretized by variational discretization method. A finite difference method is used to discretize the time fractional derivative. A priori error estimates for the semi-discrete approximations are derived. Numerical example is given to illustrate the theoretical findings.

**MS-Th-D-30-3 14:30–15:00**
**Multiscale Analysis and Algorithms for Optimal Control and Optimal Design in Composite Materials**
Liqun, Cao
Chinese Acad. of Sci.

**Abstract:** In this talk, I will introduce the recent advances in multiscale approach for optimal control and optimal design in composite materials. The homogenization method and the multiscale asymptotic method are presented. The associated algorithms and convergence analysis are provided. Finally, numerical examples are carried out to confirm the above theoretical results.

**MS-Th-D-30-4 15:00–15:30**
**An All-at-once Approach to PDE-constrained Optimal Control Problems with Uncertain Inputs**
Benner, Peter
Max Planck Inst. for Dynamics of Complex Technical Sys.

**Abstract:** We consider the numerical solution of PDE-constrained optimization problems involving random coefficients. Discretizing such problems by the stochastic Galerkin finite element method leads to prohibitively high dimensional saddle point systems with Kronecker product structure. We derive robust Schur complement-based preconditioners for solving the resulting resulting linear systems with all-at-once low-rank solvers. We illustrate the effectiveness of our solvers with numerical experiments for the random heat and Stokes equations. [Joint work with Martin Stoll and Akwum Onwunta.]
Abstract: Conforming Rectangular Elements and Nonconforming Simplex Elements for Elasticity Problem

Chen, Shao-chun
Zhengzhou Univ.

Abstract: First we construct a conforming rectangular element and a conforming cubic element only with the degrees of freedom on an element $8+2$ and $18+3$ for stress and displacement, respectively. We prove that two elements are convergence on anisotropic meshes. Then we construct a family of simplex nonconforming elements (tetrahedral for 3D and triangular for 2D). These elements only use the degrees of freedom defined on faces and elements.

**MS-Th-D-32** 13:30–15:30 307A

Structured-mesh methods for interface problems. - Part V of VIII

For Part 1, see MS-Tu-E-32
For Part 2, see MS-We-D-32
For Part 3, see MS-We-E-32
For Part 4, see MS-Th-B-32
For Part 6, see MS-Th-E-32
For Part 7, see MS-Fr-D-32
For Part 8, see MS-Fr-E-32

Organizer: Chen, Huanzhen College of Mathematical Sci. Shandong Normal Univ.
Organizer: He, Xiaoming Missouri Univ. of Sci. & Tech.
Organizer: KWAK, Do Young Korea Advanced Inst. of Sci. & Tech.
Organizer: Zhang, Xu Purdue Univ.

Abstract: In many real world applications it is more convenient or efficient to utilize structured meshes for solving different types of interface problems. Since the structured meshes may not fit the non-trivial interfaces, special methods need to be developed to deal with the difficulties arising from the interface problems in order to solve them on these meshes. Therefore, great efforts have been made for solving interface problems and tracing the moving interfaces based on structured meshes in the past decades. This mini-symposium intends to create a forum for researchers from different fields to discuss recent advances on the structured-mesh numerical methods for interface problems and their applications.

**MS-Th-D-32-1** 13:30–14:00

Interface Capturing in A Hybrid Finite Volume/Element Method for Two-Fluid Flow Problems

Tu, Shuang
Jackson State Univ.

Abstract: The interface capturing capability is added to our hybrid finite volume/element incompressible ow solver for solving two-uid flow problems. The interface is captured by solving the level set equation. The zero level set is initialized by the signed distance field. To ensure that the level sets remain as the signed-distance field, reinitialization is implemented by extending the normal speed from the interface to the locationwithin the narrow band surrounding the interface.

**MS-Th-D-32-2** 14:00–14:30

IMMERSE ELEMENT METHOD FOR EIGENVALUE PROBLEM

Sim, Imbo National Inst. for Mathematical Sci.
KWAK, Do Young Korea Advanced Inst. of Sci. & Tech.

Abstract: We consider the approximation of elliptic eigenvalue problem with an immersed interface. The main aim of this paper is to prove the stability and convergence of an immersed finite element method (IFEM) for eigenvalues using Crouzeix-Raviart P1-nonconforming approximation. We show that spectral analysis for the classical eigenvalue problem can be easily applied to our model problem. We analyze the IFEM for elliptic eigenvalue problem with an immersed interface and derive the optimal convergence of eigenvalues.

**MS-Th-D-32-3** 14:00–14:30

A High-Order Method at Material Interface for FDTD Method Solving Maxwell's Equation

Li, Shengtai Los Alamos National Laboratory

Abstract: We present a simple method at material interface to remove numerical oscillations when the finite-difference time domain (FDTD) method is used to solve Maxwell’s equation. Fictitious points are added near the material interface and their values are derived using the physical boundary conditions of wave propagation at the interface and high-order FDTD numerical schemes. A hybrid model is proposed to improve the efficiency and achieve high-order accuracy in interested region.

**MS-Th-D-33** 13:30–15:30 406

Mathematical and computational methods for coupling local and nonlocal models - Part I of IV

For Part 2, see MS-Th-E-33
For Part 3, see MS-Fr-D-33
For Part 4, see MS-Fr-E-33

Organizer: D’Elia, Marta Sandia National Laboratories
Organizer: Seleson, Pablo Oak Ridge National Laboratory
Organizer: Bochev, Pavel Sandia Labs

Abstract: Nonlocal continuum and atomistic models are used in many scientific and engineering applications, where material dynamics depends on microstructure. The numerical solution of nonlocal models might be prohibitively expensive; therefore, concurrent multiscale methods have been proposed for efficient and accurate solutions of such systems. These methods employ nonlocal models in parts of the domain and use local, macroscopic, models elsewhere. A major challenge is to couple these models at interfaces or in overlapping regions. This minisymposium invites contributions on coupling local and nonlocal continuum models and concurrent multiscale methods for atomistic-to-continuum coupling. Related domain decomposition methods are also considered.

**MS-Th-D-33-1** 13:30–14:00

Multiscale Methods Based on Coupled Solvers

Abdulle, Assyr EPFL


**MS-Th-D-33-2** 14:00–14:30

QMMM Multiscale Methods for Crystalline Defects

Ortner, Christoph Univ. of Warwick

Abstract: QM/MM methods are a prototypical class of multiscale simulation schemes. They embed a quantum mechanical simulation of a "region of interest" in a bulk region that is modelled by a classical interatomic potential model. In this talk I will present new constructions of QM/MM schemes, both force-based and energy-based, specifically targeted for materials defect simulations. Moreover, I will present a rigorous error analysis of these schemes.

**MS-Th-D-33-3** 14:30–15:00

Formulation, Analysis and Computation of An Optimization-based Local-to-nonlocal Coupling Method

D’Elia, Marta Sandia National Laboratories
Bochev, Pavel Sandia Labs

Abstract: Nonlocal models are very accurate in modeling materials where the dynamics depends on the microstructure; however, they can be computationally expensive. We formulate the coupling as a control problem where the states are the nonlocal and local solutions, the objective is to minimize their mismatch on the overlap of their domains, and the controls are volume constraints and boundary conditions. We conduct a mathematical and numerical analysis of our method and we provide numerical examples.

**MS-Th-D-33-4** 15:00–15:30

The Morphing Method for Coupling Local and Nonlocal Continuum Models
Han, Fei
King Abdullah Univ. of Sci. & Tech. (KAUST)

**Abstract:** Recently the Morphing method has been proposed by Lubineau G. et al. for coupling conventional continuum and peridynamic models. The Morphing coupling method is inspired by the homogenization idea. Using the equivalent energy density of both models, it constructs a balance between local stiffness and weighted non-local modulus. Because the Morphing method is simple and easy to use widely, we present here a brief introduction and its latest development in mathematics and applications.

**MS-Th-D-34**  13:30–15:30  112
Modeling and Simulation of Complex Fluids and Biological Systems - Part I of IV

For Part 2, see MS-Th-E-34
For Part 3, see MS-Fr-D-35
For Part 4, see MS-Fr-E-35

Organizer: Zhang, Hui
Beijing Normal University

Organizer: Forest, M. Gregory
Univ. of North Carolina at Chapel Hill

Abstract: This mini symposium will bring together researchers in complex fluids and biological systems to exchange ideas and perspectives as well as to share their most recent findings. The goal is to integrate advances in mathematics (theory, modeling, data analytics, algorithms, simulations, high performance computing techniques) with new experimental data from complex fluids and biological systems, and targeted applications. The specific systems represented include single living cells, biofilms, active molecular fluids, and transport properties of biological fluids such as lung mucus.

We would like to invite you to give a talk on your current research at the proposed mini-symposium. The talks are scheduled to be 25 minutes each + 5 minutes for discussion.

**MS-Th-D-34-1**  13:30–14:00
Polymer Models of Interphase Chromosomes
Vasquez, Paula A
Univ. of South Carolina
Forest, M. Gregory
Univ. of North Carolina at Chapel Hill

Organizer: Wang, Qi
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: This mini-symposium will bring together researchers in complex fluids and biological systems to exchange ideas and perspectives as well as to share their most recent findings. The goal is to integrate advances in mathematics (theory, modeling, data analytics, algorithms, simulations, high performance computing techniques) with new experimental data from complex fluids and biological systems, and targeted applications. The specific systems represented include single living cells, biofilms, active molecular fluids, and transport properties of biological fluids such as lung mucus.

We would like to invite you to give a talk on your current research at the proposed mini-symposium. The talks are scheduled to be 25 minutes each + 5 minutes for discussion.

**MS-Th-D-34-2**  14:00–14:30
Anisotropic Particle in Viscous Shear Flow: Navier Slip, Reciprocal Symmetry, and Jeffery Orbit
Qian, Tiezheng
Hong Kong Univ. of Sci. & Tech.

Organizer: Wang, Qi
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: The hydrodynamic reciprocal theorem for Stokes flows is generalized to incorporate the Navier slip boundary condition, which can be derived from Onsager’s variational principle of least energy dissipation. The hydrodynamic reciprocal relations and the Jeffery orbit, both of which arise from the motion of a slippery anisotropic particle in a simple viscous shear flow, are investigated theoretically and numerically using the fluid particle dynamics method.

**MS-Th-D-34-3**  14:30–15:00
Neck-linking Condition for the Limit State of A Budding Lipid Vesicle
Tu, Zhanchun
Beijing Normal Univ.

Organizer: Wang, Qi
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: When a lipid vesicle is budding, the mean curvatures of two daughter vesicles near the neck satisfy a specific identity. This neck-linking condition for the limit state of a budding lipid vesicle was proposed twenty years ago, it is still lack of a general proof without the consideration of the axisymmetrical assumption. This general proof is presented in this talk. A conjecture of minimal geodesic disks is also proposed.

**MS-Th-D-34-4**  15:00–15:30
Kinetic Monte Carlo Simulations of Multicellular Aggregate Self-Assembly in Bioprinting
Sun, Yi
Univ. of South Carolina
Wang, Qi
Univ. of South Carolina & Beijing Computational Sci. Research Center

Organizer: Wang, Qi
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: We present a 3D lattice model to study self-assembly of multicellular aggregates by using kinetic Monte Carlo (KMC) simulations. This model is developed to describe and predict the time evolution of postprinting structure formation during tissue or organ maturation in a novel biofabrication technology—bioprinting. Here we simulate the self-assembly and the cell sorting processes within the aggregates of different geometries, which can involve a large number of cells of multiple types.
Advances in MCMC and related sampling methods for large-scale inverse problems - Part I of IV

For Part 2, see MS-Th-E-36
For Part 3, see MS-Th-F-36
For Part 4, see MS-Th-E-36

Organizer: Bu-Thanh, Tan The Univ. of Texas at Austin
Organizer: Cui, Tiangang MIT
Organizer: Marzouk, Yousef Massachusetts Inst. of Tech.

Abstract: Inverse problems convert indirect measurements into useful characterizations of the parameters of a physical system. Parameters are typically related to indirect measurements by a system of partial differential equations (PDEs), which are complicated and expensive to evaluate. Available indirect data are often limited, noisy, and subject to natural variation, while the unknown parameters of interest are often high dimensional, or infinite dimensional in principle. Solution of the inverse problem, along with prediction and uncertainty assessment, can be cast in a Bayesian setting and thus naturally tackled with Markov chain Monte Carlo (MCMC) and other posterior sampling methods. However, designing scalable and efficient sampling methods for high dimensional inverse problems that involve expensive PDE evaluations poses a significant challenge. This mini-symposium presents recent advances in sampling approaches for large scale inverse problems.

High Dimensional Non-Gaussian Bayesian Inference with Transport Maps

Spantini, Alessio MIT
Marzouk, Yousef Massachusetts Inst. of Tech.

Abstract: Characterizing high dimensional posterior distributions in the context of nonlinear and non-Gaussian Bayesian inverse problems is a well-known challenging task. A recent approach to this problem seeks a deterministic transport map from a reference distribution to the posterior. Thus posterior samples can easily be obtained by pushing forward reference samples through the map. In this talk, we address the computation of the transport map in high dimensions. In particular, we propose a scalable adaptive algorithm.

Advances in Generalised Metropolis-Hastings Algorithms

Calderhead, Ben Imperial College London

Abstract: A recent generalization of the Metropolis-Hastings algorithm allows for parallelizing a single chain using existing MCMC methods (Calderhead, PNAS, 2014). The construction involves proposing multiple points in parallel, then defining and sampling from a finite-state Markov chain on the proposed points such that the overall procedure has the correct target density as its stationary distribution. In this talk I’ll discuss this algorithm and some of the most recent advances employing this approach.

Multilevel Sequential Monte Carlo Samplers

Law, Kody ORNL
TEMPONE, RAUL KING ABDULLAH Univ. OF Sci. & Tech.

Abstract: The approximation of the posterior distribution associated to a Bayesian inverse problem is decomposed into a hierarchy consisting of a telescoping sum of increments with decreasing variance and increasing cost, and then probed with a sequential Monte Carlo sampler. The number of samples per level is optimized with respect to cost for a fixed root-mean square error, which then optimally scales as the inverse square-root of the cost.

Operator-weighted MCMC on Function Spaces

Cui, Tiangang MIT
Law, Kody ORNL
Marzouk, Yousef Massachusetts Inst. of Tech.

Abstract: Many inference problems require exploring the posterior distribution of high-dimensional parameters, which in principle can be described as functions. We introduce a family of operator-weighted MCMC samplers that can adapt to the intrinsically low rank and locally complex structure of the posterior distribution while remaining well defined on function space. Posterior sampling in a nonlinear inverse problem and a conditioned diffusion process are used to demonstrate the efficiency of these dimension-independent operator-weighted samplers.

Networked Systems and Optimization

Organizer: Li, Shaoyuan Shanghai Jiao Tong Univ.

Abstract: There is a class of complex large-scale systems which are composed of many physically or geographically divided subsystems. Each subsystem interacts with some so-called neighboring subsystems which is interconnected by the communication networks for their states and inputs information exchange. The distributed (or decentralized) framework, where each subsystem is controlled by an independent controller, has the advantages of error-tolerance, less computational effort, and being flexible to system structure. Thus, the distributed control framework is usually adopted in this class of system in spite of the fact that the dynamic performance of centralized framework is better than it. Thus, to improve global performance under distributed control framework is a valuable problem. The minisymposium aims to present the state-of-the-art progress in analysis and control of the networked systems, including 1) the distributed predictive controller design; 2) the control system synthesis for networked control systems; 3) the decentralized tracking algorithms subject to the system constraints; and 4) the applications for the multiphase sea glider.
of complex systems theoretically challenging. This mini-symposium aims to present some recent theoretical progresses in several branches of complex system control and some further applications, including: 1) communication-based fault detection and isolation; 2) rehabilitation robot research; 3) stable strategy of networked evolutionary games; 4) finite time fuzzy control.

**Rehabilitation Robot: A Personal Perspective of Control Theory & Practice.**

Zeng-Guang, Hou.
Inst. of Automation, Chinese Acad. of Sci.

Abstract: This talk will address the system design of a reclining type rehabilitation robot for lower limbs, and also discuss the control strategies and related issues for the passive training, active training and assistance training, with the needs of neurological rehabilitation and motor function of lower limbs for SCI or stroke patients.

**MS-Th-D-38-1** 13:30–14:00

**Communication-based Fault Detection and Isolation for Multi-agent Systems**

Hao, Fang.
Beijing Inst. of Tech.

Abstract: We propose a communication-based fault detection and isolation framework for multi-agent systems. All the fault processing operation is achieved by controlling the contents of communication. A fault detection scheme based on status information exchanging and gossip algorithm is introduced. Then, we propose a new calculation and compensation algorithm for fault isolation to reduce the restriction of the control protocol. All the schemes are proved to be effective in theory and several simulations are presented.

**MS-Th-D-38-2** 14:00–14:30

**On Evolutionarily Stable Strategy of Networked Evolutionary Games**

Qi, Hongsheng.
Chinese Acad. of Sci.

Abstract: This talk will introduce the evolutionarily stable strategy (ESS) of networked evolutionary games (NEGs). Analyzing the ESS of infinite populations in evolutionary games and comparing it with networked games, a new verifiable definition of ESS for NEGs is proposed. Then the fundamental evolutionary equation is investigated and used to construct the strategy profile dynamics of homogeneous NEGs. Some illustrative examples are included to demonstrate the theoretical results.

**MS-Th-D-38-3** 14:30–15:00

**Finite Time Fuzzy Control Design with PDE State Constraint for A Class of Nonlinear Coupled ODE-PDE Systems**

Wu, Hua-Ning.
Beihang Univ.

Abstract: This paper considers a class of nonlinear systems modeled by ordinary differential equations (ODEs) coupled with a parabolic partial differential equation (PDE). A fuzzy control design is developed in terms of linear matrix inequalities (LMIs), such that the ODE subsystem is finite time quasi-contractively stable with a terminal time as small as possible, while a PDE state constraint is respected. Finally, the proposed method is applied to the control of a hypersonic rocket car.

**MS-Th-D-39-4** 15:00–15:30

**Hybrid Optimization of Dynamic Deployment for Networked Fire Control System**

Chen, CHEN.
Beijing Inst. of Tech.

Xin, Bin.
School of Automation, Beijing Inst. of Tech.

Abstract: Considering a variety of tactical indexes and actual constraints in air defense, a mathematical model is formulated to minimize the enemy target penetration probability. An assistance-based algorithm is put forward which combines the artificial potential field method with memetic algorithm. The constrained optimization problem transforms into an optimization problem of APF parameters adjustment, and the dimension of the problem is reduced greatly. The dynamic deployment is accomplished by generation and refinement of feasible solutions.

**Adaptive Control of Complex Systems**

Organizer: TCCT.

13:30–15:30 303A

MS-Th-D-40-1 13:30–14:00

**Semi-Parametric Adaptation: Motivation, Principle, and Examples**

Ma, Hongbin.
Beijing Inst. of Tech.

Abstract: Simultaneous existence of parametric and nonparametric uncertainties can bring challenges to the control design problem. In this talk, some new ideas on semi-parametric adaptation, based on the so-called information-concentration (IC) estimators, will be introduced with its motivation, its basic principle as well as some examples of applications in control systems.

**MS-Th-D-40-2** 14:00–14:30

**Stability and Dissipativity of Stochastic Nonlinear Systems with Dynamic Inputs**

Wu, Zhaoqing.
School of mathematics & informational Sci., Yantai Univ.

Xie, Xuejun.
Gufu normal Univ.

Abstract: Stability, dissipativity and small-gain theorem for stochastic nonlinear systems with dynamic inputs are researched. ISS-P is initially defined by regulating the previous notions of SISS. Conditional dissipativity together with its criterion is then presented regarding non-smooth storage function and a relationship between ISS-P and CD is established. A small-gain theorem based
on dissipativity is established for the interconnected systems and a criterion on ISS-P for cascaded systems is presented.

**Adaptive Control of Nonlinear Uncertain Discrete-time Systems**
Chanying Li, The Chinese Acad. of Sci.
Abstract: This talk is concerned with the adaptive control of nonlinear uncertain systems in discrete time. A series of "stabilization theorems" and "impossibility theorems" have been established, and a new tool called "stochastic imbedding approach" has been developed accordingly in this study.

**Stability and Performance Analysis of Adaptive Diffusion Filters**
Chen Chen, Huawei
Abstract: We will consider the diffusion adaptive filters where a network of sensors is required to collectivly estimate time-varying signals (or parameters) from noisy measurements. Stability and performance analysis of the distributed LMS algorithm will be established, which shows that the network of sensors can cooperate to estimate successfully, even though any single sensor does not have such a capability. This is the main difference from the available literatures concerning LMS type distributed algorithms.

**Complex Networks and Event-based Control**
Organizer: TCCT, TCCT
Technical Committee on Control Theory, CAA
Abstract: A complex network is a network with non-trivial topological features—features that do not occur in simple networks such as lattices or random graphs but often occur in real-world networks such as computer networks and social networks. Event-triggered control is an efficient way to reduce the transmitted data in the networks, which can relieve the burden of network bandwidth occupation in comparison with a traditional periodic sampling method. This mini-symposium will present the state-of-the-art progress in theoretical analysis and related applications of complex networks and event-based control, including: 1) Structure and complexity for dynamics analysis of Boolean networks; 2) Co-design of feedback controller, event-triggered condition and the bound of controller perturbations in linear event-triggered control systems; 3) Industrial remote control with the virtual reality networked control systems; 4) A small-gain approach for event-based control of nonlinear systems.

**Structure of Boolean Networks and Complexity for Dynamics Analysis**
Zhao, Qianchuan, Tsinghua Univ.
Abstract: As a compact model of natural and man-made nonlinear dynamical network systems, Boolean networks have drawn attentions from wide backgrounds. In this talk, we will discuss the size of feedforward vertex set as a measure of complexity for dynamics analysis for Boolean Networks.

**Stability of Model-Based Event-Triggered Control Systems: the Separation Property**
Hao, Fei, Beihang Univ.
Yu, Hao, School of Automation Sci. & Electrical Engineering, Beihang Univ.
Abstract: To reduce resource of communication, this paper investigates the combination of model-based control and event-triggered control strategies, namely, the model-based event-triggered control. Two main problems are studied. One is, for a given plant and model, how to design an event condition to guarantee the stability of the system. The other is, how the model influences the stability of the system. By solving the two problems, a separation property of model-based event-triggered control is proposed.

**3D Virtual Reality for Networked Remote Control Systems**
Hu, Wenshan, Wuhan Univ.
Abstract: This minisymposium talks about the virtual reality networked control systems which are based on the latest networked control, virtual reality and internet technologies. In the proposed systems, remote industrial scenes are reconstructed in 3D virtual reality interfaces, which are synchronized with the practical processes through internet datalinks. Users are able to monitor and control the remote industrial devices by operating inside virtual environment, with the similar sense of presence as they work locally.

**Event-Based Control of Nonlinear Systems: A Small-Gain Approach**
Liu, Tengfei, Northeastern Univ.
Abstract: As an alternative to the traditional periodic data-sampling, the aperiodic event-triggered data-sampling depends on the real-time system state, and in this way, takes into account the system behavior between the sampling time instants. In this talk, we present a new small-gain approach to event-based control of nonlinear systems. Applications of the new approach to event-based control of the systems subject to external disturbances and the systems with partial state feedback are discussed.

**Control of Large-scale Dynamic Systems: A Viewpoint from Robust Adaptive Dynamic Programming**
Jiang, Zhong-Ping, New York Univ.
Abstract: A new approach to decentralized and adaptive optimal control design for large-scale systems is proposed using the framework of robust adaptive dynamic programming developed by the author and his co-workers. Robust adaptive dynamic programming integrates tools from two separate areas - adaptive/approximate dynamic programming and nonlinear control and aims to design biologically-driven, non-model-based, optimal controllers for systems in the presence of both parametric and dynamic uncertainties. Applications to electric power systems are considered.

**A General Result on Global Leader Following Consensus of A Group of Linear Systems Using Bounded Controls**
Zhao, Zhiyun, Shanghai Jiao Tong Univ.
Lin, Zongli, Univ. of Virginia
Abstract: For a multi-agent system whose follower agents and leader agent are all described by a general linear system, a bounded state, or output, feedback control law using a multi-hop relay protocol is constructed for each follower agent. These control laws achieve global leader-following consensus when the communication topology among the follower agents is a strongly connected and detailed balanced directed graph and the leader is a neighbor of at least one follower.

**Event-Triggered Control for Cooperative Output Regulation of Linear Multi-agent Systems**
Feng, Gang, City Univ. of Hong Kong
Liu, Lu, City Univ. of Hong Kong
Abstract: A solution to cooperative output regulation of heterogeneous linear multi-agent systems by event-triggered control is presented. Simpler leader-following consensus of homogeneous linear multi-agent systems with event-triggered control is considered. Then an approach to cooperative output regulation of heterogeneous linear multi-agent systems by event-triggered control is developed. To avoid the problem of continuous monitoring of measurements typical for event-triggered control schemes, self-triggered control schemes are also developed. Feasibility of the proposed schemes is finally studied.

**Flocking of Second-order Multi-agent Systems with Connectivity Preservation Based on Algebraic Connectivity Estimation**
Jie, Chen, Beijing Inst. of Tech.
Abstract: The problem of flocking of second-order multi-agent systems with connectivity preservation is investigated. First, a new kind of decentralized inverse power iteration algorithm is formulated to estimate the algebraic connectivity as well as the corresponding eigenvector. Furthermore, based on the estimation of the algebraic connectivity, decentralized gradient-based flocking control protocols is built on top of a new class of generalized potential fields.
Simulations are performed to demonstrate the effectiveness of the theoretical results.

**MS-Th-D-43**
13:30–15:30
VIP4-1
Optimization algorithms and application - Part II of V
For Part 1, see MS-Th-BC-43
For Part 3, see MS-Th-E-43
For Part 4, see MS-Fr-D-44
For Part 5, see MS-Fr-E-43

Organizer: Wen, Zawen  
Peking Univ.
Organizer: Yuan, Yu-xiang  
Inst. of Computational Mathematics & Scientific/Engineering Computing
Organizer: Xia, Yong  
Beihang Univ.

Abstract: This minisymposium consists 5 sessions. It highlights recent advances in theory, algorithms and applications of mathematical optimization on solving huge problems that are intractable for current methods.

**UP: MS-Th-D-43-1**
13:30–14:00
Sparse Tucker Tensor Representation for Multidimensional Seismic Data
Ma, Jianwei  
Harbin Inst. of Tech.

Abstract: Exploiting multidimensional sparsity structure of seismic data is important for seismic data processing and inversion. In this talk, we will apply a sparse Tucker tensor decomposition for multidimensional seismic data denoising and interpolation. Fast optimization methods will be applied for each dimension simultaneously to obtain adaptive filters. We will compare the new method to previous data-driven tight frame (DDTF) method that first uses a vectorization step the high-dimensional seismic data.

**UP: MS-Th-D-43-2**
14:00–14:30
The Trace Ratio Problem
Zhang, Leihong  
Shanghai Univ. of Finance & Economics

Abstract: Maximizing the trace ratio over orthogonal constraints has a crucial role in pattern recognition. We shall discuss the characterization of the global optimal solutions of TRP and show the global and high-order convergence of an SCF iteration. We will explain why such SCF iteration is so efficient for TRP and also present perturbation analysis. Numerical experiments are reported and extension of TRP to maximize sum of two trace ratios will be also briefly discussed.

**UP: MS-Th-D-43-3**
14:30–15:00
Behavior Analysis and Greedy Algorithm for Optimal Portfolio Liquidation with Market Impact
XU, FFENGMIN  
Xi’an Jiaotong Univ.

Abstract: We analyze a nonconvex portfolio liquidation problem that maximize equity after trading subject to specified liability-equity requirements and box constraints, with no restrictions on the relative magnitudes of permanent and temporary market impact. Through the intuition behind price factor, we naturally endow some important conclusions in Brown et al. (2010) and Chen et al. (2014) with new financial explanations. And the optimal state of this nonconvex problem is revealed through the monotonicity of margin constraint functions, in which the margin constraint is active and the equity and liability after trading reaches the maximum at the same time. That is, it is just beyond the ability to take the risk and holds the most available funds. Meanwhile, a policy recommendation on determining an appropriate asset-liability ratio is also given through the feasibility of portfolio liquidation. Further, we prove that this problem is NP-hard, and a greedy algorithm and its general convergence are proposed. Numerical examples are presented to show the effectiveness of the greedy algorithm compared to the Lagrangian algorithm in Chen et al. (2014).

**UP: MS-Th-D-43-4**
15:00–15:30
Stochastic Compositional Gradient Descent: Algorithms for Minimizing Compositions of Expected-Value Functions
Wang, Mengdi  
Princeton Univ.

Abstract: We focus on the minimization of a composition of two expected-value functions. In order to solve this stochastic composite problem, we propose a class of stochastic compositional gradient descent (SCGD) algorithms that can be viewed as stochastic versions of quasi-gradient method. The convergence involves the interplay of two iterations with different time scales. We prove that the almost sure convergence and different rates of convergence of SCGD under a variety of assumptions.

**MS-Th-D-44**
13:30–15:30
VIP2-1
Pseudo-Differential Operators in Industries and Technologies - Part I of IV
For Part 2, see MS-Th-E-44
For Part 3, see MS-Fr-D-44
For Part 4, see MS-Fr-E-44

Organizer: Wong, M.W.  
York Univ.

Abstract: Pseudo-differential operators, first appeared in 1960s in the paper by Joseph K. John and Louis Nirenberg in the Communications on Pure and Applied Mathematics, have been used in the explicit descriptions of solutions of Partial Differential Equations. Since wavelet transform and related transforms came to the fore and became understood by scientists and engineers in the physical sciences, biomedical sciences, atmospheric sciences and geological sciences in the context of time-space-frequency representations, pseudo-differential operators and their variants such as Weyl transforms and noncommutative quantization with operator-valued symbols have become instrumental in signal and image analysis in the role of filters. Extensions of classical pseudo-differential operators to Weyl transforms and pseudo-differential operators to H-type groups can be thought of as noncommutative quantization. The aim of this minisymposium is to provide a platform for dialogues on several developments of pseudo-differential operators in some areas of industries and technologies such as information, communication and signal.

**UP: MS-Th-D-44-1**
13:30–14:00
Analysis of In-Core Flux Detector Noise Using the Generalized S Transform
Liu, Cheng  
Kinectrics Inc
Zhu, Hongmei  
York Univ.
Wallace, Andrew  
Kinectrics Inc
Yan, Yusong  
Beijing Inst. of Tech.

Abstract: The CANDU reactor is a Canadian-invented, pressurized heavy water reactor. In-core flux detector signal data is routinely acquired from all CANDU reactors, which contains noise, (referred to as neutron noise) that can see a number of mechanical vibrations within the reactor cores. It has been suggested that indirect monitoring of vibration frequency via the noise on the in-core flux detector signals could be used to detect abnormal conditions and predict failure. A new form of the generalized S transform is introduced and its mathematical properties have been investigated in the framework of the operator theory. Controlled by the parameters, the generalized S transform is able to vary its time-frequency resolution, which provides a class of multi-resolution representations with distinct resolution. Analysis of in-core flux detector noise using the generalized S transform is performed to reveal the vibration frequencies of major components in the reactor core of CANDU.

**UP: MS-Th-D-44-2**
14:00–14:30
Time-frequency Analysis as An Analysis Tool of Brain Networks
Sejdic, Ervin  
Univ. of Pittsburgh

Abstract: Time-frequency representations depict variations of the spectral characteristics of signals as a function of time, which is ideally suited for nonstationary biomedical signals. Many biomedical signals (e.g., swallowing accelerometry signals) are multicomponent, one-dimensional signals. But, modern medical data sets are time-varying, large and/or stemming from multiple sensors/electrodes (e.g., electroencephalographs). In this talk, I will overview some of our recent efforts to adopt time-frequency tools for signals stemming from multimodal imaging systems.

**UP: MS-Th-D-44-3**
14:30–15:00
Pulse Wave Analysis in Time-frequency Domain
Zhu, Hongmei  
York Univ.
Jin, Wei  
Shandong Acad. of Chinese Medicine
Zhang, Xiling  
Shandong Acad. of Chinese Medicine
Zhang, Yuhai  
Shandong Univ.

Abstract: Assessment of the pulse character for disease diagnosis is one of the key medical skills in Traditional Chinese Medicine practice. When and where abnormalities occurred in one’s pulse waves provide important information for disease detection and diagnosis. In this talk, we explore the use of time-frequency analysis in analyzing digitally recorded pulse waveforms.

**UP: MS-Th-D-44-4**
15:00–15:30
A Blind Separation Method Based on Multiwavelet Analysis
Aishina, Ryuichi  
Osaka Kyoiku Univ.
Mandai, Takeshi  
Osaka Electro-Communication Univ.
Yokoyama, Akiro  
Osaka Kyoiku Univ.
Kogure, Takanori  
Osaka Kyoiku Univ.

Abstract: The purpose of blind source separation is to separate the original sources from the sensor array, without knowing the transmission channel characteristics. A new blind separation method based on multiwavelet analy-
sis is presented. Examples of image separation are demonstrated.

**MS-Th-D-45**
13:30–15:30
Optimization Methods for Inverse Problems - Part II of V
For Part 1, see MS-Th-BC-45
For Part 3, see MS-Th-E-45
For Part 4, see MS-Fr-D-45
For Part 5, see MS-Fr-E-45

Organizer: LIU, XIN
AMSS
Organizer: WANG, YANFEI
The Inst. of Geology & Geophysics, CAS

Abstract: In this minisymposium, inverse problems arisen from various areas such as geoscience and petroleum engineering, related optimization models like L1 norm regularization, and advanced optimization methods for solving these models such as first order methods, subspace methods, alternating direction method of multipliers and distributed optimization approaches are discussed.

**MS-Th-D-45-1**
13:30–14:00
Some Real Problem on Inverse of Optimal Approximation of Water Flow
Yuan, Jinyun
Federal Univ. of Para

Abstract: In Brazil some big river passes inside the city. During the rain season, it causes civil troubles because of water-plant on the surface of river. We like to decide the surface condition of distribution of water-plant to approximate the desired velocity of water flow such that we can reduce civil troubles for society. We shall use optimal approximation model with flow constraints to solve the problem.

**MS-Th-D-45-2**
14:00–14:30
A Dual Method for Minimizing A Nonsmooth Objective over One Smooth Inequality Constraint
Teboulle, Marc
Tel Aviv Univ.

Abstract: We consider the class of nondifferentiable convex problems which minimizes a nonsmooth convex objective over a smooth inequality constraint. Exploiting the smoothness of the feasible set and using duality, we introduce a simple first order algorithm proven to globally converge to an optimal solution with a sublinear rate. The performance of the algorithm is demonstrated by solving large instances of the convex sparse recovery problem. This is joint work with Ron Shefi.

**MS-Th-D-45-3**
14:30–15:00
A General Inertial Proximal Point Method for Mixed Variational Inequality Problem
Yang, Junfeng
Nanjing Univ.

Abstract: We propose inertial variants of the proximal point method and the ADMM. Under certain conditions, we are able to establish the global convergence and \( \frac{1}{k} \) convergence rate results (under certain measure). We also demonstrate the effect of the inertial extrapolation step via experimental results on the compressive principal component pursuit problem and some imaging problems.

**MS-Th-D-45-4**
15:00–15:30
Multidimensional Ill-posed Problems in Applications
Yagola, Anatoly
Lomonosov Moscow State Univ.

Abstract: It is very important now to develop methods of solving multidimensional ill-posed problems using regularization procedures and parallel computers. The main purpose of the talk is to show how 2D and 3D Fredholm integral equations of the 1st kind can be effectively solved. We will consider inverse problems of image restoration in electron microscopy and recovery of magnetic target parameters from magnetic sensor measurements. This paper was supported by the RFBR grant 14-01-91151-NSFC-a.

**MS-Th-D-46**
13:30–15:30
Inverse Problems for Image Reconstruction and Processing - Part IV of IV
For Part 1, see MS-We-D-46
For Part 2, see MS-We-E-46
For Part 3, see MS-Th-BC-46

Organizer: WEI, SUHU
Inst. of Applied Physics & Computational Mathematics

Organizer: Nikolova, Mila
CMLA, CNRS - ENS Cachan
Organizer: TAI, XUECHENG
Department of Mathematics, Univ. of Bergen
Organizer: SHI, YUYING
North China Electric Power Univ.

Abstract: Many image reconstruction tasks amount to solving ill-posed inverse problems. Indeed, measurement devices typically cannot record all the information needed to recover the sought-after object; furthermore, the operators that model these devices are seldom accurate and data are corrupted by various perturbations. A common approach to find an approximate to the unknown object is regularization. The key points are the correct choices of the data fidelity term and the regularization term, as well as the trade-off between these terms. This is a challenging problem since the optimal solutions of the whole functional should correctly reflect the knowledge on the data-production process and the priors on the unknown object. The optimal solutions usually cannot be computed explicitly and iterative schemes are used. This symposium focuses on imaging inverse problems’ mathematical models, numerical algorithms, theoretical analysis and various applications, especially, applied to CT reconstruction and some processing techniques for images.

**MS-Th-D-46-1**
13:30–14:00
A PDE-free Variational Model for Multiphase Image Segmentation
Julia, Dobrosotskaya
Case Western Reserve Univ.
Guo, Weihong
Case Western Reserve Univ.

Abstract: We introduce a PDE-free variational model for multiphase image segmentation in a modified diffuse interface context. This model uses such features of diffuse interface behavior as coarsening and phase separation to merge relevant image elements (coarsening) and separate others into distinct classes (phase separation). The model has edge-preserving feature that naturally balances out the regularity implemented by wavelet Ginzburg-Landau energy. Numerical experiments show that the model is robust to noise yet can segment fine details.

**MS-Th-D-46-2**
14:00–14:30
CT Metal Artifacts Reduction by An Iterative Algorithm Based on Impainting
Lee, Chang-Ock
KAIST
Jeon, Soomin
KAIST

Abstract: The streaking artifacts in computed tomography (CT) image caused by the metallic objects (dental implants, surgical clips, or steel-hip) limit the applications of CT image. We propose a new algorithm for reducing the streaking artifacts in CT images. We implement the corrupted part in sinogram, iteratively, using the basic principle of CT. The numerical experiments show that our algorithm reduces the metal artifacts efficiently. We analyze the simulation results both quantitatively and qualitatively.

**MS-Th-D-46-3**
14:30–15:00
Meteorological Objects Tracking with Modified Region Scalable Fitting Model and Parallel Computation
Murong, Jiang
School of Information Sci. & Engineering, Yunnan Univ.

Abstract: We modify the Region Scalable Fitting (RSF) model by using a phase congruence function as the boundary detection term, and redefine RS-F energy functional by putting a total variance regular function into the gradient descent flow equation. We call this functional as PRSF model. We use PRSF model to segment the meteorological objects with Split Bregman algorithm, implement the meteorological multi-objects tracking fast computation in parallel.

**MS-Th-D-46-4**
15:00–15:30
Limitations of Splitting Methods for Total Variation-based Image Reconstruction
Hintermüller, Michael
Humboldt-Univ. of Berlin

Abstract: Variable splitting schemes for image reconstruction problem with total variation regularization (TV-problem) in its primal and pre-dual formulations are considered. For primal splitting it is shown that quasi-minimizers of the penalized problem are asymptotically related to the solution of the original TV-problem. For the pre-dual formulation, a family of parametrized problems is introduced and a parameter dependent contraction of an associated fixed point iteration is established.

**MS-Th-D-47**
13:30–15:30
Numerical methods for compressible multi-phase flows - Part V of VI
For Part 1, see MS-Mo-D-08
For Part 2, see MS-Mo-E-08
For Part 3, see MS-We-E-47
For Part 4, see MS-Th-BC-47
For Part 6, see MS-Th-E-47

Organizer: DENG, XIAOLONG
Beijing Computational Sci. Research Center

Organizer: WEI, SUHU
Inst. of Applied Physics & Computational Mathematics

Organizer: TIAN, BADIN
Institute of Applied Physics & Computational Mathematics

Organizer: TIEGANG, LIU
Beihang Univ.
Organizer: SUSSMAN, MARK
Florida State Univ.
Organizer: WANG, SHUANGHU
IAPCM

Abstract: Compressible multi-phase flows appear in many natural phenom-
ena, and are very important in many applications, including space science, aerospace engineering, energy, homeland security, etc. Numerical calculation is a key for understanding many related problems. More and more numerical methods are being developed and improved. In this mini-symposium, novel numerical methods will be presented to show the progress in the area of compressible multi-phase flows, including interface capturing/tracking methods, phase change calculations, mixing methods, fluid-structure interaction methods, multi-physics calculations, adaptive mesh refinement, and high performance computing.

**MS-Th-D-47-1**

**High-resolution Compact Scheme for Compressible Multifluids**

Liu, Na  
Inst. of applied physics & computational mathematics  
Chen, Yibing  
Beijing Inst. of applied physics & computational mathematics

**Abstract:** In this paper, a high-order, efficient, compact method is developed for multifluid simulation which is an extension of spectral volume method for conservation laws. The idea of quasi-conservation scheme is borrowed to avoid the spurious oscillations in the vicinity of a material contact discontinuity and the PFGM limiter is used to avoid numerical oscillation by high order reconstruction which can keep high order accuracy at the meantime.

**MS-Th-D-47-2**

**High Order Positivity-preserving Discontinuous Galerkin Method for Compressible Multi-phase Flow**

Wang, Chunwu  
Nanjing Univ. of Aeronautics & Astronautics

**Abstract:** The positivity of the variables such as density and pressure is very important in the simulation of the multi-medium flow. In this paper a high order accurate positivity-preserving discontinuous Galerkin (DG) scheme is presented. The limiter is constructed and can be proven to maintain high order accuracy and is easy to implement. The extension to higher dimensions is straightforward. Several numerical tests are provided to demonstrate the effectiveness of the method.

**MS-Th-D-47-3**

**Wave Number Selectivity in Strongly Accelerated Thin Liquid Layers**

Deng, Xiaolong  
Beijing Computational Sci. Research Center  
Chang, Chih-Hao  
Theoanous Co. Inc  
Theoanous, Theo  
Univ. of California, Santa Barbara

**Abstract:** We present first-of-a-kind direct numerical simulations of Rayleigh-Taylor instability in thin liquid layers (Atwood number 1) under different kinds of external support—solid wall, slip wall, free interface. The character of wave selectivity (peaking of dispersion plots) is markedly changed with layer thickness (flattening out as thickness decreases), and type of boundary condition is straightforward. Several numerical tests are provided to demonstrate the effectiveness of the method.

**MS-Th-D-47-4**

**What is Wrong with Effective-field and Point-particle Models in High-speed Disperse Flows?**

Chang, Chih-Hao  
Theoanous Co. Inc  
Deng, Xiaolong  
Theoanous, Theo  
Beijing Computational Sci. Research Center  
Univ. of California, Santa Barbara

**Abstract:** We use experiments and direct numerical simulations to investigate the dynamics of particle clouds subjected to shock waves. The experiments (JFM, to appear) cover particle volume fractions of 0.2-0.4 and flow Mach numbers of 0.3-1.2. The simulations are carried out with a compressible Navier-Stokes solver. The particles are allowed to move and collide. Cloud expansion is predicted quantitatively while effective-field and point-particle models fail severely. We presents ideas about causes and possible fixes.

**MS-Th-D-48**

**Regularization methods for biomedical image analysis on manifolds - Part I of II**

For Part 1, see MS-Th-BC-48

**Organizer:** Chen, Chong  
Chinese Acad. of Sci.  
Organizer: Dong, Guozhi  
Univ. of Vienna

**Abstract:** Inverse problems of functions defined on manifolds and Image analysis with data on surfaces are emerging topics, while the biomedical image and many other biological data analysis provide one the main sources of these problems. This minisymposium will be devoted to recent advances of regularization methods and the related topics, with respect to biomedical image analysis in the context of a manifold domain. The aim is to provide a platform to researchers and scientists for exchanging ideas and developing new research topics. It is supposed to contain two sections, and speakers consist of both leading experts and young researchers.

**MS-Th-D-48-1**

**A Extended Regularization for Recovering Vector Fields on Manifolds**

Dong, Guozhi  
Univ. of Vienna

**Abstract:** We will discuss what is the extended regularization, and what is the motivation behind and the convergence analysis of this method. More over, we will discuss the convergence rates based on the discretization of both manifolds and vector field spaces on manifolds, which lay the fundamental for an efficient numerical discretization of this type of problem. This is a joint work with Bert Juellett, Otmar Scherzer and Thomas Takacs.

**MS-Th-D-48-2**

**Landmark and Intensity-based Registration with Large Deformation via Quasiconformal Maps**

LUI, Lok Ming Ronald  
The Chinese Univ. of Hong Kong

**Abstract:** A new approach to obtain diffeomorphic registrations with large deformations using landmark and intensity information via quasi-conformal maps will be presented. The basic idea is to minimize an energy function involving a Beltrami coefficient term, which measures the distortion of the quasiconformal map. The Beltrami coefficient effectively controls the bijectivity and smoothness of the registration. In this talk, both landmark-based and intensity-based registration between images or surfaces will be presented.

**MS-Th-D-48-3**

**Augmented Lagrangian Method for Total Variation Based Image Restoration and Segmentation over Triangulated Surfaces**

Wu, Chunlin  
Nankai Univ.

Tai, Xue-Cheng  
Department of Mathematics, Univ. of Bergen

**Abstract:** Recently total variation (TV) regularization has been proven very successful in planar image restoration and segmentation. In this paper we extend TV regularization to image restoration and segmentation over triangulated surfaces. We also present augmented Lagrangian method for the related optimization problems, yielding fast solvers to our problems. Experiments on both gray and color images on surfaces demonstrate the efficiency of our algorithms.

**MS-Th-D-48-4**

**An Analysis-suitable Representation of 2-d Manifolds and Its Application**

Wu, Meng  
Hefei Univ. of Tech.

**Abstract:** In this talk, we will present a global representation of 2-d manifolds with splines defined recently. After that, we will present how to solving PDEs on a 2-d manifolds globally with this type of representation.

**MS-Th-D-49**

**Modelling abnormal brain haemodynamics and its link to neurodegenerative diseases**

**Organizer:** Toro, Eleuterio  
Univ. of Trento

**Abstract:** There is medical evidence of the biologically plausible association of extracranial vein malformations to neurodegenerative diseases, e.g. Parkinson’s disease. This minisymposium concerns mathematical modeling of the brain venous haemodynamics of subjects with extracranial venous malformations. Anatomical data and brain flow measurements are obtained from advanced magnetic resonance imaging. New model equations and advanced numerical methods for blood flow are described. These form the bases of a new global, closed-loop mathematical model for the human circulation. Our model predicts that extracranial venous strictures cause anomalous venous return from the brain and chronic intracranial venous hypertension. Potential implications are discussed.

**MS-Th-D-49-1**

**Modelling Brain Venous Haemodynamics: Challenges and Opportunities**

Toro, Eleuterio  
Univ. of Trento

**Abstract:** We addressed challenges and opportunities regarding mathematical modeling of venous haemodynamics of the Central Nervous System, including physiological, mathematical, algorithmic and pathological aspects. In addition we describe a recently proposed global mathematical model for the human circulation and show here some applications to neurological diseases thought to have a venous origin.

**MS-Th-D-49-2**

**Computational Models for Fluid Exchange between Microcirculation and Tissue Interstitium Applied to Cerebrospinal Flow**

Formaggia, Luca  
Alessio, Fumagalli  
Politecnico di Milano  
Politecnico di Milano
Abstract: This work aims at developing a numerical multiscale model for the interplay between microcirculation and interstitial flow. Such phenomena are at the basis of the exchange of nutrients, wastes and pharmacological agents between the cardiovascular system and the organs. In particular, we develop a model applicable at the microscopic scale, where the capillaries and the interstitial volume can be described as independent structures capable to propagate flow.

**MS-Th-D-50-2** 14:00–14:30
**Error Estimates of Some Numerical Atomic Orbitals in Molecular Simulations**
Chen, Huajie
Univ. of Warwick
Abstract: Numerical atomic orbitals provide a nature, physical description of the electronic states and is suitable for O(N) calculations based on the strictly localized property. We present a numerical analysis for some simplified atomic orbitals, with polynomial-type and confined Hydrogen-like radial basis functions respectively. We give some a priori error estimates to understand why numerical atomic orbitals are computationally efficient in electronic structure. This is a joint work with Reinhold Schneider (TU Berlin).

**MS-Th-D-50-3** 14:30–15:00
**Linear Scaling Discontinuous Galerkin Methods for Density Functional Theory**
Liu, Tiao
Cai, Wei
Univ. of North Carolina at Charlotte
Abstract: In this talk, we will introduce a discontinuous Galerkin (DG) framework for many electron quantum systems. The salient feature of this framework is the flexibility of using hybrid physics-based local orbitals and accuracy-guaranteed piecewise polynomial basis in representing the Hamiltonian of the many body system. A linear-scaling algorithm and the advantage of using the local orbital enriched finite element basis in the DG approximations are verified by studying examples of one dimensional lattice models system.

**MS-Th-D-51-1** 13:30–14:00
**Re-entrant Neural Circuits for Actively Controlled Computations**
Tao, Louis
Sornborger, Andrew
Peking Univ.
UC Davis
Abstract: We have shown that pulse-gated synfire chains can exactly (in the mean) propagate information in the form of graded current amplitudes. Furthermore, with appropriate pulse sequences, current amplitudes may be dynamically routed through neural subcircuits. A considerable literature shows that coherent pulse trains in neural circuits can improve feature recognition, mediate interactions between neurons and modulate learning and memory. We have proposed that pulse-gated synfire chains are the theoretical mechanism responsible for this observed coherent activity. In a framework based on our pulse-gating mechanism, we have described methods for constructing neural circuits capable of actively controlling sequences of linear maps. As an example, we demonstrate a neural circuit that combines split operator methods with re-entrant synaptic connectivity and pulse-gated control to create arbitrary rotations of vector coordinates on the sphere.

**MS-Th-D-51-2** 14:00–14:30
**Response Dynamics and Network Connection in Primary Visual Cortex**
Xing, Dajun
Beijing Normal Univ.
Abstract: Cortical areas in the brain have distinct intra- and inter-connection patterns with different inputs and output. Understanding the response dynamics is crucial for understanding network connectivity in the brain. We chose Macaque primary visual cortex to study network interactions. Our result reveals a variety of laminar response patterns including receptive field properties, nonlinear dynamic response, and gamma band (20-60 Hz) activity. The response dynamics implies the important role of recurrent and feedback connections.

**MS-Th-D-51-3** 14:30–15:00
**Dissecting the Neural Circuit Underlying Motor Control in C. Elegans**
Wen, Quan
Univ. of Sci. & Tech. of China
Abstract: Within only 300 hundred neurons and a known wiring diagram, C. elegans could be seen as the "hydrogen model" in systems neuroscience.
Despite its simplicity, we still do not have a good understanding of the neural basis of its sensorimotor behaviors. By combining optical neurophysiology and modeling, we will discuss on-going endeavors aiming at developing a complete understanding of motor control in C. elegans from both algorithmic and mechanistic standpoint of view.

**MS-Th-D-51-4**  
**Neural Dynamics of Animal Navigation**  
**Si, Bailu** Chinese Acad. of Sci.  
**Abstract:** We propose a dynamical model based on attractor neural network to accounts for the responses of grid cells in medial entorhinal cortex, the neural substrate for mammalian navigation. In the model, grid cells collectively represent arbitrary conjunctions of positions and movements of the animal. A pattern formation process generates grid patterns in the population activity of the network, and achieves robust tracking of the position of the animal in the environment.

**MS-Th-D-52**  
**Recent Development of Mathematical Models in Computational Biology - Part I**  
**For Part 1, see MS-Th-BC-52**  
**For Part 3, see MS-Th-E-52**  
**For Part 4, see MS-Fr-D-52**  
**For Part 5, see MS-Fr-E-52**

**Organizer:** Zhang, Lei Peking Univ.  
**Organizer:** Ge, Hao Peking Univ.  
**Organizer:** Lei, Jinzhi Tsinghua Univ.  
**Abstract:** One of the central problems in biology is to understand the design principles of complex biological systems. Mathematical and computational models of biological processes can be characterized both by their level of biological detail and by their mathematical complexity. In this minisymposium, we focus on recent findings of computational models and methods to gain insights into the complexity of cellular life and efficiently analyze the experimental observations. Topics of interests include stem cells, developmental pattern, gene regulatory networks, neuron networks, uncertainty quantification of biological data, etc.

**MS-Th-D-52-1**  
**Mathematical Modeling, Optimization and Control for Networks of Complex Diseases Based on the High-throughput Data**  
**Xiufen, Zou** Wuhan Univ.  
**Abstract:** We focus on developing quantitative tools and indexes to provide early diagnosis and drug targets of complex diseases and control of complex diseases. In this talk, I first introduce the work in identifying dynamical network biomarkers of complex diseases. Then, I present the analysis of pathogenic mechanisms of influenza virus (IAV) by combining mathematical model-based optimization and dynamical analysis. Finally, the control problems of complex diseases are discussed.

**MS-Th-D-52-2**  
**Stochastic Phenotype Transition of A Single Cell in An Intermediate Region of Gene State Switching**  
**Ge, Hao** Peking Univ.  
**Abstract:** Recent experiments have shown that at least in E. coli, the gene state switching can be neither extremely slow nor exceedingly rapid. Under this condition, from a full chemical-master-equation description we derive a simplified fluctuating-rate model. The simplified kinetics yields a nonequilibrium landscape function, which, similar to the energy function for equilibrium fluctuation, provides the leading orders of fluctuations around each phenotypic state, as well as the transition rates between the two phenotypic states.

**MS-Th-D-52-3**  
**Robust and Precise Morphogen-mediated Patterning**  
**Lo, Wing Cheong** City Univ. of Hong Kong  
**Abstract:** The perturbations of gene expression limit the accuracy of morphogen-mediated patterning. While it has been found that the robustness of patterning to the perturbation of morphogen synthesis can be enhanced by particular mechanisms, how such mechanisms affect robustness to other perturbations, such as to receptor synthesis, has been little explored. Here we elucidate how different mechanisms improve the robustness of patterning to receptor and morphogen syntheses and to the effects of cell-to-cell variability.

**MS-Th-D-52-4**  
**Robust and Stochastic Dynamics in Signal Transduction, Stem Cells, and Development Patterning**  
**Nie, Qing** Univ. of California, Irvine  
**Abstract:** Noise and stochastic effect exist in most biological systems due to many intrinsic and extrinsic factors. In this talk, I will discuss strategies and principles for noise attenuation and robustness to genetic and environmental perturbations in signal transduction, embryonic patterning, and regeneration driven by stem cells. In one case, I will introduce a critical quantity that dictates capability of attenuating temporal noise in feedback systems. In another case, I will show that noise in gene regulations actually enables reduction of stochastic effects in spatial patterns during embryonic development. Finally, novel experimental data that support our modeling and computational predictions will be presented and several multi-scale, stochastic, and computational modeling frameworks that are required for simulating such complex biological systems will be introduced.
MS-Th-D-54 13:30–15:30 VIP1-2

Modeling and Simulations of Complex Biological Systems - Part I of IV

For Part 2, see MS-Th-E-54
For Part 3, see MS-Fr-D-54
For Part 4, see MS-Fr-E-54

Organizer: Liu, Xinteng  
Univ. of South Carolina
Organizer: Ju, Lili  
Univ. of South Carolina

Abstract: This mini-symposium aims to bring together researchers focusing on using modeling and numerical approach to study complex biological systems including (but not limited to) cell signaling pathways, complex bio-fluids, biofilms, cell polarization, developmental and cell biology, and stem cells, and etc. Such complex biological systems in general consist of multiple interacting components that exhibit complicated temporal and spatial dynamics. Furthermore, feedback, nonlinearities and multiple time and length scales often make such systems extremely difficult to describe, model or predict. The invited speakers will discuss the challenges of modeling such complex systems, introduce new computational techniques to simulate them and, where possible, present novel analytical techniques to extract meaningful information.

► MS-Th-D-54-1 13:30–14:00

Competing Interactions on Bilayer Membrane and Modeling of Lipid Rafts
Zhou, Yongcheng  
Colorado State Univ.

Abstract: Competing interactions on bilayer membrane and modeling of lipid rafts

► MS-Th-D-54-2 14:00–14:30

Protein Function Discovery Using A New 3D Structure Comparison Algorithm
Gong, Xinqi  
Rennin Univ. of China

Abstract: Proteins can interact with other partners or change their conformations to show different biological functions. But it’s difficult and expensive for experiments to verify which functions may be observed for a protein. It is believed that protein functions relate closely with their 3D structures. So we propose a new protein 3D structure comparison method for discovering new functions for traditionally considered different functional proteins, whose better performances over other methods was verified on a dataset.

► MS-Th-D-54-3 14:30–15:00

Efficient and Stable Exponential Time Differencing Runge-Kutta Methods for Phase Field Elastic Bending Energy Models
Ju, Lili  
Univ. of South Carolina
Wang, Xiaoliang  
Florida State Univ.
Du, Qiang  
Columbia Univ.

Abstract: In this talk, we present efficient and stable high-order numerical methods for the Willmore flow formulated by phase field elastic bending energy models. Our methods combine explicit exponential time differencing Runge-Kutta approximations for time integration with spectral discretization on regular meshes in space. In addition, linear operator splitting techniques and an augmented Lagrange multiplier approach are particularly used to circumvent numerical instabilities. Various experiments are presented to demonstrate stability and accuracy of the proposed methods.

► MS-Th-D-54-4 15:00–15:30

Computer Simulations of Cell-to-Cell Interactions
Chou, Ching-Shan  
The Ohio State Univ.
Chen, Wei Tao  
Univ. of California, Irvine

Abstract: Cell-to-cell communication is fundamental to biological processes which require cells to coordinate their functions. In this talk, we will present the first time computer simulations of the yeast mating process, which is a model system for investigating proper cell-to-cell communication. Computer simulations revealed important robustness strategies for mating in the presence of noise. These strategies included the polarized secretion of pheromone, the presence of the alpha-factor protease Bar1, and the regulation of sensing sensitivity.

MS-Th-D-55 13:30–15:30

Wavelet Methods for Inverse Problems Modelling Real World Systems - Part I of IV

For Part 2, see MS-Th-E-55
For Part 3, see MS-Fr-D-55
For Part 4, see MS-Fr-E-55

Organizer: Siddiqui, Prof. Abul  
Sharda Univ.NCR
Organizer: Al-Lawati, M.A.  
Sultan Qaboos Univ.

Abstract: In a direct problem an effect is determined by a cause while in an inverse problem cause is determined from an effect. In an image processing the direct problem is to find out how a given sharp photograph would look like while camera is incorrectly focused. A related inverse problem is to find a sharp photograph from a given blurry image. Inventors of CAT and MRI were awarded Nobel Prize of Medicine and Physiology respectively in 1979 and 2003. Inverse problems typically involve certain quantities based on indirect measurements of these quantities. Seismic exploration, CAT, MRI, X-ray are examples of inverse problems. Bio metric identifiers are measurements from human body/eyes are ear, face, facial thermogram, hand thermogram, hand geometry/fig, fingerprint, iris, retina, signature and voice. The directional and indirect problems of biometrics correspond to the analysis and synthesis of biometric information respectively. Recognition of face is a direct problem while face reconstruction is an an inverse problem. Refinement of Fourier methods, called wavelet methods including curve lets, shear lets play important role for study of inverse problems occurring in above themes. The symposium is devoted to updated research on applications of wavelets to the above problems.

► MS-Th-D-55-1 13:30–14:00

Singular Fourier Integral Operators Arising in Some Radar Imaging Problems
Krisman, Venky  
TIFR Centre for Applicable Mathematics

Abstract: We consider the microlocal properties of transforms arising in some radar imaging problems. We study the forward operators and image reconstruction operators associated to these transforms in a microlocal framework. The microlocal analysis of these operators help us understand whether artifacts arise in image reconstruction or not, and in the cases where artifacts do arise, we compare the strengths of the artifacts with that of the true images.

► MS-Th-D-55-2 14:00–14:30

NEW CONVEX INVERSION FRAMEWORK FOR THE ELASTICITY IMAGING INVERSE PROBLEM
Khan, Akhtar  
Rochester Inst. of Tech.

Abstract: This talk will focus on the elasticity imaging inverse problem of tumor identification in the softissue of the human body. A general optimization framework for the identification of parameters in small point problems will be discussed along with a new modified output least-squares (MOLS) objective functional. Both continuous and discontinuous numerical examples will be shown.

► MS-Th-D-55-3 14:30–15:00

Wavelet Analyses of Water Cycling
ASLAN, ZAFER  
ISTANBUL AUDIYUN Univ.

Abstract: The main aim of the paper is to understand spatial and temporal variation of water cycle, heat fluxes and thermo-dynamical structure of atmospheric boundary layer. By using wavelet techniques, role of micro-meso and large scale events on rainfall and evaporation variations will explain water deficit and role of climate changing. The results of the study will improve prediction of evaporation and precipitation by defining role of small, meso and large scale factors.

► MS-Th-D-55-4 15:00–15:30

Application of Wavelets to Biometrics
Manchanda, Pammy  
Guru Nanak Dev Univ., Amritsar

Abstract: Feature extraction is fundamental preprocessing step for pattern recognition, and machine learning problems. Determination of ages with knowledge of fingerprints of a person is a challenging problem. DWT and SVD based fingerprint feature extraction along with determination of age will be discussed in this talk.

MS-Th-D-56 13:30–15:30

Mathematical trends, challenges and future applications for liquid crystal theories - Part I of IV

For Part 2, see MS-Th-E-56
For Part 3, see MS-Fr-D-56
For Part 4, see MS-Fr-E-56

Organizer: Majumdar, Apala  
Purdue Univ.
Organizer: Wang, Changyou  
Peking Univ.
Organizer: Zhang, Pingwen  
Peking Univ.

Abstract: Liquid crystals are mesogenic phases of matter intermediate between the solid and liquid phases of matter. Liquid crystals typically exhibit partial ordering and are consequently, highly sensitive to light, electric fields, mechanical and rheological effects. The proposed minisymposium focuses on key questions in liquid crystal research, based on defects, atomistic to continuum modelling, phase transitions, pattern formation and hydrodynamics. The minisymposium will comprise four themed sessions on (i) analysis, (ii) modelling, (iii) simulations and (iv) related areas, with invited talks from physicists, mathematicians and materials scientists, thus providing an ideal platform for the cross-fertilization of expertise from around the globe.

► MS-Th-D-56-1 13:30–14:00

ICIAM 2015 Schedules
Global Solution of A Simplified Ericksen-Leslie Equation with Non-zero Circulation Reynolds Number

YU, Yong
The Chinese Univ. of Hong Kong

Abstract: In order to simplify and meanwhile preserve the dissipative property of the original Ericksen-Leslie equation, a simplified Ericksen-Leslie equation was proposed by Lin and later studied by Lin-Lin-Wang for the bounded domain case in dimension two. So far most of works are about finite-kinetic-energy solution, which has zero circulation Reynolds number. In this talk we are going to discuss global weak solution of the simplified Ericksen-Leslie equation with non-zero circulation Reynolds number in dimension two. This work is partially supported by RGC grant 409613 and 14306414.

-MS-Th-D-56-2
14:00–14:30
Finite Time Singularity of Nematic Liquid Crystal Flows
Wang, Changyou
Purdue Univ.
Lin, Fanghua
Courant Inst./NYU
Liu, Chun
Penn State Univ.

Abstract: In this talk, I will describe the example of finite time singularity of the simplified nematic liquid crystal flows in dimension three. This is a joint work with Tao Hang, Fanghua Lin, and Chun Liu.

-MS-Th-D-56-3
14:30–15:00
Local Existence of Unique Strong Solution to Nonisothermal Model for Incompressible Nematic Liquid Crystals in 3D
Ding, Shijin
South China Normal Univ.

Abstract: In this paper, we consider the non-isothermal model for incompressible flow of nematic liquid crystals in three dimensions and prove the local existence and uniqueness of the strong solution with periodic initial conditions on T3.

-MS-Th-D-56-4
15:00–15:30
Defects of Liquid Crystals
Zhang, Pingwen
Peking Univ.

Abstract: Defects in liquid crystals are of great practical importance and theoretical interest. Despite tremendous efforts, predicting the location and transition of defects under various topological constraint and external field remains to be a challenge. We investigate defect patterns of nematic liquid crystals confined in three-dimensional spherical droplet and two-dimensional disk under different boundary conditions, within the Landau-de Gennes model. A spectral method that numerically solves the Landau-de Gennes model with high accuracy is implemented, which allows us to study the detailed static structure of defects. We observe five types of defect structures. Among them the 1/2 disclination lines are the most stable structure at low temperature. Inspired by numerical results, we obtain the profile of disclination lines analytically. Moreover, the connection and difference between defect patterns under the Landau-de Gennes model and the Oseen-Frank model is discussed. Finally, four conjectures are made to summarize the common characteristics of defects in the Landau-de Gennes theory, in the hope of providing a deeper understanding of the defect pattern in nematic liquid crystals.

-MS-Th-D-57-1
13:30–15:30
402A
Modeling, Applications, Numerical Methods, and Mathematical Analysis of Fractional Partial Differential Equations - Part I of IV
For Part 1, see MS-Th-BC-57
For Part 3, see MS-Th-E-57
For Part 4, see MS-Th-F-57
For Part 5, see MS-Fr-E-57
Organizer: Wang, Hong
Univ. of South Carolina
Organizer: Karniadakis, George
Brown Univ.

Abstract: Fractional Partial Differential Equations (FPDEs) are emerging as a new powerful tool for modeling many difficult complex systems, i.e., systems with overlapping microscopic and macroscopic scales or systems with long-range time memory and long-range spatial interactions. They offer a new way of accessing the mesoscale using the continuum formulation and hence extending the continuum description for multiscale modeling of viscoelastic materials, control of autonomous vehicles, transitional and turbulent flows, wave propagation in porous media, electric transmission lines, and speech signals. FPDEs raise modeling, computational, mathematical, and numerical difficulties that have not been encountered in the context of integer-order partial differential equations. The aim of this mini-symposium is to cover the recent development in mathematical and numerical analysis, computational algorithms, and applications in the context of FPDEs and related nonlinear problems.

-MS-Th-D-57-2
14:30–15:00
Efficient Spectral Methods for Solving PDEs with Two-sided Fractional Derivatives
Shen, Jie
Purdue Univ.

Abstract: For the PDEs with Riesz derivatives, we construct spectral methods using special basis functions based on generalized Jacobi functions which lead to diagonal systems, and we derive rigorous error estimates which show that the convergence rate is of spectral type in properly weighted Sobolev spaces despite the fact that the solutions have singularities at the endpoints. For PDEs with more general two-sided fractional derivatives, we construct efficient spectral-element methods to achieve spectral accuracy.

-MS-Th-D-57-3
14:00–14:30
Tempered Fractional Sturm-Liouville Eigen- Problems
Zayernouri, Mohsen
Karniadakis, George
Brown Univ.
Brown Univ.

Abstract: We introduce two classes of regular and singular tempered fractional Sturm-Liouville problems (TFSLPs). We prove the well-posedness of the TFSLPs and show that the corresponding eigensolutions are real-valued. We also demonstrate that the explicitly obtained eigenfunctions of TFSLPs, called Tempered Jacobi Poly-fractonomials, possess several key properties such as orthogonality, recurrence formula, etc. Hence, we employ them as new basis/test functions in developing Petrov-Galerkin spectral methods for tempered problems, followed by stability and error analysis.

-MS-Th-D-57-4
15:00–15:30
Finite Difference/finite Element Method for Two-dimensional Space and Time Fractional Bloch-Torrey Equations
Tang, Yifa
Acad. of Mathematics & Sys. Sci., CAS

Abstract: In this paper, a class of two-dimensional space and time fractional Bloch-Torrey equations (2D-STFBTEs) are considered. By finite difference method and Galerkin finite element method, a semi-discrete variational formulation for 2D-STFBTEs is obtained. The stability and convergence of the semi-discrete system are discussed. Then, a fully discrete scheme of 2D-STFBTEs is derived and the convergence is investigated. Finally, some numerical examples are given to prove the correctness of our theoretical analysis.

-MS-Th-D-58
13:30–15:30
401
Theoretical and numerical studies of phase field model - Part I of IV
For Part 2, see MS-Th-E-58
For Part 3, see MS-Fr-D-58
For Part 4, see MS-Fr-E-58
Organizer: Wang, Cheng
Univ. of Massachusetts Dartmouth
Organizer: Qiao, Zhonghua
The Hong Kong Polytechnic Univ.
Organizer: Wang, Xiaoping
Hong Kong Univ. of Sci. & Tech.

Abstract: Phase field equations, which treat the phase variable as a continuous function instead of a sharp interface, model a great number of physical and biological phenomena, such as phase transformations of materials at different scales, the process in biological growth and development, and the topological change involved in multi-phase flows. This mini-symposium is focused on the developments of the phase field models. Both the theoretical analysis for these highly nonlinear PDEs and the numerical approximations are of great interests.

-MS-Th-D-58-1
13:30–14:00
A Second-order Accurate Convex Splitting Finite Difference Scheme for the Cahn-Hilliard Equation and Its Improved Error Analysis
Wang, Cheng
Univ. of Massachusetts Dartmouth
Yue, Xingye
Soochow Univ.
Wise, Steven
Univ. of Tennessee
Guo, Jing
Soochow Univ.

Abstract: A second order accurate finite difference scheme is presented for the 2-D and 3-D Cahn-Hilliard equation, and an error analysis with an improved convergence constant is provided. The unique solvability and unconditional energy stability results from its convex splitting nature. Meanwhile, it is observed that a standard error estimate gives a convergence constant which depends on ε−1 in an exponential growth form, with the interface parameter...
very small. To overcome this well-known difficulty, we apply a spectrum esti-
mate for the linearized Cahn-Hilliard operator and get an improved estimate,
in which the convergence constant depends on \( \varepsilon^{-1} \) only in a polynomial or-
der, other than the exponential growth one.

**Abstract:** A linear iteration algorithm is proposed and implemented for the
convex splitting numerical scheme applied to epitaxial thin film growth model
with slope selection. The convex splitting nature assures an unconditional en-
ergy stability and unique solvability. Meanwhile, the linear iteration approach
greatly simplifies the computational efforts to implement these highly nonlin-
eral numerical schemes. In addition, both the theoretical analysis and the
numerical evidences have shown a contraction mapping property of the
proposed linear iteration. Both the first and second order splitting schemes are
considered in this work.

**Optimal Energy Scaling for Branched Transport Networks**

Wirth, Benedikt  
Univ. of Munster

**Abstract:** Several models for transport networks take into account that it is
more efficient to transport material in bulk. Optimal networks then typically
exhibit branching structures. The network complexity and ramification de-
pends on a parameter epsilon describing the cost reduction due to bulk trans-
port. We analyze the scaling of the network costs as epsilon approaches zero.
In two dimensions we furthermore establish a close relation of network
optimization to so-called Mumford-Shah image segmentation. (With Alessio
Brancolini)

**Linear Iteration Algorithm for Epitaxial Thin Film Growth Model with Slope Selection**

Conde, Sidsa  
Univ. of Massachusetts Dartmouth

Wang, Cheng  
Univ. of Massachusetts Dartmouth

Narayan, Akil  
Univ. of Massachusetts Dartmouth

**Abstract:** A linear iteration algorithm is proposed and implemented for the
convex splitting numerical scheme applied to epitaxial thin film growth model
with slope selection. The convex splitting nature assures an unconditional en-
ergy stability and unique solvability. Meanwhile, the linear iteration approach
greatly simplifies the computational efforts to implement these highly nonlin-
eral numerical schemes. In addition, both the theoretical analysis and the
numerical evidences have shown a contraction mapping property of the
proposed linear iteration. Both the first and second order splitting schemes are
considered in this work.

**On the Geometry of Dissipative Evolution Equations**

Reina, Celia  
Univ. of Pennsylvania

**Abstract:** The modeling of continuum dissipative evolution equations remains
a challenge and is currently based on phenomenological constitutive rela-
tions such as Fourier’s law for heat transfer. In this talk we present some
connections between the geometry of dissipative gradient flows, the principle
of maximum entropy production, large deviation principles for stochastically
augmented evolution equations and fluctuation-dissipation relations. (Joint
work with Johannes Zimmer)

**Rigidity, Non-rigidity and Scaling for the Cubic-to-Orthorhombic Phase Tran-
sition**

Rueland, Angkana  
Univ. of Oxford

**Abstract:** In this talk I will discuss a geometrically linearized model of the
cubic-to-orthorhombic phase transition in an exactly stress-free setting. I will
show that it is one of the simplest, physically relevant phase transitions in
which already in the linearized theory pathological convex integration solu-
tions exist. Complementary to that, I will show that under surface energy
constraints only very specific patterns can arise. Finally, I will discuss stability
under small energy perturbations.
nested one, the time discretization is based on the backward Euler method. Optimal order a posteriori error estimates in $L^\infty(L^2)$ and $L^2(H^1)$-norms are established using energy method. Our analysis relies on the appropriate adaptation of the elliptic reconstruction technique introduced by Makridakis and Nochetto [SIAM J. Numer. Anal., 41(4):1585-1594, 2003] and the stability of $L^2$ projection in $H^1(\Omega)$.

**CP-Th-D-61-2** 13:50–14:10

**Mixed Finite Element Methods for Time Fractional Parabolic Optimal Control Problems - A Priori Error Estimates**

Kandasamy, Manickam Periyar Univ., Salem 636011, Tamil Nadu, INDIA

Abstract: In this paper, a numerical theory based on mixed finite element methods for time fractional parabolic optimal control problems is presented and analyzed. The space discretization of the state variable is done using usual mixed finite elements, whereas the time discretization is based on difference methods. We derive a priori error estimates for both the control variable and the state variables. We illustrate these numerical results to confirm our theoretical results.

**Finite Element Approximation for Parabolic Integro-Differential Equations with Discontinuous Coefficients**

Deka, Bhupen Indian Inst. of Tech. Guwahati

Abstract: Finite element treatment for parabolic integro-differential equations with discontinuous coefficients are analyzed in this work. Convergence for the backward difference scheme in time direction are discussed. Optimal error estimates are derived in $L^2(L^2)$ and $L^2(H^1)$ norms when initial data $u_0 \in H^1 \cap H^2_0(\Omega)$. $\Omega$

**CP-Th-D-61-4** 14:30–14:50

**NONCONFORMING MIXED FINITE ELEMENT APPROXIMATIONS OF THE VON KARMAN EQUATIONS**

Malik, Gouranga Indian Inst. of Tech. Bombay

Nataraj, Neela Indian Inst. of Tech. Bombay

Abstract: In this talk, we consider the von Karman equations which describe bending of thin elastic plates governed by two non-linear fourth order partial differential equations defined on polygonal domain. The main contributions include (i) derivation of an approximation for an isolated solution using the nonconforming Morley elements for discretization; (ii) development of optimal order energy norm and $H^1$ norm error estimates; (iii) numerical realization of the theoretical results.

**CP-Th-D-61-5** 14:50–15:10

**A Constrained Finite Element Method Based on Domain Decomposition Satisfying the Discrete Maximum Principle for Diffusion Problems**

Chen, Xingding Beijing Tech. & Business Univ.

Abstract: In this paper, we are concerned with the constrained finite element method based on domain decomposition satisfying the discrete maximum principle for diffusion problems with discontinuous coefficients on distorted meshes. The basic idea of domain decomposition methods is used to deal with the discontinuous coefficients. To get the information on the interface, we generalize the traditional Neumann-Neumann method to the discontinuous diffusion tensors case. Then, the constrained finite element method is used in each subdomain. Comparing with the method of using the constrained finite element method on the global domain, the numerical experiments show that not only the convergence order is improved, but also the nonlinear iteration time is reduced remarkably in our method.

**Convergence of Adaptive Mixed Finite Element Method for Second Order Elliptic Problems**

Don, Asha Indian Inst. of Tech. Bombay

Nataraj, Neela Indian Inst. of Tech. Bombay

Pani, Amiya Indian Inst. of Tech. Bombay

Abstract: The talk addresses the convergence of an adaptive mixed finite element method (AMFEM) for nonsymmetric, indefinite second order elliptic problems. First we analyze a nonconforming finite element discretization which converges owing to some a priori $L^2$-error estimates under reduced regularity assumptions. An equivalence result of nonconforming FE scheme to the mixed finite element method (MFEM) leads to the well-posedness of the discrete solution and to a priori error estimates for the MFEM. The explicit residual-based a posteriori error analysis allows some reliable and efficient error control. The main difficulties in the analysis of convergence of AMFEM are posed by the non-symmetric and indefinite form of the problem along with the lack of the orthogonality property in MFEM. The important tools in the analysis are a posteriori error estimators, quasi-orthogonality property and quasi-discrete reliability established using representation formula for the lowest-order Raviart-Thomas solution in terms of the Crouzeix-Raviart solution.

**CP-Th-D-62** 13:30–15:30

**Linear Algebra, Discrete Mathematics, Physics and Statistical Mechanics, Other Mathematical Topics and Their Applications**

Chair: Bu, Changjiang Harbin Engineering Univ.

**Some Results on the Generalized Inverse of Tensors and Idempotent Tensors**

Bu, Changjiang Harbin Engineering Univ.

Abstract: Let $A$ be an order $t$ dimension $m \times n \times \cdots \times n$ tensor over complex field. In this paper, we study some generalized inverses of $A$, the $k$-T-dedemptent tensors and the idemptent tensors based on the general tensor product. Using the tensor generalized inverse, some solutions of the equation $A \cdot x^{k-1} = b$ are given, where $x$ and $k$ are dimension $n$ and $m$ vectors, respectively. The generalized inverses of some block tensors, the eigenvalues of $k$-T-idempotent tensors and idempotent tensors are given. And the relation between the generalized inverses of tensors and the $k$-T-idempotent tensors is also showed.

**Finding Distance Magic and Antimagic Graphs**

Simanjuntak, Rinovia Institut Teknologi Bandung

Abstract: For an arbitrary set of distances $D \subseteq \{0, 1, \ldots, d\}$, a graph $G$ is said to be $D$-distance magic if there exists a bijection $f : V \rightarrow \{1, 2, \ldots, v\}$ and a constant $k$ such that for any vertex $x, \sum_{y \in N_D(x)} f(y) = k$, where $N_D(x) = \{y \in V \mid d(x, y) \in D\}$. Additionally, a graph $G$ is said to be $D$-distance antimagic if the $\sum_{x \in N_D(x)} f(x) = k$ is unique for each vertex $x$.

A $D$-distance graph of a graph $G$, denoted by $X_D(G)$, is the graph with vertex set $V(G)$ and edge set $\{\langle x, y \rangle \mid d(x, y) \in D\}$.

In this talk we shall study the relationships between $D$-distance magic and antimagic graphs for various $D$ by using the notion of $D$-distance graph.

**Phase Transitions in Three-channel Totally Asymmetric Simple Exclusion Process with Langmuir Kinetics**

Gupta, Arvind Indian Inst. of Tech. Ropar

Abstract: In the past few years, due to its important role in understanding the nonequilibrium phenomena, totally asymmetric simple exclusion processes (TASEP) a paradigmatic model for self-driven many particle systems has attracted much attention. This simple model can describe some of the complex phenomenon such as boundary induced phase transitions, phase separation, spontaneous symmetry breaking and shock formation etc. The present study deals with the three-lane TASEPs with particles attachment and detachment in the bulk under open boundary conditions. The particles can hop along the lanes as well as to the adjacent lanes. The phase diagrams are obtained using singular perturbation technique on mean field equations. Several interesting dynamic phenomena are observed. The theoretical results are validated with extensive Monte-Carlo simulations.

**Results on Mixed Anisotropic L2-BV Regularization of Ill-posed Problems and Applications to Image Restoration**

Spies, Ruben Inst. for Applied Mathematics of Litoral , IMAL, CONICET-UnL

Temperini, Karina IMAL-FICH, CONICET -UNL

Mazzieri, Gisela IMAL-FBCB

Abstract: Several generalizations of the traditional Tikhonov-Phillips regularization method for inverse ill-posed problems have been proposed during the last decades. Many of these variants consists essentially in modifications of the penalizing term, which forces certain features in the obtained regularized solution. If it is known that the regularity of the exact solution is homogeneous it is often desirable the use of mixed, spatially adaptive methods. These methods are also highly suitable when the preservation of borders and edges is also an important issue, since they allow for the inclusion of penalizers appropriate for border detection. In this work, we propose the use of a convex spatially-adaptive combination of classic L2 penalizers and anisotropic bounded variation semi-norm. Results on existence and uniqueness of minimizers and corresponding Tikhonov-Phillips functional are presented. Stability results of these minimizers with respect to different perturbations are presented and applications to image restoration problems are shown.
New Monotone Finite Volume Schemes for Diffusion Equations on Distorted Meshes

Yue, Jing-yan Inst. of Applied Physics & Computational Mathematics, Beijing, China
Yuan, Guang-wei Inst. of Applied Physics & Computational Mathematics, Beijing, China

Abstract: We construct a new monotone finite volume method for diffusion equations on star-shaped polygonal meshes. A distinct feature of the new scheme is that the discrete stencil of normal flux on a cell-edge can contain the cell-edge, which is different from the existing monotone schemes based on a nonlinear two-point flux approximation. The new scheme is proved to be monotone, i.e. it preserves positivity of analytical solutions for diffusion equations with strongly anisotropic and heterogeneous full tensor coefficients. Numerical results are presented to demonstrate the numerical performance of our new monotone scheme such as solution positivity-preserving, conservation, accuracy and efficiency on distorted meshes.

On Connected Ramsey (3K2,K3)-minimal Graphs with Small Order

Wijaya, Kristiana Univ. of Jember
Baskoro, Edy Tri Institut Teknologi Bandung
Assiyatun, Hilda Institut Teknologi Bandung
Suprijanto, Djoko Institut Teknologi Bandung

Abstract: Ramsey graphs theory deals with regularity and coloring of graphs. There are many interesting applications of Ramsey graphs theory, such as in the fields of communications, information transmission, and decision making. Let F, G and H be simple graphs. We write \( F \to (G,H) \) to mean that any red-blue coloring of all edges of F contains either a red copy of G or a blue copy of H. The graph F (without isolated vertices) satisfying F \( \to (G,H) \) and (F-e) \( \not\to (G,H) \) for every e in E(F) is called a Ramsey (G,H)-minimal graph. The set of all Ramsey (G,H)-minimal graphs is denoted by R(G,H). In this paper, we characterize all connected Ramsey (3K2,K3)-minimal graphs of order 9.

Some Bounds on Restricted Size Ramsey Number for P3 Versus Pn

Silaban, Denny Riama Univ. of Indonesia/ Institut Teknologi Bandung
Baskoro, Edy Tri Institut Teknologi Bandung
Uttinggadewa, Saladin Institut Teknologi Bandung

Abstract: Let F, G and H are simple graphs. We say \( F \to^*(G,H) \) if for every 2-coloring of the edges of F there exist a monochromatic G or H in F. The Ramsey number \( r(G,H) \) is defined as min \( V(F) \) such that \( F \to^*(G,H) \) and the restricted size Ramsey number \( r^*(G,H) \) is defined as min \( E(F) \) such that \( F \to^*(G,H) \). In this paper we give lower and upper bounds for restricted size Ramsey number for \( P_3 \) versus \( P_n \). In particular, we give the exact size Ramsey number for some small values of n.

Prime Cordial Labeling for Some Operations on Graphs

Sudaransan, I Wayan Tadulako Univ.

Abstract: All graphs in this paper are connected, finite, simple and undirected with \( p \) vertices and \( q \) edges. The greatest common divisor of two positive integers \( a \) and \( b \) is denoted by gcd\((a,b)\). A prime cordial labeling (PCL) of a graph \( G \) is a bijection \( f : V \rightarrow \{1, 2, 3, ..., p\} \) and the induced function \( f^* : E \rightarrow \{0, 1\} \) is defined by

\[
\begin{align*}
&f^*(uv) = \left\{ \begin{array}{ll}
1, & \text{if } \gcd(f(u), f(v)) = 1; \\
0, & \text{otherwise.}
\end{array} \right.
\end{align*}
\]

satisfies the condition \( |c_0(f) - c_1(f)| \leq 1 \), where \( c_i(f) \) is the number of edges of \( G \) having label \( i \) under \( f^* \) with \( i = 0 \) and \( 1 \). A graph which admits PCL is called prime cordial (PC) graph. In this note, we proved that fan and friendship corona path order two admit PCL. We also give a technique to construct PCL for union of paths.

On the Separation of Linear Constant-weight Codes

Li, Xin Beijing Inst. of Tech.
Liu, Zihui Beijing Institution of Tech.

Abstract: By using the finite projective geometry method, the separating properties of linear constant-weight codes are presented. An algorithm is given for computing the cardinality of separating coordinates positions of certain disjoint codeword sets of linear constant-weight codes.
utilization and speed up the iterative solver, respectively. An experiments were conducted and the results were compared with the standard iterative method. The results shown good in space utilization and relatively good in execution time.

Abstract: Least Absolute Deviation Criteria and Method
Gu, Lemin
Tongji Univ.

Least Absolute Deviation criteria, proposed by mathematician Bosovitch in 1755 and Laplace in 1795, source in classical research on the 18th century astronomical meridian problem, is about the sum of the absolute value of error minimization criteria. The solution of LAD, a pending problem for more than 200 years in mathematics, is not easy to calculate because of the absolute value function. LAD solution problem has a big breakthrough in recent years, the breakthrough point is based on the “Zero-error principle” and “Representative manner” solution way. The paper carries out the following research: (1) Zero-error principle is presented. Error in the condition of zero, the absolute value is loss its meaning, thus overcome the two iron chain of blocking calculations, and makes LAD method become one as simple as Least Squares method. It is pointed out that LAD method is the best method to find the implicit function who is hidden behind the data and control data changes. (2) “Representative manner” solution way is put forward. This is an ideal and the best way to prevent and isolate the unusual data negative effect. It is completely different from LS method’s “bundling manner” solving way. Both Zero-error principle and “Representative manner” solution way make some good characteristics of LAD method appear gradually, such as initial robustness, zero-error, generalized, predictable and so on. The paper introduces these characteristics. Finally an application example that 2000-2013 China’s total crude oil production and consumption change rule as well as future tendency is given.

A Family of Accelerated Four-Point-Explicit Group Iterative Solvers
Shaharuddin, Shafiqah
Univ. Putra Malaysia
Othman, Mohamed
Univ. Putra Malaysia
Senu, Norazak
Univ. Putra Malaysia

Abstract: In this paper, we investigated a family of four-points explicit group iterative based solution for solving two-dimensional Poisson problem with Dirichlet boundary condition. The family consists of four-points Explicit Group (EG), Explicit Decoupled Group (EDG), ModI$$64257$$ed Explicit Group (MEG), ModI$$64257$$ed Explicit Decoupled Group (MEDG) and Octo ModI$$64257$$ed Explicit Group (OEG) iterative methods. The high order &$$64257$$nd difference approximation is used to derive the methods, thus ended with a huge system of linear equation. By introducing an optimal accelerated factor to the linear equation, several experiments were conducted and the results will be compared with the computed theoretical complexity of all the methods. An evaluation of both results have shown some degree of agreements between them.

Control of Hindmarsh-Rose Neuron Model
Benzekri, Tounisia
Univ. Sci. & Tech. Houari Boumediene

Abstract: In this work, we use the Nonlinear-Open-Plus-Closed-Loop (NOPCL) method to control a nonlinear model: the Hindmarsh-Rose model in which we can exhibit regular and chaotic dynamics. The aim of the NOPCL method is to entrain complex dynamics to arbitrary given goal dynamics, by adding a suitable control term to the system. We use this method to suppress chaos, by entraining chaotic dynamics to a periodic one for the Hindmarsh-Rose model.

Effect of Data Transformation on Long Term Memory of Chaotic Time Series
Ogunyje, Samuel
Federal Univ. of Tech., Akure

Abstract: There are many situations in which data set has to be subjected to mathematical manipulations such as differencing, logarithmic scaling, logarithmic differencing etc. In this paper, the effect of mathematical transformation on long term memory of chaotic data set was investigated using Hurst exponent. Using four chaotic systems, two common approaches to the computation of Hurst exponent was studied. From the results obtained, the effects ranged from small changes to large differences. Further more, data transformation highlights difference between the two methods of obtaining the Hurst exponents.
Abstract: This talk is a brief introduction into the theory of Painlevé equations and the isomonodromy. We review definitions of continuous and discrete Painlevé equations, providing some historical context. We will show that these two properties are closely related to each other through the space of initial conditions in the sense of Okamoto.

Abstract: This talk is a brief introduction to continuous and discrete Painlevé equations from a geometric viewpoint. While Painlevé equations are defined by the Painlevé property, i.e., the branch points of solutions are independent of the initial conditions, discrete Painlevé equations are characterized by so-called the singularity confinement criterion. We will show that these two properties are closely related to each other through the space of initial conditions in the sense of Okamoto.

Abstract: This talk is a brief introduction into the theory of Painlevé-type equations and isomonodromic deformations of linear equations on the Riemann sphere. In mathematics and physics, we also explain the connection between Painlevé equations and isomonodromic deformations of linear equations on the Riemann sphere. These Painlevé-type equations, there are 40 types of them. In this talk, we consider autonomous limit, which are integrable systems. By studying the spectral curves fibrations, we are able to grasp the characteristics of these systems.

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Abstract: This talk is a brief introduction into the theory of Painlevé equations and isomonodromic deformations of linear equations on the Riemann sphere. These Painlevé-type equations, there are 40 types of them. In this talk, we consider autonomous limit, which are integrable systems. By studying the spectral curves fibrations, we are able to grasp the characteristics of these systems.
boundaries. Here, two free boundaries which may intersect each other are used to describe the spreading fronts of two competing species, respectively. The spreading mechanism for species is determined by a Stefan condition, which is proposed by Du and Lin (2010). We mainly study the dynamics and offer some biological insight.

**MS-Th-E-03-4 17:30–18:00**

**Persistence and Spread of A Species with A Shifting Habitat Edge**  
Li, Bingtuan  
Univ. of Louisville

**Abstract:** We discuss a reaction-diffusion model that describes the growth and spread of a species along a shifting habitat gradient. We assume that the linearized species growth rate is positive near positive infinity and is negative near negative infinity. We provide the conditions under which the species goes extinct, and determine the spreading speed at which the species spreads along the shifting habitat gradient. Joint work with Sharon Bewick, Jin Shang, and William F. Fagan.

**Curves and Surfaces in Computer Aided Geometric Design - Part III of III**  
For Part 1, see **MS-Th-BC-04**  
For Part 2, see **MS-Th-D-04**

**Organizer:** Jia, Xiaohong  
Chinese Acad. of Sci.

**Organizer:** Cheng, Jin-San  
Chinese Acad. of Sci.

**Abstract:** The symposium is aimed at bridging between people who are working theoretically on curves and surfaces in algebraic geometry and those who are endeavoring to seek for suitable modeling forms of curves and surfaces in Computer Aided Geometric Design. Therefore, the symposium includes wide-ranging topics on curves and surfaces from classic theory aspects to their applications in modern industry. The forms of curves and surfaces consist of but are not limited to: algebraic curves and surfaces, parametric curves and surfaces including NURBS as well as triangular surface patches.

**MS-Th-E-04-1 16:00–16:30**

**How Many Regions Does A Real Algebraic Curve Divide the Plane?**  
Cheng, Jin-San  
Chinese Acad. of Sci.

**Abstract:** In this talk, we investigate the number of regions of a real algebraic curve and surfaces in algebraic geometry and those who are endeavoring to seek for suitable modeling forms of curves and surfaces in Computer Aided Geometric Design. Therefore, the symposium includes wide-ranging topics on curves and surfaces from classic theory aspects to their applications in modern industry. The forms of curves and surfaces consist of but are not limited to: algebraic curves and surfaces, parametric curves and surfaces including NURBS as well as triangular surface patches.

**MS-Th-E-04-2 16:30–17:00**

**An Algebraic Approach of Computing the Variations of the Intersection Curve of Two Moving Quadrics**  
Jia, Xiaohong  
Chinese Acad. of Sci.

**Abstract:** We propose a symbolic algorithm for detecting the variations in the topological and algebraic properties of the intersection curve of two quadratic surfaces (QSIC) that are moving or deforming in PR3 (real projective 3-space). The core of our algorithm computes all the critical instants when the QSIC changes type using resultants and Jordan forms. These critical instants partition the time axis into intervals within which the QSIC is invariant. The QSIC at the computed critical instants and within the time intervals can both be exactly determined using symbolic technique. Examples are provided to illustrate our algorithm.

**MS-Th-E-04-3 17:00–17:30**

**Quaternion Rational Surfaces: Rational Surfaces Generated from the Quaternion Product of Two Rational Space Curves**  
Wang, Xuhui  
Hefei Univ. of Tech.

**Abstract:** A quaternion rational surface is a surface generated from two rational space curves by quaternion multiplication. The goal of this talk is to demonstrate how to apply syzygies to analyze quaternion rational surfaces. We show that we can easily construct three special syzygies for a quaternion rational surface from a $\mu$-basis for one of the generating rational space curves. The implicit equation of any quaternion rational surface can be computed from these three special syzygies and inversion formulas for the nonsingular points on quaternion rational surfaces can be constructed. Quaternion rational ruled surfaces are generated from the quaternion product of a straight line and a rational space curve. We investigate special mu-bases for quaternion rational ruled surfaces and use these special mu-bases to provide implicitization and inversion formulas for quaternion rational ruled surfaces. Finally, we show how to determine if a real rational surface is also a quaternion rational surface.

**MS-Th-E-04-4 17:30–18:00**

**Geometric Iteration Method and Its Applications in Geometric Design**

[Institute]  
Hongwei, Lin  
Zhejiang Univ.

**Abstract:** Geometric iteration method, also called progressive-iterative approximation, is an iterative method with clear geometric meaning. By adjusting the control points of curves or surfaces iteratively, the limit curve or surface interpolates (approximates) the given data point set. In this report, we present the iterative formats of the interpolatory and approximating geometric iteration methods, show their convergence and local property, and develop the accelerating techniques. Moreover, some successful applications of the geometric iteration method are demonstrated.

**Geometric Understanding of Data in 3D and Higher - Part I of III**

**For Part 2, see MS-Fr-D-05**

**For Part 3, see MS-Fr-E-05**

**Organizer:** Lai, Rongjie  
Rensselaer Polytechnic Inst.

**Organizer:** Zhao, Hongkai  
UC Irvine

**Abstract:** Rapid development of data acquisition technology stimulates research on developing new computational tools for analyzing and processing data to make more effective decisions. In many problems, coherent structures of data allows us to model data as low dimension manifold in a high dimension space. More recently, there has been increasing interests in using geometric based method to analyze and infer underlying structures from the given data. This minisymposium aims to bring together people from different research groups with common interest. We hope that this symposium can propel further collaborations and developments in this field.

**MS-Th-E-05-1 16:00–16:30**

**Multi-scale Non-Rigid Point Cloud Registration Using Robust Sliced-Wasserstein Distance via Laplace-Beltrami Eigenmap**  
Zhao, Hongkai  
Lai, Rongjie  
Rensselaer Polytechnic Inst.

**Abstract:** Point clouds sampled from manifolds are transformed to new point clouds by Laplace-Beltrami(LB) eigenmap defined intrinsically on the manifolds which is invariant under isometric transformation of the original manifolds. We design computational models and algorithms for registration of the transformed point clouds in distribution/probability form based on optimal transport theory and incorporate a rigid transformation to handle ambiguities. Our method provides an efficient, robust and accurate multi-scale approach for non-rigid point cloud registration.

**MS-Th-E-05-2 16:30–17:00**

**Graph Cut Methods for Semi-supervised and Unsupervised Data Classification**  
Bertozzi, Andrea  
UCLA

**Abstract:** We present variational methods for semi-supervised and unsupervised data classification involving graph cuts, which are equivalent to minimizing the graph total variation of an assignment function. We discuss performance and efficiency of various algorithms for such problems including max flow, augmented Lagrangian, and geometric methods such as the MBO scheme and Allen-Cahn flow.

**MS-Th-E-05-3 17:00–17:30**

**Convergence of the Laplace-Beltrami Operator from Point Clouds**  
Sun, Jian  
Tsinghua Univ.

**Abstract:** The spectral convergence of the weighted graph Laplacian is a theoretical foundation of the Laplacian based algorithms such as spectral clustering, and dimensionality reduction using diffusion maps and Laplacian eigenmaps. In this talk, we present our recent results showing the eigenvalues and eigenvectors of the weighted graph Laplacian converges to the eigenvalues and eigenfunctions of the Laplace-Beltrami operator of the manifold with the Neumann boundary in the limit of infinitely many sample points. We consider the convergence problem from the point of view of solving the Poisson equations on submanifolds. This new perspective also leads to the methods for computing the eigensystem of the Laplace-Beltrami operator with Dirichlet boundaries and for solving the harmonic extension problem from point clouds. I will also present some numerical results.

**MS-Th-E-05-4 17:30–18:00**

**New Old Methods for Manifold Correspondence**  
Bronstein, Michael  
Univ. of Lugano (USI) / Intel

**Abstract:** In recent years, geometric data is gaining increasing interest both in the academia and industry. In this talk, I will use the problem of manifold correspondence (a fundamental problem with a wide range of applications in geometric processing, graphics, vision, and learning) as a showcase for signal processing (sparse coding, joint diagonalization, matrix completion) applied to geometric problems. I will show applications to 3D shape correspondence.
Data-driven methods for quantifying uncertainty of multiscale dynamical systems - Part II of IV

For Part 1, see MS-Th-D-06
For Part 3, see MS-Fr-D-06
For Part 4, see MS-Fr-E-06

Organizer: Harlim, John The Pennsylvania State Univ.
Organizer: Sapsis, Themistoklis MIT
Organizer: Giannakis, Dimitrios New York Univ.

Abstract: A major challenge in contemporary applied science is to design efficient models for predicting dynamical behavior resulting from complex interaction of multiple scale processes. This task, implicitly, requires one to account for uncertainties of the models due to initial conditions, boundary conditions, model errors, and observation errors. A promising interdisciplinary approach to address such issue is with a data-driven statistical methods that combine ideas from dynamical systems theory, stochastic processes, statistics, and data analysis. This special session aims to bring together researchers from across the spectrum of disciplines related to data-driven methods to discuss the development and application of emerging ideas and techniques for these important and difficult practical issues.

► MS-Th-E-06-1 Modeling of Unresolved Scales with Data-inferred Stochastic Processes
Crommelin, Daniel CWI Amsterdam

Abstract: I will discuss a data-driven stochastic approach to modeling unresolved scales in multiscale systems, in which feedback from micro-scales is represented by a network of Markov processes. The Markov processes are conditioned on macro-scale model variables, and their properties are inferred from pre-computed high-resolution (micro-scale resolving) simulations. These processes are designed to emulate, in a statistical sense, the feedback observed in the high-resolution simulations, thereby providing a statistical-dynamical coupling between micro- and macro-scale models.

► MS-Th-E-06-2 Improving Prediction Skill of Imperfect Turbulent Models Through Statistical Response and Information Theory
Qi, Di Courant Inst. of Mathematical Sci.

Abstract: Simplified imperfect models are useful in areas like climate science where the true climate system is vastly more complicated than any conceivable approximation. Simple statistical closure models using additional damping and enhanced noise in replacement of the higher order moments are constructed for resolving turbulent systems with quadratic nonlinearities. An information consistent strategy to improve imperfect model performance ensuring statistical equilibrium fidelity and optimal model responses to different perturbations is developed in a low-order subspace.

► MS-Th-E-06-3 Perspectives on Nonlinear Filtering
Law, Kody ORNL

Abstract: This talk will survey some recent theoretical results involving accurate signal tracking with noise-free (degenerate) dynamics in high-dimensions (infinite, in principle, but say $d$ between 10$^4$ and 10$^5$, depending on the size of your application and your computer), and high-fidelity approximations of the filtering distribution in low dimensions (say $d$ between 1 and several 10s).

► MS-Th-E-06-4 Analog Forecasting with Dynamics-Adapted Kernels
Zhao, Zhiwen Courant Inst. of Mathematical Sci., NYU
Giannakis, Dimitrios New York Univ.

Abstract: We introduce a suite of forecasting methods which improve traditional analog forecasting by combining ideas from state-space reconstruction in dynamical systems and kernel methods developed in harmonic analysis and machine learning. The first improvement is to use Takens’ delay-coordinate maps to recover information lost through partial observations. Then, weighted ensembles of analogs are chosen according to similarity kernels featuring an explicit dependence on the dynamical vector field generating the data.

► MS-Th-E-06-5 A Continuum Perspective on Eigenmaps and Diffusion Maps
Portegies, Jacobus Max Planck Inst. for Mathematics in the Sci.

Abstract: We present a continuum perspective on several nonlinear data analysis methods, with a special focus on Eigenmaps and Diffusion Maps. We derive bounds on the complexity of the continuous versions of these algorithms, in terms of the geometry of the manifold they are trying to learn. In particular, we bound the number of eigenfunctions needed to accurately represent the manifold in a (low-dimensional) Euclidean space.

Computational Methods in Ice Sheet Modeling for Next Generation Climate Simulations - Part II of II

For Part 1, see MS-Th-D-07

Organizer: Tezaur, Irina Sandia national Laboratories
Organizer: Wei, Leng Lawrence Berkeley National Laboratory
Organizer: Martin, Daniel Lawrence Berkeley National Laboratory
Organizer: Ng, Esmond Lawrence Berkeley National Laboratory
Organizer: Perego, Mauro Sandia National Laboratories

Abstract: Changes in glaciers and ice sheets are expected to have a tremendous impact on sea-level rise and global climate change. Many mathematical challenges in simulating ice sheet dynamics arise: ill-conditioned systems; a wide range of scales; complex evolving geometries; ill-posed inverse problems; sparse observational data; large-scale forward and inverse UQ problems in high-dimensions ("curse of dimensionality"). Speakers in this MS will present recent developments aimed at overcoming these and other difficulties arising in ice sheet modeling. A broad range of topics will be covered, including forward and inverse problems, UQ, solvers/preconditioners, and coupling to global climate models.

► MS-Th-E-07-1 A Model for Temperature Ice Formation
Hewitt, Ian Univ. of Oxford

Abstract: Many ice-sheets contain ice that is at the melting temperature and contains pore water. We examine a model to determine the heat/water content of such ice, and to locate the boundaries between cold and temperate ice. In some circumstances, the model reduces to common treatments of temperate ice employed in ice-sheet models, but in some cases it does not. We examine different boundary-layer behaviour that can occur using a combination of asymptotic and numerical approaches.

► MS-Th-E-07-2 Improving Discretization of Grounding Lines Using An Embedded-Boundary Approach in BISICLES
Martin, Daniel Lawrence Berkeley National Laboratory
Schwartz, Peter Lawrence Berkeley National Laboratory

Abstract: Correctly representing grounding line dynamics is of fundamental importance in modeling marine ice sheets. We have developed a grounding-line discretization based on the Chombo embedded-boundary cut-cell framework. This promises better representation of grounding lines vs. a traditional stair-step discretization on Cartesian meshes like those used in the block-structured AMR BISICLES code. Also, the fundamental discontinuous nature of flow across the grounding line is respected by treating it as a material phase change.

► MS-Th-E-07-3 Coupling of Momentum Balance and Thickness Evolution Equations for Ice Sheet Modeling
Perego, Mauro Sandia National Laboratories

Abstract: The main components of an ice sheet model are the equations for: (1) the momentum balance (typically Stokes equations or their approximations) and (2) the ice thickness evolution. These two components are strongly coupled, and a straightforward sequential solution of them leads to prohibitively small time steps. In this talk we analyze the coupled problem and we propose a method to solve it effectively. We show numerical results on idealized and realistic geometries.

► MS-Th-E-07-4 Development of the Adjoint of A Higher-order Ice Sheet Model
Goldberg, Daniel Univ. of Edinburgh

Abstract: Development of the efficient adjoint generation of a higher-order ice sheet model using Algorithmic Differentiation (AD) methods is presented. Recent innovations are adjoint generation with open-source AD software and the implementation of a specialized treatment of the fixed-point problem for ice velocities which decreases computation time and reduces memory overflows which are important considerations for large scale simulation. Recent assimilation results using time-dependent remote sensing data is also presented.
Minisymposium on Inverse Problems in Wave Propagation - Part I of II
For Part 2, see MS-Fr-D-08
Organizer: Bao, Gang Zhejiang Univ.
Organizer: Li, Peijun Purdue Univ.
Organizer: Triki, Faouzi Joseph Fourier Univ.
Abstract: Inverse problems in wave propagation have played a fundamental role in diverse scientific areas such as radar and sonar, geophysical exploration, medical imaging, near-field optical microscopy, and nano-optics. Due to the complexity of material properties and uncertainty in physical models and parameters, precise modeling and accurate computing present challenging and significant mathematical and computational questions, and remain the subject matter of much ongoing research.

The minisymposium aims at recent mathematical and computational studies of inverse problems in various wave propagation models, including acoustic, electromagnetic, optical, elasticity, and quantum wave propagation. It seeks to bring together leading researchers in these fields to present recent developments, promote exchange of ideas, and discuss new directions including treatment of multi-frequency and near-field data, and multi-wave imaging. The talks will cover all the aspects of inverse scattering problems like asymptotic techniques, sensitivity analysis, numerical computation, and wave propagation in complex and random media.

Abstract:
Based on some recent theoretical understanding of the identification problem of single photon emission computerized tomography (SPECT), we propose an adjoint state method to solve the identification problem numerically so that we can verify the theory and demonstrate uniqueness and non-uniqueness, stability and instability of the inverse problem.

Abstract:
Computerized Tomography (SPECT) can be used to reconstruct wave speed in a stable way.

Abstract:
From boundary measurements. Two cases are considered: the hyperbolic Dirichlet to Neumann map and the scattering relation. We showed that hyperbolic equations. This method can achieve subgridding effect, by using TO to enlarge certain small regions so that they look much larger in the transformed space.

Abstract:
For modeling of electromagnetic cloaks, backward wave propagations and the optical black holes. The permit tivity and permeability of the cloak model are independent of the frequency. 2-D and 3-D numerical examples demonstrate the performance of the new method.

Abstract:
Efficient Evaluation of Green's Function for 2D Scattering in Layered Medium
Lai, Jun New York Univ.
Abstract: Conventional Green's function evaluation for layered medium through Sommerfeld integral suffers from slow convergence when the point source is near the interface. In this talk, we propose a novel method to efficiently evaluate the layered Green's function via the combination of Sommerfeld integral and physical density along the interface. Numerical experiments for scattering problem with object imbedded in the layered medium are provided to show the efficiency.

Abstract:
Fast Huygens Sweeping Methods for Helmholtz Equations in the High Frequency Regime
Qian, Jianliang Michigan State Univ.
Abstract: We propose the fast Huygens sweeping methods for Helmholtz equations in inhomogeneous media in the high frequency regime. With four to six points per wave length, the new method is of nearly optimal complexity independent of the frequency. 2-D and 3-D numerical examples demonstrate the performance of the new method.

Abstract:
Stability of Recovering Wave Speed from Boundary Measurements
Zhang, Hai ENS, Paris
Abstract: We report recent progress on the stability of recovering wave speed from boundary measurements. Two cases are considered: the hyperbolic Dirichlet to Neumann map and the scattering relation. We showed that hyperbolic D-t-N map is not good for the reconstruction, while the scattering relation can be used to reconstruct wave speed in a stable way.

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considered systems. There are exactly 37 classes. We exploit the long-run behavior for 3-dimensional competitive Lotka-Volterra Systems

Abstract: In this talk, making use of interesting connections between stochastic differential equations and information theory, we derive the capacity region of several classes of continuous-time Gaussian channels. The complete results obtained in this work stand in stark contrast to the status quo of network information theory in discrete-time, where the capacity regions of all the above-mentioned channels are known only for a handful of special scenarios.

Random Periodic Processes, Periodic Measures and Strong Law of Large Numbers
Zhao, Huaizhong Loughbrough Univ.

Abstract: We first prove that a random periodic path of a random dynamical system gives a periodic measure (p.m.), and conversely construct random periodic process on an enlarged probability space. The law of the random periodic process is the p.m. We further prove the strong law of large numbers (SLLN) of the random periodic processes. Joint work with Chunrong Feng.

Stability in Distribution of Stochastic Delay Recurrent Neural Networks with Markovian Switching
Enwen, Zhu Changsha Univ. of Sci. & Tech.

Abstract: This paper investigates the stability in distribution of stochastic delay recurrent neural networks with Markovian switching. Using Lyapunov function and stochastic analysis techniques, sufficient conditions on the stability in distribution are given. For such recurrent neural networks, it reveals that the limit distribution of transition probability for segment process associated with solution process is indeed a unique ergodic invariant probability measure. Moreover, a numerical example is also provided to demonstrate the effectiveness and applicability of the theoretical results.

On the Complete Dynamical Behavior for Three-Dimensional Stochastic Competitive Lotka-Volterra Systems
Jiang, Jifa Shanghai Normal Univ.

Abstract: We exploit the long-run behavior for 3-dimensional competitive Lotka-Volterra systems with the equal growth rate perturbed by the same multiplicative noise. Firstly, it is proved that the solutions of considered systems can be expressed in terms of the solutions of the noise-free system multiplied by appropriate solutions of the scalar logistic equation driven by the same kind noise. This decomposition helps us to classify the long-run behavior for considered systems. There are exactly 37 classes.

Matrix computations using structures and other innovative techniques - Part I
For Part 1, see MS-Th-E-10-1
For Part 2, see MS-Th-E-10-4
For Part 3, see MS-Th-E-11-2

Organizer: Chen, Jie IBM Thomas J. Watson Research Center
Abstract: This minisymposium is concerned with a wide range of innovative matrix computation techniques, including structures, randomization, splitting preconditioning, etc. The techniques make it feasible to develop new fast and reliable direct or iterative solutions. In particular, certain block or hierarchical structures can be used to obtain effective preconditioners or nearly linear complexity direct solvers for challenging numerical problems. Interesting applications to imaging, PDE/inegral equation solutions, optimization, parallel computing, and engineering simulations will also be shown.

Superfast Divide-and-Conquer Eigensolvers and Structured Perturbation Analysis
Xia, Jianlin Purdue Univ.

Abstract: We present nearly O(n) complexity divide-and-conquer methods for finding all the eigenvalues and eigenvectors of a class of symmetric matrices, as well as the perturbation analysis. The matrices have certain rank structures, as often encountered in practical applications such as Toeplitz matrices and some discretized problems. We show how to quickly and stably perform the major operations. Eigenvalue approximation accuracies, clustered eigenvalues, and generalizations to SVDs are studied. This is joint work with James Vogel.

High Performance Parallel Implementation of A Novel HSS-structured Sparse Solver Using Randomized Sampling
Ghysels, Pieter Lawrence Berkeley National Lab
Rouet, Francois-Henry Lawrence Berkeley National Laboratory
Li, Xiaoye Lawrence Berkeley National Laboratory

Abstract: We present an efficient code for solving large sparse linear systems using the multifrontal method with hierarchically semi-separable (HSS) matrices. The low rank compression in HSS limits fill-in and reduces complexity of the solver. The HSS matrices are constructed using randomized sampling and rank-revealing QR. ULV decomposition replaces the traditional dense LU. The factorization acts as solver or preconditioner. Shared and distributed memory parallel results are presented for a range of applications.

A New Integral Formulation and Fast Direct Solver for Periodic Stokes’ Flow
Gillman, Adrianna Rice Univ.

Abstract: Many solution techniques have recently been developed to accurately and efficiently numerically model vesicle flow. The introduction of a periodic confining geometry adds further complications to such simulation. This talk presents a new integral formulation which avoids the use of the periodic Green’s function. Additionally, a fast direct solver for the discretized confining geometry is presented. This solver allows for efficient time stepping by decoupling the static geometry from the moving vesicles.

Some Accelerated Solvers for the Eigenvalue and SVD Problems
Li, Shengguo National Univ. of Defense Technologt

Abstract: In this report, we present some accelerated eigenvalue and SVD solvers by using the hierarchically semiseparable (HSS) matrix techniques. We mainly exploit the off-diagonal low-rank property of some intermediate matrices. By comparing with some highly optimized packages such as Intel MKL, our proposed algorithms can be faster in both serial and parallel cases. We will present some numerical results to show that.

Orthogonal Polynomials, Special Functions, and their Applications - Part I of III
For Part 2, see MS-Fr-D-12
For Part 3, see MS-Fr-E-12

Organizer: Qiu, Weiyuan Fudan Univ.
Organizer: Wong, Roderick City Univ. of Hong Kong
Organizer: Zhang, Lun Fudan Univ.
Organizer: Zhao, Yiqiu Sun Yat-sen Univ.

Abstract: Special functions and orthogonal polynomials is a very classical subject with numerous applications in both pure and applied mathematics. Tremendous progresses in this area have been achieved recently and new connections with other research areas such as random matrices, Riemann-Hilbert problems, etc. have been found. It is the aim of this minisymposium to provide a forum for researchers with diverse backgrounds whose research interests overlap with special functions and orthogonal polynomials. The speakers will report the latest developments in these areas, exchange their expertise, experience and insights. We hope this minisymposium will strengthen the connections among people in the relevant areas and stimulate future research.

Complex Singularities of Ordinary Differential Equations
Huang, Min City Univ. of Hong Kong
Zhang, Lun Fudan Univ.

Abstract: Global singular behavior of solutions to ODEs in the complex plane is an important and challenging topic in both theory and applications. We introduce a new constructive method of studying global behavior and singularities of complex ODEs, based on generalized asymptotic formulas with rigorous error estimates. We prove special cases of a conjecture concerning pole distributions of Painlevé transcendents proposed by Novokshenov, namely tritronquees to PI and the Hastings-McLeod solution to PII.

Asymptotic Analysis of Associated Orthogonal Polynomials via Three-term Recurrence Relations
Wang, Xiang-Sheng Southeast Missouri State Univ.

Abstract: We study a group of orthogonal polynomials satisfying certain three-
term recurrence relations with coefficients being linear or quadratic in the polynomial degree. Plancherel-Rotach type asymptotic formulas of the orthogonal polynomials as the polynomial degree tends to infinity are obtained by successive approximation and matching principle. Applications are given to asymptotic analysis of associated orthogonal polynomials.

**MS-Th-E-12-3 17:00–17:30**

Semi-classical Orthogonal Polynomials and the Painleve Equations

Clarkson, Peter

Univ. of Kent

Abstract: In this talk I shall discuss semi-classical orthogonal polynomials arising from perturbations of classical weights. It is shown that the coefficients of the three-term recurrence relation satisfied by the polynomials can be expressed in terms of Wronskians which involve special functions. These Wronskians are related to special function solutions of the Painleve equations. Using this relationship recurrence relation coefficients can be explicitly written in terms of exact solutions of Painleve equations.

**MS-Th-E-13 16:00–18:30**

Progress in hyperbolic problems and applications - Part IV of VI

For Part 1, see MS-We-E-13
For Part 2, see MS-Th-BC-13
For Part 3, see MS-Th-D-13
For Part 5, see MS-Fr-D-13
For Part 6, see MS-Th-E-13

Organizer: Wang, Ying

Univ. of Oklahoma

Organizer: Tesdall, Allen

City Univ. of New York, College of Staten Island

Abstract: Hyperbolic conservation laws form the basis for the mathematical modeling of many physical systems, and describe a wide range of wave propagation and fluid flow phenomena, including shock waves in nonlinear situations. For one dimensional systems with small data, a well-posedness theory of entropy weak solutions is well known. Analysis in several space dimensions, however, remains an enormous challenge. In this minisymposium, recent results in the theory and numerical analysis of hyperbolic problems will be presented. A variety of computational techniques, including finite volume, finite element, spectral, WENO, and discontinuous Galerkin methods, will be represented.

**MS-Th-E-13-1 16:00–16:30**

A Fully Conservative Discontinuous Galerkin Method for Third-order Linear Equations in One Dimension

Dong, Bo

Univ. of Massachusetts Dartmouth

Abstract: We introduce a Bassi-Rebay type discontinuous Galerkin (DG) method for both stationary and time-dependent third-order linear equations. This method is the first DG method which conserves the mass and the L2-, H1-, and H2-norms of the solution. We prove that projections of the errors are superconvergent when the polynomial degree k is even, and converge sub-optimally, but sharply, with order k when it is odd. (Joint work with Yanlai Chen and Bernardo Cockburn.)

**MS-Th-E-13-2 16:30–17:00**

Lax-Friedrichs Multigrid Fast Sweeping Methods for Steady State Problems for Hyperbolic Conservation Laws

Chen, Weitao

Univ. of California, Irvine

Kao, Chiu-Yen

Claremont McKenna College

Chou, Ching-Shan

The Ohio State Univ.

Abstract: We propose Lax-Friedrichs fast sweeping multigrid methods which allow efficient calculations of viscosity solutions of stationary hyperbolic problems. Due to the choice of Lax-Friedrichs numerical fluxes, general problems can be solved without difficulty. In high order discretization can be incorporated to achieve high order accuracy. In addition, we use multigrid methods coupled with biased WENO interpolation to speed up the computation by smoothing errors of low frequencies on coarse meshes.

**MS-Th-E-13-3 17:00–17:30**

Linear and Nonlinear Waves in Multidimensional Gas Dynamics Equations

Keyfitz, Barbara

The Ohio State Univ.

Abstract: As the community of analysts studying hyperbolic conservation laws continues to make progress on multidimensional problems, largely through the study of self-similar solutions to shock reflection phenomena, one difficulty that emerges is the interaction of nonlinear waves (such as acoustic waves in compressible flow) and linear waves (shear or entropy waves, for example). In recent work with Katarina Jegdic, Suncica Canic and Hao Ying, we have developed an approach that solves a small, local problem.

**MS-Th-E-13-4 17:30–18:00**

Low Order Polynomial Method Versus Multi-resolution Analysis for Detecting Shocks for WENO Methods

Guo, Jingyang

SUNY at Buffalo

Jung, Jae-Hun

SUNY at Buffalo

Abstract: We present the RBF WENO finite difference methods, which is based on our adaptive RBF-WENO finite volume methods. The polynomial basis is replaced with the radial basis functions. For the nonsmoothness region, the low order monotone polynomial method is used. For the hybrid method, we will explain how the low order method is enough to be used for WENO calculation and compare the results by the multi-resolution analysis popularly used for the hybrid method.

**MS-Th-E-13-5 17:00–17:30**

Optimal Energy Conserving Local Discontinuous Galerkin Methods for Second-order Wave Equation in Heterogeneous Media

Chou, Ching-Shan

The Ohio State Univ.

Shu, Chi-Wang

Brown Univ.

Xing, Yulong

Oak Ridge National Laboratory & Univ. of Tennessee

Abstract: Solving wave propagation problems within heterogeneous media has been of great interest and has a wide range of applications in physics and engineering. The design of numerical methods for such general wave propagation problems is challenging because the energy conserving property has to be incorporated to minimize the phase error after long time integration. In this talk, we will present an LDG method for multi-dimensional wave problems in heterogeneous media.

**MS-Th-E-14 16:00–18:00**

Effective dynamics of stochastic partial differential equations - Part I of III

For Part 2, see MS-Fr-D-14
For Part 3, see MS-Th-E-14

Organizer: Wang, Wei

Nanjing Univ.

Organizer: Gao, Hongjun

Nanjing Normal Univ.

Abstract: Stochastic partial differential equations (SPDEs) are appropriate mathematical models for many multiscale systems with uncertain and fluctuating influences. A complex system often contains different scales both in time and space, which make numerical simulation difficult, so effective and simplified system, governing the evolution of the system over long time scale, is desirable. The simplified system provide an effective model to be applied to simulate the complex system. This minisymposium aim to present new methods and results on the effective description complex system and application in science and engineering.

**MS-Th-E-14-1 16:00–16:30**

Impacts of Noise on A Class of Partial Differential Equations

Lu, Guangying

Henan Univ.

Abstract: This paper is concerned with effects of noise on the solutions of partial differential equations. We first provide a sufficient condition to ensure the existence of a unique positive solution for a class of stochastic partial differential equations. Then, we prove that noise could induce singularities (finite time blow up of solutions). Finally, we show that a stochastic Allen-Cahn equation does not have finite time singularities and the unique solution exists globally.

**MS-Th-E-14-2 16:30–17:00**

Large Deviations for An Stochastic Integrable Equation Governing Short-waves in A Long-wave Model

Chen, Yong

Zhejiang Sci-Tech Univ.

Gao, Hongjun

Nanjing Normal Univ.

Abstract: This paper is concerned with an stochastic integrable equation governing short-waves in a long-wave model. Firstly, the local well-posedness for this system is established by fixed point argument and (bilinear) trilinear estimates. Then the small noise large deviation principle is proved by the weak convergence approach. Some analogous results are also obtained for the small time asymptotics of the system.

**MS-Th-E-14-3 17:00–17:30**

Random Perturbations of Reaction-diffusion Waves in Biology

Tang, Yanbin

Huazhong Univ. of Sci. & Tech.

Abstract: This talk considers the statistical properties of the traveling wave fronts of the scalar Fitzhugh-Nagumo equation with random perturbations by two-parameter white noise on the whole real line, where the traveling wave front connects two stable equilibria. As well as the method of Green's function, we get the asymptotic fluctuations behavior of two stable states which are two boundaries of the traveling wave front to the Nagumo equation by the fundamental solution.

**MS-Th-E-14-4 17:30–18:00**

Dynamics for A Stochastic Reaction-diffusion Equation with Additive Noise

Clarkson, Peter

Univ. of Kent

Chou, Ching-Shan

The Ohio State Univ.

Kao, Chiu-Yen

Clarmeont McKenna College

Tang, Yanbin

Huazhong Univ. of Sci. & Tech.

Abstract: This talk considers the statistical properties of the traveling wave fronts of the scalar Fitzhugh-Nagumo equation with random perturbations by two-parameter white noise on the whole real line, where the traveling wave front connects two stable equilibria. As well as the method of Green's function, we get the asymptotic fluctuations behavior of two stable states which are two boundaries of the traveling wave front to the Nagumo equation by the fundamental solution.
In this talk, we present a new scheme of investigating some interesting problems about the dynamics of SPDE. In order to present our idea clearly, we consider a stochastic reaction-diffusion equation with the nonlinearity which satisfies a dissipative condition with polynomial growth of arbitrary order $p \geq 2$. This model is one of the basic models for rising and developing the notation, theory and method about dynamics. Joint work with Daomin Cao and Chunyou Sun.

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**MS-Th-E-15**

16:00–18:00

PDEs and applications: theory and computation - Part II of IV

For Part 1, see MS-Th-D-15
For Part 3, see MS-Fr-D-15
For Part 4, see MS-Fr-E-15

Organizer: Wang, Ying
Univ. of Oklahoma

Organizer: Nie, Hua
Shanxi Normal Univ.

**Abstract:**

Partial differential equations (PDEs) have been widely used in the mathematical modeling of physical and biological phenomena, including mixed type equations. Many problems of an applied nature reduce to finding specific solutions and properties of PDEs of elliptic, parabolic, or of mixed type; in particular, problems of plane transonic flow of a compressible medium, and problems in the theory of envelopes. In this mini-symposium, recent results in the theory and computation of PDEs and their applications will be presented. The goal of this mini-symposium is to provide a platform for the world experts in the area of PDEs, both theory and computation, to report the recent progresses, exchange ideas and build up collaborative works. We anticipate that our speakers will have expertise in a wide-ranging array of topics, possibly including: (i) qualitative and quantitative properties enjoyed by solutions to nonlinear partial differential equations of elliptic, parabolic, or of mixed type. (ii) numerical schemes derived for various types of PDEs. (iii) physical and biological modeling involving nonlinear partial differential equations of elliptic, parabolic, or of mixed type.

**MS-Th-E-15-1**

16:00–16:30

**Longtime Dynamics of the Quasi-linear Strongly Damped Wave Equation**

Yang, Zhijian
Zhengzhou Univ.

**Abstract:**

In this talk, we are concerned with the longtime dynamics of the quasilinear strongly damped wave equations. We present a new method to establish the global attractor and exponential attractor in natural phase space endowed with strong topology (rather than the weaker one as is done before) in the case of the supercritical nonlinearities.

**MS-Th-E-15-2**

16:30–17:00

**Approximate Solutions to the Korteweg-de Vries-Burgers Equation**

Feng, Zhaosheng
Univ. of Texas-Pan American

**Abstract:**

In this talk, we provide a connection between the Abel equation of the first kind, an ordinary differential equation that is cubic in the unknown function, and the Korteweg-de Vries-Burgers equation, a partial differential equation that describes the propagation of waves on liquid-filled elastic tubes. We present an integral form of the Abel equation with the initial condition. By virtue of the integral form and the Banach Contraction Mapping Principle, we derive the asymptotic expansion of bounded solutions in the Banach space, and use the asymptotic formula to construct approximate solutions to the Korteweg-de Vries-Burgers equation.

**MS-Th-E-15-3**

17:00–17:30

**The Spline Finite Element Method for Solving the Thin Plate Bending Problem**

Chen, Juan
Dongbei Univ. of Finance & Economics

Li, Chong-Jun
Dalian Univ. of Tech.

**Abstract:**

The FEM is a important method for solving PDEs. There are some difficulties involved in obtaining conforming displacement models for the thin plate bending problem. In this paper, we reconstruct two conforming quadrilateral thin plate elements by using the cubic spline Hermite interpolation bases defined on the quadrilateral elements. They both have good accuracy for plane problems and are less insensitive to mesh distortions than the well-known DQK element.

**MS-Th-E-15-4**

17:30–18:00

**Quasilinear Elliptic Equations on Convex Domains**

JIA, HUILIAN
Xi’an Jiaotong Univ.

**Abstract:**

In this talk, we want to discuss the global regularity for $p$-Laplacian type elliptic equations on convex domains with very rough boundary data. The maximal function, Vitali covering lemma and approximation (or compactness method) are the main techniques. To derive the approximation lemma, we need Lipschitz estimates for the corresponding homogeneous equations, where the convexity of the domain plays an important role. This is a joint work with prof. Lihe Wang.

**MS-Th-E-16**

16:00–18:00

System of Conservation Laws and Related Models - Part II of IV

For Part 1, see MS-Th-D-16
For Part 3, see MS-Fr-D-16
For Part 4, see MS-Fr-E-16

Organizer: Li, Yachun
Shanghai Jiao Tong Univ.

Organizer: Wang, Weike
Shanghai Jiao Tong Univ.

Organizer: Wang, Yaguang
Shanghai Jiaotong Univ.

Organizer: Xie, Chunji
Shanghai Jiao Tong University

**Abstract:**

This mini-symposium focuses on the analysis for system of conservation laws and related models. It covers the following topics: 1. Multidimensional conservation laws and transonic flows; 2. Compressible Navier-Stokes system and singular limits for fluid dynamics; 3. Free boundary problems arising in fluid mechanics and related models.

**MS-Th-E-16-1**

16:00–16:30

**Global Behavior of Large Solutions of Compressible Viscous and Heat Conductive Fluids**

Pan, Ronghua
Georgia Inst. of Tech.

**Abstract:**

In this talk, we report some recent progress on the global existence and large time behavior for compressible Navier-Stokes-Fourier system with temperature-dependent viscosity and/or heat conductivity coefficients with large initial data. The talk is based on joint works with W. Zhang, X. Qin, and Z. Yao.

**MS-Th-E-16-2**

16:30–17:00

**Transonic Problems for the Euler System of Equations in Two Space Dimensions**

Zeng, Xiu
The Pennsylvania State Univ.

**Abstract:**

We build smooth solutions at a given smooth sonic curve for the compressible Euler system of equations in two space dimensions for both time-dependent and steady cases. We try to reduce the regularity requirements on the solutions so as to match the general sense of weak solutions for hyperbolic conservation laws. For self-similar solutions, our efforts illustrate various structures of solutions to the two-dimensional Riemann problems. Talk is based on recent work with Tianyou Zhang.

**MS-Th-E-16-3**

17:00–17:30

**Global Weak Solutions to A Cahn-Hilliard-Stokes-Darcy System For Two Phase Incompressible Flows in Karstic Geometry**

Wu, Hao
Fudan Univ.

**Abstract:**

We will present our recent results on a Cahn-Hilliard-Stokes-Darcy system which is a diffuse-interface model for immiscible two phase incompressible flows with matched density in a karstic geometry. Existence of finite energy weak solution that is global in time is established in both 2D and 3D. Weak-strong uniqueness property of the weak solutions is provided as well. This is a joint work with Prof. Xiaoming Wang and Dr. Daozhi Han.

**MS-Th-E-16-4**

17:30–18:00

**Rigorous Compressible to Incompressible Limit in 1D**

Colombo, Rinaldo M.
Univ. of Brescia

**Abstract:**

Consider 2 inviscid, immiscible, compressible and isentropic fluids in 1 space dimension. We consider the limit in which one of the fluids becomes incompressible. For data with small total variation, we prove the rigorous convergence of compressible equations and solutions to their incompressible counterpart.

**MS-Th-E-17**

16:00–18:00

Singular limits in mathematical physics - Part IV of V

For Part 1, see MS-We-E-17
For Part 2, see MS-Th-B-17
For Part 3, see MS-Th-D-17
For Part 4, see MS-Fr-D-17

Organizer: Cheng, Bin
Univ. of Surrey

Organizer: Secchi, Paolo
Univ. of Brescia

Organizer: Ju, Qiangchang
Inst. of Applied Physics & Computational Mathematics (IAPCM)

Organizer: Jiang, Ning
Tsinghua Univ., Beijing

**Abstract:**

This minisymposium will address recent advances in analytical and numerical studies of singular limits of multiscale physical models as certain parameters approach zero or infinity. It shall cover such areas as incompressible and fast rotating limits in fluid dynamics, hydrostatic limits of complex fluid and kinetic models, and relaxations. The singular nature of these models makes it challenging to rigorously justify and quantify their limits and to...
numerically simulate them in a way consistent with theory. Novel techniques and results in partial differential equations, stochastic differential equations and numerical analysis will be discussed.

**MS-Th-E-17-1**

*Stochastic 3D Rotating Navier-Stokes Equations: Averaging, Convergence and Regularity*

Mahalov, Alex  
Arizona State Univ.

Abstract: Regularity results are established by bootstrapping from global regularity of the limit stochastic equations and convergence theorems. The energy injected into the system by the noise is large, the initial condition has large energy, and the regularization time horizon is long. Regularization is the consequence of a precise mechanism of relevant three-dimensional nonlinear interactions and the averaged covariance operator for the stochastic dynamics.  

**MS-Th-E-17-2**

*Meso-scale Weakly Compressible Atmospheric Flow: A Three Time Scale Asymptotic Problem*

Klein, Rupert  
Freie Universität Berlin

Abstract: "Sound-proof models" are the atmospheric analogue of the classical incompressible flow equations. Their mathematical justification is non-trivial because they result from the full compressible flow equations by elimination of only one of three asymptotically separated scales. As a consequence, the sound-proof equations still constitute an asymptotic two-scale system rather than a limit system that is free of the singular parameter. I will report on recent efforts towards a rigorous justification that circumvents these issues.

**MS-Th-E-17-3**

*Time-averaging and Error Estimates for Reduced Fluid Models*

Cheng, Bin  
Univ. of Surrey

Abstract: I will discuss the application of time-averaging in getting rigorous error estimates of some reduced fluid models, including the incompressible approximation and quasi-geostrophic approximation. The spatial boundary can be present as a non-penetrable solid wall. I will show a very recent (and somewhat surprising) result on the $r^2$ accuracy of incompressible approximation of Euler equations, thanks to several decoupling properties.

**MS-Th-E-17-4**

*Backward Behavior of Dissipative Evolution Equations*

Guo, Yanqi  
Weizmann Inst. of Sci.

Abstract: In this talk, I will discuss the backward-in-time behaviors of several dissipative evolution equations. This study is motivated by investigating the Bardos-Tartar conjecture on the 2D Navier-Stokes equations. Besides the rigorous mathematical treatment, we provide physical interpretation of the mechanism of singularity formulation, backward in time, for perturbations of the KdV equation. Finally, I present the connection between the backward behavior and the energy spectra of the solutions. This is a joint work with E.S.Titi.

**Schedules: Thursday Sessions**

**MS-Th-E-18-2**

*Approximate Cloaking via Change of Variables*

Nguyen, Hoai-Minh  
École Polytechnique Fédérale de Lausanne EPFL

Abstract: Cloaking using transformation optics was suggested by Pendry et al. and Leonhardt. A similar scheme was previously used by Greenleaf et al. for electrical impedance tomography. In this talk, I discuss approximate cloaking using transformation optics. Emphasis is on the occurence of the resonance and the cloaking on the time domain. The approximate scheme considered is due to Kohn et al.

**MS-Th-E-18-3**

*Vertical Mode Expansion Method for Electromagnetic Scattering Problems*

Lu, Ya Yan  
City Univ. of Hong Kong

Abstract: In many applications, it is necessary to solve the 3D Maxwell's equations for scattering problems where the scatter is a layered cylindrical object in a layered background. The vertical mode expansion method (VMEM) is a recently developed method that expands the field in 1D modes with "coefficients" satisfying 2D Helmholtz equations, and finds the solution by matching field components along the boundaries of different layered regions. We present the VMEM with applications in plasmonics.

**MS-Th-E-18-4**

*Spectral Theory in the Absence of Ellipticity for High Contrast Photonic Crystals*

Lipton, Robert  
LSU

Viator, Robert  
Louisiana State Univ.

Abstract: Photonic crystals employ high contrast media for controlling light. Here we identify an underlying quasiperiodic resonance spectra and use it to represent solution operators associated with the Maxwell system for high contrast photonic crystals. We develop representation formulas for the resolvent for selfadjoint holomorphic families of operators. This technique is applied to compute and to design dispersion characteristics for photonic crystals. Computational examples of this approach are provided to illustrate the ideas.

**MS-Th-E-19**

*Women in Applied Mathematics: Recent Advances in Modeling, Numerical Algorithms, and Applications - Part IV of IV*

Career Panel Session

For Part 1, see MS-We-E-19  
For Part 2, see MS-Th-BC-19  
For Part 3, see MS-Th-D-19

Organizer: Li, Fengyan  
Rensselaer Polytechnic Inst.

Organizer: Cheng, Juan  
Inst. of Applied Physics & Computational Mathematics

Abstract: This mini-symposium aims at bringing women mathematicians to share recent progress and to inspire new ideas in applied mathematics. Talks may address modeling, theoretical and computational aspects of numerical methods, as well as various applications arising from biomedical problems, fluid dynamics, electromagnetism, rarefied gas dynamics, and constrained optimal control problems etc. Besides the scientific aspects, the fourth part of this mini-symposium is a career panel session, which is to create a platform for women mathematicians at different stages with different career paths to network, to exchange experiences and advises in career advancement, and to discuss challenges and strategies for a successful career.

**MS-Th-E-19-1**

*Discovering Partial Differential Equations*

Keyfitz, Barbara  
The Ohio State Univ.

Abstract: I don't see how one can become a mathematician without being motivated by the excitement of a problem, or of an entire field. In my case, the field was PDE, and the problem was the nature of wave propagation in nonlinear media. The obstacles to having a career fade when one has a goal. Contributing through service repays, for me, the ability to work, throughout my career, on the problems that I still find exciting.
Abstract: In this talk, I will talk about my experience on building international cooperation networks with many mathematicians from different countries.

**MS-Th-E-19-3**

**Applying in the UK and Surroundings**

Ryan, Jennifer  
Univ. of East Anglia

Abstract: This portion of the panel will present information regarding the differences in the application and interview process for jobs in the US and the UK.

**MS-Th-E-19-4**

**Recent Advances on Imaging Sciences**

Zhang, Xiaogun  
Shanghai Jiao Tong Univ.

Abstract: In this short talk, I will discuss some recent advances on imaging sciences from my prospective. I will also share my personal experience of development of an academic career in China and discuss challenges and strategies.

**MS-Th-E-19-5**

**Communication and Supporting Networks**

Liu, Fengyuan  
Rensselaer Polytechnic Inst.

Abstract: I would like to share some aspects from my own academic experiences, such as holding positive attitudes, the importance of communication and building supporting networks.

**MS-Th-E-20**

**Computational Inverse Problems - Part II of IV**

Organizer: Jin, Bangti  
Univ. College London

Organizer: Lu, Xiliang  
Wuhan Univ.

Abstract: Inverse problems arise in a wide variety of applications, e.g., medical imaging, tomography, anomalous diffusion and compressed sensing. Their efficient and stable numerical solution is however very challenging due to the ill-posed nature of inverse problems. There have been significant progress in recent years, in novel application, new mathematical techniques and efficient optimization algorithms. In this mini-symposium, we aim to present and discuss recent advances in the area.

**MS-Th-E-20-1**

**Inverse Transport Problems with Internal Data and Applications**

Ren, Kui  
Univ. of Texas at Austin

Abstract: We consider here some inverse coefficient problems for the transport equation with multiple internal data sets. Such problems find applications in recent hybrid imaging modalities such as (fluorescence) photoacoustic tomography. We will discuss some theoretical results on the uniqueness and stability of the inverse problems and propose some efficient reconstruction strategies which we demonstrate with numerical simulations.

**MS-Th-E-20-2**

**Recovery by a Single Far-field Measurements**

Liu, Hongyu  
Hong Kong Baptist University

Abstract: In this talk, the speaker will present several inverse scattering schemes of recovering inhomogeneous scatterers by a single acoustic or electromagnetic far-field measurement. The proposed schemes work for very general and practical scenarios. They are classified according to whether the frequency of the detecting plane wave is from the low-frequency, resonant-frequency, or high-frequency regimes.

**MS-Th-E-20-3**

**Case Studies for Two Classical Inverse Problems for Fractional Derivatives.**

Rundell, William  
Texas A&M Univ.

Jin, Bangti  
Univ. College London

Abstract: Two classical inverse problems that exhibit extreme ill-conditioning are the backwards heat problem and the sideways heat problem. This talk looks at these when the heat operator is changed to one involving fractional derivatives. In both cases one obtains results quite counter to the classical situation.

**MS-Th-E-20-4**

**Cine Cone Beam CT Reconstruction Using Low-rank Matrix Factorization**

Zhao, Hongkai  
UC Irvine

Abstract: Respiration-correlated CBCT, commonly called 4DCBCT, provide respiratory phase-resolved CBCT images. In many clinical applications, it is more preferable to reconstruct true 4DCBCT with the 4th dimension being time, i.e., each CBCT image is reconstructed based on the corresponding instantaneous projection. We propose in this paper a novel algorithm for the reconstruction of this truly time-resolved CBCT, called cine-CBCT, by effectively utilizing the underlying temporal coherence, such as periodicity or repetition, in those cine-CBCT images.
tion. In particular, we can not well separate the stiff and non-stiff components for these problems, which makes the traditional implicit-explicit methods nearly meaningless. We couple the semi-implicit method with LDG method to obtain high order accuracy both in space and time.

Recent development and applications of weighted essential non-oscillatory methods - Part III of V
For Part 1, see MS-Th-BC-22
For Part 2, see MS-Th-D-22
For Part 3, see MS-Fr-D-22
For Part 4, see MS-Fr-E-22

Organizer: Qiu, Jianxian Xiamen Univ.
Organizer: Shu, Chi-Wang Brown Univ.

Abstract: The spectrum covered by the minisymposium ranges from recent development, analysis, implementation and applications, for the weighted essential non-oscillatory (WENO) methods. The WENO methods provide a practical effective framework to solve out many nonlinear wave-dominated problems with discontinuities or sharp gradient regions, which play an important role arising in many applications of computational fluid dynamics, computational astrophysics, computational plasma physics, semiconductor device simulations, among others. Devising robust, accurate and efficient WENO methods for solving these problems is of considerable importance and, as expected, has attracted the interest of many researchers and practitioners. This minisymposium serves as a good forum for researchers to exchange ideas and to promote this active and important research direction.

MS-Th-E-22-1 16:00–18:00 206A
Multidimensional, Self-similar, strongly-Interacting, Consistent (MuSIC) Riemann Solvers – Applications to Divergence-Free MHD and ALE Schemes
Balsara, Dinshaw Univ. of Notre Dame

Abstract: The majority of Riemann solvers are still one-dimensional. The present talk describes the design of multidimensional Riemann solvers and their applicability to higher order schemes. Such multidimensional Riemann solvers act at the vertices of the mesh, where the multidimensional flow structure becomes visible to the Riemann solver. At any vertex, all the adja-
cent one-dimensional Riemann problems interact to form a strongly interacting state. The strongly interacting state evolves self-similarly and we find its structure.

MS-Th-E-22-2 16:30–17:00
An Eulerian-Lagrangian WENO Scheme for Nonlinear Conservation Laws
Huang, Chieh-Sen National Sun Yat-sen Univ.

Abstract: We develop a formally high order Eulerian-Lagrangian WENO finite volume scheme for nonlinear scalar conservation laws that combines ideas of Lagrangian traceline methods with WENO reconstructions. The particles within a grid element are transported in the manner of a standard Eulerian-Lagrangian (or semi-Lagrangian) scheme using a fixed velocity v. A flux correction computation accounts for particles that cross the v-traceline during the time step. If v=0, the scheme reduces to an almost standard WENO5 scheme.

High Order Multi-dimensional Semi-Lagrangian Finite Difference WENO Approaches for Incompressible Euler Equations
Xiong, Tao Univ. of Houston

Abstract: Many existing grid-based semi-Lagrangian approach are based on one-dimensional splitting, which is subject to splitting errors. We will propose a multi-dimensional strategy of tracing characteristics without splitting. It is high order in time via a prediction-correction approach. WENO interpolation is then used to recover function values with accurately located foot of characteristics between grid points. The algorithm does not have time step restrictions. The application to incompressible Euler equations will demonstrate its good performance.

A Direct Arbitrary-Lagrangian-Eulerian ADER-WENO Finite Volume Scheme on Unstructured Tetrahedral Meshes for Conservative and Nonconservative Hyperbolic Systems in 3D
Boscheri, Walter Univ. of Trento

Abstract: We present a new family of high order accurate Arbitrary-Lagrangian-Eulerian (ALE) one-step ADER-WENO finite volume schemes for the solution of nonlinear systems of conservative and non-conservative hyperbolic partial differential equations with stiff source terms on moving tetrahedral meshes in three space dimensions. We consider the 3D Euler equations of compressible gas dynamics, the equations of classical ideal magnetohydrodynamics (MHD) as well as the non-conservative seven-equation Baer-Nunziato model with stiff relaxation source terms.

Computational Methods of PDE-based Eigenvalue Problems and Applications in Nanosstructure Simulations - Part II of IV
For Part 1, see MS-Th-D-23
For Part 3, see MS-Fr-D-23
For Part 4, see MS-Fr-E-23

Organizer: Bai, Zhaojun Univ. of California, Davis
Organizer: Yang, Chao Lawrence Berkeley National Laboratory
Organizer: Zhou, Aihui Acad. of Mathematics & Sy., Chines, Chinese Acad. of Sci.

Abstract: PDE based eigenvalue problems arise from electronic structure calculations, band structure calculations in photonic crystals and dynamics of electromagnetic fields. This minisymposium brings together researchers working on PDE-based eigenvalue problems from areas of mathematical modeling and analysis, numerical analysis, high-performance computing and applications. This minisymposium features the latest progress on developing adaptive discretizations, stable nonlinear iterations and fast algebraic solvers, code designing and high performance computing on modern computer systems.

MS-Th-E-23-1 16:00–16:30
A Tucker-tensor Approach for Kohn-Sham Density Functional Theory Calculations.
Motamarri, Phani Univ. of Michigan Ann Arbor
Gavini, Vikram Univ. of Michigan

Abstract: In this talk, we describe a systematic way of computing a globallyadapted Tucker-type basis for solving the Kohn-Sham DFT eigenvalue problem, by using a separable approximation of the Kohn-Sham Hamiltonian. The rank of the Tucker representation and the computational complexity of the resulting self-consistent DFT calculations using these Tucker basis are examined on representative benchmark examples involving metallic and insulating systems.

MS-Th-E-23-2 16:30–17:00
A Mixed FEM for the Quad-curl Eigenvalue Problem
Sun, Jiguang Michigan Technological Univ.

Abstract: We present the first systematic work for deriving a posteriori error estimates for general non-polynomial basis functions in an interior penalty discontinuous Galerkin (DG) formulation. The main merit of our residual type upper and lower bound error estimates is that the method is almost parameter-free, in the sense that all but one solution-dependent constants are explicitly computable. We develop an efficient numerical procedure to compute the error estimators. (Joint work with Benjamin Stamm)

MS-Th-E-23-3 17:00–17:30
A Posteriori Error Estimates for Discontinuous Galerkin Methods Using Non-polynomial Basis Functions
Lin, Lin Univ. of California at Berkeley

Abstract: We present the first systematic work for deriving a posteriori error estimates for general non-polynomial basis functions in an interior penalty discontinuous Galerkin (DG) formulation. The main merit of our residual upper and lower bound error estimates is that the method is almost parameter-free, in the sense that all but one solution-dependent constants are explicitly computable. We develop an efficient numerical procedure to compute the error estimators. (Joint work with Benjamin Stamm)

Linear Response Eigenvalue Problem Solved by Extended Locally Optimal Preconditioned Conjugate Gradient Methods
Li, Ren-Cang Univ. of Texas at Arlington

Abstract: A deflation technique is a way to remove already known eigenvalues/eigenpairs from possibly being computed again. It is critical for any efficient eigensolver. In this talk, we will investigate a couple of deflation techniques for the linear response eigenvalue problem. We will also discuss an extended locally optimal preconditioned conjugate gradient method and present numerical examples to demonstrate the efficiency of both the deflation techniques and the conjugate gradient type methods.
Computational Electromagnetism and Its Engineering Applications - Part II of IV

For Part 1, see MS-Th-D-25
For Part 3, see MS-Fr-D-25
For Part 4, see MS-Fr-E-25

Organizer: Duan, Huoyuan Collaborative Innovation Centre of Mathematics, School of Mathematics & Statistics, Wuhan Univ., Wuhan 430072, China

Organizer: Zheng, Weiying Chinese Acad. of Sci.

Abstract: In recent years, there arises a surge of numerical studies for electromagnetic problems in complex engineering systems, such as large power transformers, electrical machinery, magnetic fusion, etc. The mathematical models turn out to be nonlinear, multiscale, strongly singular, and coupled with multiple physical fields. It brings new challenges to researchers from both mathematical and engineering communities in developing practical mathematical models and effective and efficient numerical methods and solvers. This mini-symposium seeks to bring together researchers in both computational mathematics and electromagnetic engineering that involve the mathematical modeling, analysis, computation, and experimental validation for electromagnetic problems. The main theme will be focused on new efficient numerical methods and fast solvers for Maxwell’s equations and magnetohydrodynamic equations and will address their extensive applications to engineering problems. It will promote exchange of ideas and recent developments on mathematical modeling, numerical discretization, solvers and engineering practices of computational electromagnetism.

MS-Th-E-24-1 16:00–16:30
Gyrokinetic Simulation of Micromagnetism in Tokamaks
Xiao, Yong IFTS, Zhejiang Univ.

Abstract: The newly-developed capabilities enable the gyrokinetic code GTC to simulate the turbulent transport for real tokamak plasma shape and profiles. Linear and nonlinear simulations are carried out with the new capabilities in GTC for recent EAST and HL-2A tokamak experiments. We found that in the pedestal region with strong electron temperature gradient, the unstable waves propagate in the electron diamagnetic direction, showing a trapped electron mode (TEM) feature.

MS-Th-E-24-2 16:30–17:00
Parallel PIC Simulation Based on Fast Electromagnetic Field Solver
Cui, Tao ICMSEC, AMSS, CAS
Zheng, Weiying Chinese Acad. of Sci.
Lin, Deng The Inst. of Computational Mathematics & Scientific/engineering Computing

Abstract: In this talk, a parallel symplectic PIC program for solving non-relativistic Vlasov-Maxwell system on unstructured grids for realistic applications will be introduced. The implicit scheme is used in our code. We solve Maxwell equations on tetrahedral mesh by finite element method. An efficient and scalable parallel algebraic solver is used for solving the discrete system. Numerical results will be given to show that our method and parallel program is robust and scalable.

MS-Th-E-24-3 17:00–17:30
Seamless Integration of Global DNI Nonreflecting Boundary Conditions in Spectral Elements for Invisibility Cloak Simulations
Wang, Li-Lian Nanyang Technological Univ.
Yang, Zhiguo Nanyang Technological Univ.

Abstract: In this talk, we shall present efficient and accurate semi-analytic techniques for seamless integration of global Drichlet-to-Neumann (DNI) boundary conditions with local spectral elements, and discuss the applications in invisibility cloak simulations. We introduce special transformation between curved elements and the reference element, which lead to seamless coupling of local elements with DNI boundary conditions only on spectral-element grids.

MS-Th-E-24-4 17:30–18:00
Adaptive Finite Element Method for Incompressible Magnetohydrodynamics
Mao, Shipeng LSEC, Inst. of Computational Mathematics, AMSS, Chinese Acad. of Sci.

Abstract: We consider a mixed finite element method for the numerical discretization of a stationary incompressible magnetohydrodynamics problem in three dimensions with its velocity field is discretized using H1 conforming elements and the magnetic field is approximated by curl-conforming N1d/3 elements. Under the assumption that the original model has a unique solution pair, we derive a posteriori error estimates of the incompressible magnetohydrodynamic (MHD) equations with a sharp upper bound. Using these a posteriori error estimates, we construct an adaptive algorithm for computing the solution of 3D magnetohydrodynamics. Numerical experiments are carried out to show the performance of the adaptive finite element method.

MS-Th-E-25 16:00–18:00
Emerging PDEs: Analysis and Computation - Part II of IV

For Part 1, see MS-Th-D-25
For Part 3, see MS-Fr-D-25
For Part 4, see MS-Fr-E-25

Organizer: Chen, Zhiming AMSS, Chinese Acad. of Sci.
Organizer: Nochetto, Ricardo Univ. of Maryland
Organizer: Zhang, Chensong Acad. of mathematics & Sys. Sci.

Abstract: Novel models in science and engineering are governed by nonlinear integro-differential equations with increasing complexity which demand innovative techniques in both analysis and computation, such as adaptivity, fast methods and preconditioning, and structure preserving algorithms. Areas of special interest include complex fluids and new materials, electromagnetism and wave propagation, uncertainty quantification, and fractional PDEs, among others. This minisymposium intends to gather about 16 world experts and young researchers in analysis and computation of PDE to discuss the most recent progress in this exciting field as well as future directions for research.

MS-Th-E-25-1 16:00–16:30
Analysis of Upwinded Der Rham Sequences
Christiansen, Snorre Univ. of Oslo

Abstract: The author has recently introduced a method to modify the shape functions in mixed finite element methods, to treat vanishing viscosity problems such as those that appear in fluid mechanics, in a Petrov Galerkin setting. The method retains some of the good properties of Raviart-Thomas-Nedelec elements, such as the existence of commuting projections and is related to exponential fitting. The talk will present our latest results on the stability of the method.

MS-Th-E-25-2 16:30–17:00
 Blowup of 1D Models for 3D Incompressible Axisymmetric Euler Equations
Hou, Thomas Caltech

Abstract: Inspired by the recent computational of 3D Euler singularity, we investigate the self-similar singularity for a 1D model of the 3D axisymmetric Euler equations. This work is motivated by a particular singular formation scenario observed in numerical computation. We provide the existence of a discrete family of self-similar profiles for this model and analyze their far-field properties. The self-similar profiles we find agree with direct simulation of the model and seem to have some stability.

MS-Th-E-25-3 17:00–17:30
 Non-adaptive Quasi-optimal Points Selection for Least Squares Linear Regression
Shin, Yeonjong Xi, Dongbin Univ. of Utah

Abstract: We present a quasi-optimal sample set for ordinary least squares regression. The quasi-optimal set is designed in such a way that, for a given number of samples, it delivers the near optimal regression model. The quasi-optimal set is defined by maximization of a quantity measuring the mutual orthogonality and determinant of the model matrix. We present its theoretical justification, efficient implementation and demonstrate its efficiency via several numerical examples.

MS-Th-E-25-4 17:30–18:00
Space-time Adaptive Wavelet Methods for Evolutionary Problems
Stevenson, Rob Korteweg-de Vries (KdV) Inst. for Mathematics, Univ. of Amsterdam, P.O. Box 94248, 1090 GE Amsterdam, The Netherlands

Abstract: Adaptive wavelet methods solve (semi-) linear operator equations at optimal rates. With time evolutionary problems, the spaces can be equipped with products of temporal and spatial wavelet bases. Consequently, the evolutionary problem can be solved at a complexity of solving the stationary problem. In an adaptive wavelet scheme, the residual is used as an a posteriori error estimator. A reformulation as a system of first order enables a much more efficient approximate residual evaluation.

MS-Th-E-26 16:00–18:00
Disturbance rejection control: novel designs and performance analysis
Organizer: Xue, Wenchao Key Lab. of Sys. & control, Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: This session concerns with the novel design methods and theoreti-
MS-Th-E-26-1 16:00–16:30
**Predictive Disturbance Rejection Control Solution for Engine Waste Heat Recovery System**
Xie, Hui
Tianjin Univ.

Abstract: The energy management of engine waste heat recovery system is a complex problem characterized by great coupling, large inertia and uncertain delay. A commander-tracker energy management framework was proposed as the solution, in which a predictive disturbance rejection method was designed as a tracking controller to follow the power splitter’s command gotten online from the top level. The system performance was achieved by the combination of the dynamic system model and a predictive controller.

MS-Th-E-26-2 16:30–17:00
**Decentralized PID Controller Tuning Based on Desired Dynamic Equations**
Li, Donghai
Tsinghua Univ.

Abstract: We show the ability of the desired-dynamic-equations (DDE) based decentralized PID controller tuning method with its application to the ALSTOM gasifier benchmark control problem. The DDE-based PID controller tuning method was deduced from a kind of nonlinear adaptive controller, which behaves good tracking performance and robustness by using an extended state observer and DDE to estimate and compensate the uncertainty and disturbance. Moreover, the tunable parameters of DDE-based PID controller have explicit physical meanings.

CP-Th-E-26-3 17:00–17:20
**Extended State Observer Based Controller and Filter Designs for Nonlinear Uncertain Systems**
Xue, Wenchao
Key Lab. of Sys. & control, Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Bai, Wenyuan
Chinese Acad. of Sci.
Huang, Yi
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Fang, Haitao
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: The Extended State Observer (ESO), which is featured with timely convergences and L2 norm error estimate will also be discussed in the talk. Via performance analysis on both time-domain and frequency-domain, we will also discuss the open problems which will have huge impacts in developing the control theory of disturbance rejection.

CP-Th-E-26-4 17:20–17:40
**On Tuning of Linear Active Disturbance Rejection Control**
Sun, Mingwei
Zengqiang, Chen
Nankai Univ.

Abstract: Several tuning guidelines are provided for Linear Active Disturbance Rejection Control (LADRC). At first, the tuning rules are obtained to avoid overshoot for typical industrial processes. Secondly, the difficulty or impossibility of a general stability analysis is revealed. Finally the effects of the observer bandwidth on the closed-loop sensitivity to the input time-delay perturbation are thoroughly investigated from three aspects respectively to illustrate the inherent tradeoff between robust stability and dynamic performance when using LADRC.

MS-Th-E-27 16:00–18:00
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**Decoupling methods for multi-physics and multi-scale problems - Part VI of VIII**

For Part 1, see MS-Tu-E-27
For Part 2, see MS-We-D-27
For Part 3, see MS-We-E-27
For Part 4, see MS-Th-BC-27
For Part 5, see MS-Th-D-27
For Part 7, see MS-Fr-D-27
For Part 8, see MS-Fr-E-27

Organizer: He, Xiaoming
Missouri Univ. of Sci. & Tech.
Organizer: Xu, Xuejun
Inst. of Computational Mathematics, AMSS, CAS

Abstract: The inherent multi-physics and multi-scale features of many real world problems accentuate the importance to develop efficient and stable numerical methods for the relevant PDEs, especially the decoupling methods. Although great efforts have been made for solving these problems, many practical and analytical challenges remain to be solved. This mini-symposium intends to create a forum for junior and senior researchers from different fields to discuss recent advances on the decoupling methods for multi-physics and multi-scale problems with their applications.

CP-Th-E-27-1 16:00–16:30
**Mixed Finite Element Method for the Stefan Problem with Surface Tension**
Walker, Shawn
Louisiana State Univ.
Davis, Christopher
Tennessee Technological Univ.

Abstract: A mixed formulation is proposed for the Stefan problem with surface tension (Gibbs-Thomson law). The method uses a mixed form of the heat equation in the solid and liquid domains, and imposes the interface motion law (on the solid-liquid interface) as a constraint. Well-posedness of the time semi-discrete and fully discrete (finite element) formulations is proved in 3-D, and an a priori bound, conservation law, and error estimates. Simulations are presented in 2-D.

MS-Th-E-27-2 16:30–17:00
**A CVOD Based Low-dimensional Approximation to Nonlinear Stochastic Partial Differential Equations**
Ming, Ju
Beijing Computational Sci. Research Centre

Abstract: Over past decade, reduced-order models have been found increased use to greatly reduce the computational cost in the areas such as flow control and optimization. In this lecture, we will present an effective stochastic reduced-order modeling method that combines the advantages of proper orthogonal decomposition and centroidal Voronoi tessellations. The optimality of such hybrid model for model reduction is discussed and numerical tests are performed to validate our results.

CP-Th-E-27-3 17:00–17:30
**Recent Progress in Hybrid Discontinuous Galerkin Methods**
Park, Eun-Jae
Yonsei Univ.
Shin, Dong-wook
Yonsei Univ.
Jeon, Youngmok
Ajou Univ.

Abstract: Hybrid discontinuous Galerkin methods are studied for second-order elliptic equations. Our approach is composed of generating PDE-adapted local basis and solving a global matrix system arising from a flux continuity equation. Our method can be viewed as a hybridizable discontinuous Galerkin method using a Baumann-Oden type local solver. A priori and a posteriori error estimates are derived and applied to the Stokes equations and Convection-Diffusion equations are discussed. Several numerical results are presented.

CP-Th-E-27-4 17:30–18:00
**Some Recent Advances on the Theory of High Order Finite Volume Methods**
Zou, Qingsong
Sun Yat-sen Univ.

Abstract: In this talk, we will present some of our recent results on the theory of high order finite volume methods. We will first explain how to construct these schemes. Then we will prove that these schemes have the stability (inf-sup condition) and optimal convergence rates under H1 norm. The superconvergence and L2 norm error estimate will also be discussed in the talk.

MS-Th-E-28 16:00–18:00
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**Mathematical Theory of System and Control II: analysis and control of stochastic systems**

Organizer: Tang, Shanjian
Fudan Univ.
Organizer: Zhang, Xu
Sichuan Univ.

Abstract: The minisymposium concerns analysis and control of stochastic systems.
**Weak Solutions of Mean-field Stochastic Differential Equations and Application to Zero-sum Stochastic Differential Games**

Li, Juan  
Shandong Univ., Weihai

**Abstract:** In this paper we discuss the concept of weak solution for a new type of mean-field stochastic differential equations, which drift coefficient depends on the full past of the state but also on the law of the solution. With the help of the Girsanov Theorem we prove the existence and the uniqueness in law of the weak solution, when the drift coefficient is a bounded and only measurable function of the solution process and a continuous one of the law of the solution process. In the second part of the work we apply this concept of weak solution to zero-sum stochastic differential games of mean-field type. We obtain for them the existence of generalized saddle point controls under Isaacs' condition and we discuss conditions under which we have saddle point controls.

**MS-Th-E-28-2  16:30–17:00**  
**Short Selling and Equilibrium Price Uncertainty**

Ma, Chenghu  
Fuda Univ.

**Abstract:** This paper studies the price and trading impact of margin rules for short selling within the context of Marketov (1952). It is shown that heterogeneity in margins may have price effect and lead to price indeterminacy, particularly in the presence of derivative trading. Existence of equilibrium, along with a characterization theorem on the equilibrium outcome, is proved when investors have heterogeneous beliefs and margins for short selling may vary among agents and securities.

**MS-Th-E-28-3  17:00–17:30**  
**Learning How to Consume Effectively**

Koo, Hyeng Keun  
Ajou Univ.

**Abstract:** This paper proposes a utility model in which agents require effort to learn how to consume effectively. In this model, there is an ideal utility function of consumption that requires skill to achieve. At each time, there is a range of consumption levels for which the agent can consume at the full potential described by this ideal utility function, and consuming outside this range generates less than the potential utility. We derive an optimal policy.

**MS-Th-E-28-4  17:30–18:00**  
**Dual Representation of Value Function and Applications**

Zheng, Harry  
imperial college

**Abstract:** We discuss a standard utility maximisation problem in Black-Scholes world with general utility functions. We show there is a classical solution to HJB equation with dual control method and give a representations of value function, optimal wealth process, optimal control in terms of those of dual problem. We apply results to solve wealth maximisation, turnpike problem, and efficient frontier of utility and CVaR problems. (based on papers with Bian, Baqjun and Bernard, Carole.)

**MS-Th-E-29  16:00–18:00**  
**Numerical Homogenization and Multiscale Model Reduction Methods - Part Ill of V**

For Part 1, see **MS-Th-BC-29**  
For Part 2, see **MS-Th-D-29**  
For Part 4, see **MS-Fr-D-29**  
For Part 5, see **MS-Fr-E-29**

**Organizer:** Zhang, Lei  
Shanghai Jiao Tong Univ.

**Organizer:** Peterseim, Daniel  
Universität Bonn

**Organizer:** Jiang, Lijian  
Hunan Univ.

**Organizer:** Chung, Eric  
The Chinese Univ. of Hong Kong

**Abstract:** Problems that transcend a variety of strongly coupled time and length scales are ubiquitous in modern science and engineering such as physics, biology, and materials. Those multiscale problems pose major mathematical challenges in terms of analysis, modeling and simulation. At the same time, advances in the development of multiscale mathematical methods coupled with continually increasing computing power have provided scientists with the unprecedented opportunity to study complex behavior and model systems over a wide range of scales. This minisymposium is aimed at presenting the state-of-the-art in multiscale modeling, simulation and analysis for the applications in science and engineering. It will focus on the developments and challenges in numerical multiscale methods and multiscale model reduction methods. The lectures will cover the following subjects: - Numerical homogenization methods, e.g. Generalized FEM, MsFEM, FEM-HMM, DG methods, Partition of Unity methods, multiscale domain decomposition etc. - Multiscale model reduction methods for stochastic systems, such as stochastic PDEs and random materials. - Multiscale methods for problems arising in composite materials and heterogeneous porous media. - Multiscale methods for eigenvalue problems, high frequency waves, and multiscale hyperbolic PDEs. - Multiscale modeling in various applications such as reservoir performance prediction, bio-motility, chemical vapor infiltration, etc.

**MS-Th-E-29-1  16:00–16:30**  
**Discontinuous Galerkin Methods for Elliptic Multiscale Problems**

Georgoulis, Emmanuil  
Univ. of Leicester, UK / National Technical Univ. of Athens, Greece

**Abstract:** We shall review some recent results on the use of discontinuous Galerkin methods for elliptic multiscale problems. The first part of the talk will be concerned with a-priori error analysis for a multiscale discontinuous Galerkin method for problems with multiscale diffusion coefficients, while the second part of the talk will be concerned with a stochastic collocalization discontinuous Galerkin method for elliptic multiscale problems involving randomness.

**MS-Th-E-29-2  16:30–17:00**  
**High Dimensional Finite Elements for Multiscale Wave Equations**

Hoang, Viet Ha  
Nanyang Technological Univ.

**Abstract:** For locally periodic multiscale wave equations, we solve the high dimensional multiscale homogenized problem obtained from multiscale convergence that contains all the microscopic and macroscopic information. We consider the sparse tensor product finite element method which achieves an accuracy essentially equal to that for the full tensor product, but only requires an essentially equal number of degrees of freedom as for solving a one macroscopic scale wave equation. (Joint work with Bingxing Xia, NTU, Singapore.)

**MS-Th-E-29-3  16:30–17:30**  
**Intrinsic Sparse Mode Decomposition of High Dimensional Random Fields with Application to Stochastic Elliptic PDEs**

Li, Qin  
Caltech

**Abstract:** Inspired by the recent developments in data sciences, we introduce an intrinsic sparse mode decomposition method for high dimensional random fields. This sparse representation of the random field allows us to break a high dimensional stochastic field into many spatially localized modes with low stochastic dimension. Such decomposition enables us to break the curse of dimensionality in our local solvers. We apply this technique to solve stochastic elliptic PDEs with high dimensional stochastic coefficients.

**MS-Th-E-29-4  17:30–18:00**  
**Generalized Multiscale Finite Element Methods for Interface Problems**

Chu, Chia-Chieh  
National Tsing Hua Univ.

**Abstract:** In this talk, I will introduce generalized multiscale finite element methods. The method uses local solutions to generate an efficient and accurate approximation. Reduction of the basis functions is done by spectral decomposition. This method can be generalized to interface problems that often occur in two-phase flow simulation. Convergence analysis is presented and several numerical examples confirm the theoretical results.

**MS-Th-E-30  16:00–18:00**  
**VIP2-2**  
**Numerical approaches in optimization with PDE constraints: recent progress and future challenges - Part V of VII**

For Part 1, see **MS-We-BC-30**  
For Part 2, see **MS-We-D-30**  
For Part 3, see **MS-Th-BC-30**  
For Part 4, see **MS-Th-D-30**  
For Part 6, see **MS-Fr-D-30**  
For Part 7, see **MS-Fr-E-30**

**Organizer:** Yan, Ningning  
Chinese Acad. of Sci.

**Organizer:** Hinze, Michael  
Universität Hamburg

**Abstract:** The numerical treatment of optimization problems with PDE constraints is a very active field of mathematical research with great importance for many practical applications. To achieve further progress in this field of research, the development of tailored discretization techniques, adaptive approaches, and model order reduction methods has to be intertwined with the design of structure exploiting optimization algorithms in function space. This minisymposium covers mathematical research in PDE constrained optimization ranging from numerical analysis and adaptive concepts over algorithm design to the tailored treatment of optimization applications with PDE constraints. It thereby forms a platform and fair for the exchange of ideas among young researchers and leading experts in the field, and for fostering and extending international collaborations between research groups in the field.

**MS-Th-E-30-1  16:00–16:30**  
**Optimal Control of Elastic Contact Problems**
We survey the development of mixed simplicial finite elements based on this idea, highlighting the new ideas which led to advances in this approach.

**MS-Th-E-31-2**

*Robust Preconditioners for Poroeelasticity*

**Winther, Ragnar**

Univ. of Oslo

Abstract: We will discuss the construction of robust preconditioners for finite element discretizations of Biot’s consolidation model in poroelasticity. This model describes the coupling of the deformation of an elastic porous medium and the viscous flow inside. We will discuss several possible finite element discretizations of the Biot model, and how to design preconditioners for the discrete systems which are robust with respect to the discretization parameters and various physical parameters.

**MS-Th-E-31-3**

*Mixed Finite Elements for Elasticity on Quadrilateral Meshes*

**Awanou, Gerard**

Univ. of Illinois at Chicago

Abstract: We present stable mixed finite elements for planar linear elasticity on general quadrilateral meshes. The symmetry of the stress tensor is imposed weakly and so there are three primary variables, the stress tensor, the displacement vector field, and the scalar rotation. We develop and analyze a stable family of methods as well as a simple first order element. Joint work with D. Arnold and W. Qiu.

**MS-Th-E-31-4**

*Remarks on the Hypercircle Method*

**Stenberg, Rolf**

Aalto Univ.

Abstract: The classical hypercircle theorem states: Suppose that we have a stably and kinematically admissible stress field. Then the distance in energy norm from the exact stress to the average of the statically and kinematically fields equals half the distance between these fields. We will discuss the case when the fields are not exactly admissible. We show that the errors introduced can be estimated with computable error constants and hence one obtains an asymptotically exact estimator.
Sim, Imbo  
National Inst. for Mathematical Sci.

Abstract: The order of convergence of the Monte Carlo method is 1/2 which means that we need quadruple samples to decrease the error in half in the numerical simulation. Multilevel Monte Carlo methods reach the same order of error by spending less computational time than the Monte Carlo method. To reduce the computational complexity further, we introduce a projected multilevel Monte Carlo method using hierarchical meshes. Numerical experiments validate our theoretical results.

► MS-Th-E-32-3  
17:00–17:30  
A Dynamic Interface Immersed-Finite-Element Particle-in-Cell Method for Modeling Plasma-Wall Interactions  
Cao, Yong  
harbin Inst. of Tech.

Abstract: The evolution of wall surface is an unavoidable problem in all related engineering plasma applications. An improved immersed-finite-element PIC algorithm with dynamic interface for modeling plasma-wall interactions is proposed. The Huygens wavelet method, which shows the superiority to handle interface evolution problems in the literature, is incorporated into the IFE-PIC method to simulate the dynamic changes of interfaces. A numerical example is provided to demonstrate the features of this dynamic interface method.

► MS-Th-E-32-4  
17:30–18:00  
A Fast Numerical Method for Tempered Space-fractional Diffusion Equations of Variable Order  
Wang, Hong  
Univ. of South Carolina

Abstract: Tempered, variable-order fractional partial differential equations provide very powerful alternatives to integer-order PDEs for modeling anomalous transport and long-range interactions. They model these heavy-tail behavior accurately while retaining finite high-order moments. Furthermore, they provide greater flexibility modeling challenging phenomenon instead of the current practice of tweaking free parameters that multiply pre-set integer-order operators. However, FPDEs involve complex and singular integral operators. Consequently, corresponding numerical methods generate dense stiffness matrices, for which direct solvers require $O(N^3)$ memory and $O(N^3)$ complexity for a problem of size $N$. We present a fast numerical method for tempered, variable-order space-fractional diffusion equations with optimal memory requirement and almost linear computational complexity.

MS-Th-E-33  
16:00–18:00  
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Mathematical and computational methods for coupling local and nonlocal models - Part II of IV

For Part 1, see MS-Th-D-33
For Part 2, see MS-Th-E-33
For Part 3, see MS-Fr-D-34
For Part 4, see MS-Fr-E-34

Organizer: D'Elia, Marta  
Sandia National Laboratories
Organizer: Seleson, Pablo  
Oak Ridge National Laboratory
Organizer: Bochev, Pavel  
Sandia Labs

Abstract: Nonlocal continuum and atomistic models are used in many scientific and engineering applications, where material dynamics depends on microstructure. The numerical solution of nonlocal models might be prohibitively expensive; therefore, concurrent multiscale methods have been proposed for efficient and accurate solutions of such systems. These methods employ nonlocal models in parts of the domain and use local, macroscopic, models elsewhere. A major challenge is to couple these models at interfaces or in overlapping regions. This minisymposium invites contributions on coupling local and nonlocal continuum models and concurrent multiscale methods for atomistic-to-continuum coupling. Related domain decomposition methods are also considered.

► MS-Th-E-33-1  
16:00–16:30  
Blended Atomistic-to-continuum Hybrid Methods for Modelling Crystalline Materials  
Li, Xingjie Helen  
Brown Univ.

Abstract: The development of consistent and stable atomistic-to-continuum coupling models for multi-dimensional crystalline solids remains a challenge. In this talk, we consider two prototypical atomistic-to-continuum coupling methods of blending type: the energy-based and the force-based quasicontinuum methods, with a comprehensive error analysis that is valid in two and three dimensions, for finite many-body interactions (e.g., Embedded-Atom Method potential type), and in the presence of lattice defects (point defects and dislocations). Based on a precise choice of blending mechanism, the error estimates are considered in terms of degrees of freedom. The numerical experiments confirm the theoretical predictions, and demonstrate a superior accuracy of the force-based blending over energy-based blending schemes.

► MS-Th-E-33-2  
16:30–17:00  
Seamless Coupling of Local and Nonlocal Models  
Tian, Xiaochuan  
Columbia Univ.
Tao, Yunzhe  
Du, Qiang  
Columbia Univ.

Abstract: We present some analytical and computational studies of a nonlocal model with saptially varying horizon. We demonstrate how such a model can be combined with asymptotically compatible schemes to simulate coupled local and nonlocal models.

► MS-Th-E-33-3  
17:00–17:30  
How Does One Determine the Kernel Function in A Nonlocal Model? A Heat Conduction Example  
Li, Xiantao  
The Pennsylvania State Univ.

Abstract: How to determine the kernel function in a nonlocal model is a central issue from a modeling perspective. This talk demonstrates a first-principle approach, in the context of heat conduction, in which the traditional Fourier’s Law is known to fail in nano-mechanical systems. Our derivation starts from a molecular-level models, incorporating the detailed interactions of the atomics. In additional to the statistical-mechanics derivation, we discuss numerical implementations of the nonlocal model.

► MS-Th-E-34  
16:00–18:00  
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Modeling and Simulation of Complex Fluids and Biological Systems - Part II of IV

For Part 1, see MS-Th-D-34
For Part 2, see MS-Th-E-34
For Part 3, see MS-Fr-D-34
For Part 4, see MS-Fr-E-34

Organizer: Zhang, Hui  
Beijing Normal University
Organizer: Forest, M. Gregory  
Univ. of North Carolina at Chapel Hill
Organizer: Wang, Qi  
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: This mini symposium will bring together researchers in complex fluids and biological systems to exchange ideas and perspectives as well as to share their most recent findings. The goal is to integrate advances in mathematical theory, modeling, data analytics, algorithms, simulations, high performance computing techniques) with new experimental data from complex fluids and biological systems, and targeted applications. The specific system I represent include single living cells, biofilms, active molecular fluids, and transport properties of biological fluids such as lung mucus. We would like to invite you to give a talk on your current research at the proposed mini-symposium. The talks are scheduled to be 25 minutes each + 5 minutes for discussion.

► MS-Th-E-34-1  
16:00–16:30  
Hydrodynamic Modeling of Active Liquid Crystals  
Cui, Zhenni  
Fayetteville State Univ.

Abstract: Active liquid crystals are complex fluids composed of active units. Examples include bacterial suspensions, the cell cytoskeleton and even nonliving analogues such as vibrated granular rods. They are interesting from a more fundamental perspective as their dynamic phenomenons are both physically fascinating and potentially of great biological significance. In this talk, I will present a model for flowing active liquid crystals. Hydrodynamics, instabilities and rheology as well as effects of boundary conditions will be discussed.

► MS-Th-E-34-2  
16:30–17:00  
Compact Implicit Integration Factor Method for A Class of High Order Differential Equations  
Liu, Xinfeng  
Univ. of South Carolina
Ju, Lili  
Univ. of South Carolina

Abstract: In this talk, we will present an efficient integration factor method for solving a family of semilinear fourth-order parabolic equations, in which the bi-Laplace operator is explicitly handled and the computational cost and stor-
Abstract: We present some efficient energy stable schemes to solve a phase transition model, which describes the dynamics of interfaces with surface tension. The proposed scheme is based on a first-order approximation of the surface tension term, and it is shown to be energystable. We also present a numerical method for solving the resulting system of equations, which is based on a front-tracking scheme and a relaxation method. Numerical results are presented to demonstrate the effectiveness of the proposed method.

A General Continuum Model for Active Liquid Crystals

Yang Xiaogang
Beijing Computational Sci. Research Center

Abstract: The characteristics of active liquid crystals are that they are composed of self-driven units, known as the active particles, and each particle is capable of converting the internal or external free energy, thus they can form self-assembled ordered states with respect to the orientation and self-motion. In this talk, I systematically derive a general continuum model for active liquid crystals using the general hydrodynamic theories, depending on the Onsager principle.

Some Energy Stable Schemes for Phase Field Model with Moving Contact Lines

Yang Xiaofeng
Univ. of South Carolina

Abstract: We present some efficient energy stable schemes to solve a phase field model incorporating moving contact line. The model is a coupled system that consists of incompressible Navier–Stokes equations with a generalized Navier boundary condition and Cahn–Hilliard equation in conserved form. By some subtle explicit-implicit treatments, we obtain a linear coupled energy scheme for systems with dynamic contact line conditions and a linear decoupled energy stable scheme for systems with static contact line.

A Two-grid Accelerated Sweeping Preconditioner for the Helmholtz Equation

Stolk, Chris
Univ. of Amsterdam

Abstract: Helmholtz solvers based on sweeping preconditioners have relatively high per-iteration cost. We reduce this cost by using the sweeping preconditioner at the coarse level of a two-grid method, so that it is applied to an eight times smaller problem. A new two-grid method is developed for this purpose. The effectiveness of the method is shown using large 3-D examples.

Boundary Integral Equation Method for Wave Scattering from Large Number of Layers

Min Hyung, Cho
Dartmouth College

Abstract: Modern electronic/optical devices rely on wave such as solar cells, antennae, and radar. For optimizing/characterizing these devices, we developed a robust and fast computational method based on boundary integral equations for Helmholtz equation in periodically patterned multilayered media. The new method uses near- and far-field decomposition to avoid using the quasi-periodic Green’’ function. The far-field contribution is computed using Schur-complement. The new method solved the scattering from a 1000-layer with 300000 unknown in 2.5 minutes.

Fast Solver for High Frequency Scattering in the 3D Cavity

Lai, Jun
New York Univ.

Abstract: In this talk, we consider the time harmonic scattering of a 3D axis-symmetric cavity. An integral approach is proposed to solve the full Maxwell’s equation. We prove the integral equation is uniquely solvable for any positive wavenumber. In the numerical simulation, we make use of the axis-symmetric property by designing quadratures for the Fourier modes of the singular integral and solve the system by fast direct solver to obtain efficiency and accuracy.

Source Transfer Domain Decomposition Method for Time-Harmonic Elastic Wave Equation with Spectral Element Method

Xiang, Xueshuang
Qian Xuesen Laboratory of Space Tech.

Abstract: We extend the source transfer domain decomposition method (STDMD) proposed by the author to solve time-harmonic elastic wave equation with spectral element method. Numerical examples are included to show that STDM can be used as an efficient preconditioner in the preconditioned GMRES method for solving the problems with constant and heterogeneous wave numbers. The results indicate that it take a few number of iterations to make GMRES convergence when the pollution error is reduced.
Minimization of A Cost Function for Approximate Sampling from Multimodal Posterior Distributions

Oliver, Dean
Uni Research

Abstract: We address the problem of sampling from a posterior PDF with widely separated modes. In this approach, particles samples from the prior are mapped to regions of high probability by minimizing a cost function involving distance from the prior sample and distance from perturbed observations. The error in the distribution of sampling can potentially be corrected by computation of a marginal density, but this correction is generally neglected in high-dimensional inverse problems.

MS-Th-E-36-4 17:30–18:00

Analysis and Synthesis of Networked Control Systems
Xia, Yuanqing
Beijing Inst. of Tech.

Abstract: In this presentation five parts will be given. Firstly, new results on quantization over networks are given. Secondly, new results on data fusion over networks are presented. Thirdly, a new networked predictive control scheme is proposed, which can overcome the effects caused by network data dropout. Fourthly, some results on fault detection over networks are introduced. Finally, news results on control of multi flight vehicles over networks are presented.

MS-Th-E-38-2 16:30–17:00

Consensus of Multi-agent Systems with Sign Observations
Fang, Haitao
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Jiang, Weisen
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: In multi-agent systems, to achieve consensus, relative positions with neighbors are always required. However, in many cases, exact relative positions are very difficult to be obtained. In this paper, we considered the case that each agent can only get the sign information of its neighbors, and prove in some mild conditions, consensus can be achieved in multi-agent systems with connected fixed network and a random network. Some simulation examples are provided to verify our theoretical analysis.

MS-Th-E-38-3 17:00–17:30

Electric Vehicles in Smart Grid: How to Manage Energy?
Zaiyue, Yang
Zhejiang Univ.

Abstract: Traditional grid is facing challenges and the world is making strides towards smart grid. Enabled by advanced information technologies, the smart grid is an effective way to achieve efficient power generation, distribution and utilization. Electric Vehicle (EV) is a dynamical element in smart grid, which can address the shortage of fossil energy and car emissions. In this talk, we shall discuss how to manage the energy transmission among several entities, including grid, renewable sources, charging stations.

MS-Th-E-38-4 17:30–18:00

The Remote Perception and Controlling in Smart House Based on Public Cloud Platform
Zhang, Ming
Beijing Inst. of Tech.

Dai, Zhongian
Beijing Inst. of Tech.

Dai, Yaping
Beijing Inst. of Tech.

Wang, Shuo
Beijing Inst. of Tech.

Abstract: A solution of the smart home system based on IoT public cloud platform is proposed in this paper. The PCs or some embedded devices in traditional smart home system are replaced by the cloud platform as a server in this scheme. Several environment perception and control terminals of a family’s comfort, safety, energy consumption are designed, which can communicate with the cloud platform. This system can work in remote control and local control working mode.

MS-Th-E-39 16:00–18:20

Optimal control of stochastic systems and its application to finance
Organizer: Wu, Zhen
Shandong Univ.

Abstract: Optimal control of stochastic systems plays a central and significant role in modern control theory. In the past decade, extensive studies have been conducted on this field, and many results have been obtained. In this talk, we will discuss some recent developments in this area, including: 1) analysis and synthesis of networked control systems; 2) consensus control of multi agents with sign observations; 3) energy management of electric vehicles; 4) remote perception and controlling in smart house.
conducted for the so-called maximum principle, verification theorem, HJB equation and their applications to finance, economics, insurance, etc. The minisymposium aims to present some recent developments in optimal control of stochastic systems, including 1) LO control and filtering of forward-backward stochastic systems; 2) Non-Markov zero-sum Dynkin game; 3) Maximum principle for stochastic systems driven by fractional Brownian motions; 4) Maximum principle for mean-field stochastic delay systems.

**MS-Th-E-39-1 16:00–16:30**
**An LO Optimal Control Problem of FBSDEs with Partial Information**
Wang, Guangchen
Shandong Univ.
Abstract: In this talk, we study an LO optimal control problem derived by FBSDEs. A backward separation approach is introduced. Combining it with filtering, two optimality conditions and a feedback optimal control are derived. Closed-form optimal solutions are obtained in some particular cases. As an application of the results, a recursive utility problem from financial markets is solved explicitly. (This talk is based on a joint work with Professors Zhen Wu and Jie Xiong.)

**MS-Th-E-39-2 16:30–17:00**
**Non-Markov Zero-sum Dynkin Game**
Zhou, Yang
South China Normal Univ.
Abstract: A Non-Markov zero-sum Dynkin game problem is considered. Its associated Hamilton-Jacobi-Bellman-Isaacs equation is a backward stochastic partial differential variational inequality (BSPDI, for short) with semilinear differential operator. A verification theorem is established, which shows that the strong solution of the BSPDI is the value function of the Dynkin game problem. Then the existence and uniqueness of the strong solution of the BSPDI are proved. Finally, we give two examples to show its applications.

**MS-Th-E-39-3 17:00–17:30**
**Stochastic Maximum Principle for Controlled Systems Driven by Fractional and Standard Brownian Motions**
Han, Yuecai
Jilin Univ.
Abstract: The existence and uniqueness of solution for a type of backward stochastic differential equation driven by fractional Brownian motions and underlying standard Brownian motions is investigated. The necessary conditions that the optimal control must satisfy for controlled systems driven by fractional Brownian motions and underlying standard Brownian motions is obtained by conditioning and Malliavin calculus.

**MS-Th-E-39-4 17:30–18:00**
**Maximum Principle for Mean-field Jump-diffusion Stochastic Delay Differential Equations and Its Application to Finance**
Meng, Qingxin
Huzhou University
Abstract: This paper investigates a stochastic optimal control problem with delay and of mean-field type, where the controlled state process is governed by a mean-field jump-diffusion stochastic delay differential equation. Two sufficient maximum principles and one necessary maximum principle are established for the underlying systems. As an application, a bicriteria mean-variance portfolio selection problem with delay is studied. Under certain conditions, explicit expressions are provided for the efficient portfolio and the efficient frontier, which are as

**CP-Th-E-39-5 18:00–18:20**
**The Connection between Dynamic Programming and Maximum Principle for Fully Coupled Forward-Backward Stochastic Control Systems**
Shi, Jingtao
Shandong Univ.
Abstract: This paper is concerned with the connection between dynamic programming (DP) and maximum principle (MP) for the fully coupled forward-backward stochastic control system. Where the recursive cost functional is defined as one of the solution to a controlled forward-backward stochastic differential equation (FBSDS). With some smooth assumptions, relations among the valuation function, generalized Hamiltonian function and adjoint processes are given, when the diffusion coefficient of the forward equation does not contain the state variable $x$. The general case for the problem is open. A linear example is discussed as the illustration of our main result.

**MS-Th-E-40 16:00–18:00 303A**
**Identification and Control of Complex Systems**
Organizer: TCCT
Technical Committee on Control Theory, CAA
Abstract: A complex system is a system formed out of many components whose behavior is emergent, which is the behavior of the system cannot be simply inferred from the behavior of its components. The complex nature makes the identification and control of the systems theoretically challenging and technically important in real-world applications. The minisymposium aims to show the latest developments in identification and control of several classes of complex systems, including 1) system identification under quantized inputs and quantized output observations in an FIR system; 2) dissipativity-based small-gain theorem establishment for the interconnected systems; 3) identification of the time-varying gene network for brain development; 4) multi-motor driving servo systems with backlash synchronization and tracking control.

**MS-Th-E-40-1 16:00–16:30**
**System Identification under Quantized Inputs and Quantized Output Observations**
Guo, Jin
Univ. of Sci. & Tech. Beijing
Abstract: We focus on an FIR system to investigate the system identification under quantized inputs and quantized output observations. Based on the QCC (quasi-convex combination estimator) and the weighted least squares, a two-step algorithm is proposed to estimate the unknown parameter. The input excitation condition is introduced, under which the key properties of the algorithm are obtained, including strong convergence, strong and mean-square convergence rates, asymptotic normality and asymptotic efficiency.

**MS-Th-E-40-2 16:30–17:00**
**Adaptive Lasso-Based Variable Selection for Nonlinear Nonparametric Systems**
Zhao, Wenxiao
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Abstract: The Lasso introduced in statistics community finds successful applications in diverse areas. The theoretical foundation of such kinds of algorithms is mainly for linear systems. In this talk, we investigate the variable selection problem for nonlinear nonparametric systems with a Lasso-type algorithm and show that under moderate conditions the estimates derived are strongly consistent with both parameter convergence and set convergence.

**MS-Th-E-40-3 17:00–17:30**
**Identification of the Time-Varying Gene Network for Brain Development with Application to Mental Diseases Studies**
Wan, Lin
Acad. of Mathematics & Sys. Sci., CAS
Abstract: Genetic association studies have identified dozens of susceptibility genes for mental diseases such as autism and schizophrenia. However, it remains mysterious that how these genes play their roles in the brain function. To investigate the functions of mental diseases susceptibility genes in a dynamic and systematic fashion, we develop a time-varying gene network reconstruction method using gene expression time series data of brain development. It provides new insights into the molecular mechanisms of mental diseases.

**MS-Th-E-40-4 17:30–18:00**
**Synchronization and Tracking Control for Multi-motor Driving Servo Systems with Backlash**
Ren, Xuemei
Beijing Inst. of Tech.
Abstract: This paper presents synchronization and tracking control for multi-motor driving servo systems with backlash. A sliding mode is proposed to achieve synchronization and tracking control, where an improved performance function characterizing settling time, overshoot, steady-state error, convergence rate is introduced to attain systems with prescribed performance. The backlash compensators are adopted, where a function characterizing position deviation of motors is used for switching between normal and compensation control. Simulation results demonstrate the effectiveness of the algorithm.

**MS-Th-E-41 16:00–18:00 303B**
**Majorization Theory and Its Engineering Applications**
Organizer: Chen, Wei
Hong Kong Univ. of Sci. & Tech.
Organizer: Qiu, Li
Hong Kong Univ. of Sci. & Tech.
Abstract: Majorization is an old mathematical tool which has been studied in mathematics by giants like Hardy, Littlewood, and Pólya and has been widely used in statistics in the past 100 years. Its engineering applications have been attracting more and more attention recently in various areas, such as wireless communication, information theory, control and estimation theory, operations research, and smart grid, etc. The minisymposium aims to present several most up-to-date research on majorization and its applications in information technology, including 1) wireless communication via majorization; 2) duration-differentiated energy services; 3) duration-differentiated energy services with different deadlines; 4) sensor scheduling with majorization.

**MS-Th-E-41-1 16:00–16:30**
**Majorization Theory in Wireless Communications**
Palomar, Daniel
Hong Kong Univ. of Sci. & Tech.
Abstract: Majorization precisely defines the vague notion that the components...
of a vector are “less spread out” or “more nearly equal” than the compo-
nents of another vector. Many problems arising in wireless communications
involve comparing vector-valued strategies or solving optimization problems
with vector or matrix-valued variables. Majorization theory is a key tool to sim-
plify or solve these problems. This talk will introduce the basic concepts and
results on majorization and illustrate its applications in wireless communica-
tions.

MS-Th-E-41-2 16:30–17:00
Duration-differentiated Energy Services
Negrete-Pintecic, Matias Pontificia Universidad Catolica de Chile

Abstract: We consider duration-differentiated loads requiring a constant pow-
er for a specified duration. We give conditions, written in terms of majorization
results, under which a variable power supply is adequate to meet these flexi-
ble loads, and describe how to allocate the power to the loads. We study the
problem of allocating the available power to loads to maximize welfare, and
show that the welfare optimum can be sustained as a competitive equilibrium
in a forward market.

MS-Th-E-41-3 17:00–17:30
Majorization Theory in Sensor Scheduling Problems
Yang, Chao East China Univ. of Sci. & Tech. (ECUST)

Abstract: This talk introduces the applications of majorization in the sensor
scheduling problems for networked state estimation. Two problems are con-
sidered. The first is to schedule the limited communication time of a single
sensor to optimize the average estimation performance. The second is to plan
the limited available channels among a sensor network such that the
local performance are optimized. It is shown in both problems, the optimal
schedules can be obtained by applying majorization theory.

MS-Th-E-41-4 17:30–18:00
Duration-deadline Jointly Differentiated Energy Services
Chen, Wei Hong Kong Univ. of Sci. & Tech.

Abstract: We propose a duration-deadline jointly differentiated energy ser-
vice. The adequacy of a given supply profile is addressed, which amounts to
solving a (0,1)-matrix feasibility problem. The adequacy condition is given
by the non-negativity of a structure tensor. The condition reduces to a ma-
ajorization relation when there is only one single deadline. We also discuss the
adequacy gap in the case of an inadequate given supply.

MS-Th-E-42 16:00–18:00
Cooperative Control and Multi-Agent Systems V
Organizer: TCCT Technical Committee on Control Theory, CAA

Abstract: Recent advances in sensing, communication and computation tech-
nologies have enabled a group of agents, such as robots, to communicate or
sense their relative information and to perform tasks in a collaborative fashion.
The past few years witnessed rapidly-growing research in cooperative control
technology. Multi-agent system (MAS) is a computerized system composed
of multiple interacting intelligent agents within an environment. Multi-agent
systems can be used to solve problems that are difficult or impossible for an
individual agent or a monolithic system to solve. The aim of this minisympo-
sium is to share novel approaches and innovative applications of cooperative
control and MAS, including: 1) distributed estimation for cyber-physical sys-
tems; 2) consensus-based distributed filter design; 3) environmental feasibility
on consensus control; 4) Distributed cooperative learning approach.

MS-Th-E-42-1 16:00–16:30
Situation Awareness for Cyber-Physical Systems: Distributed Estimation Method
Chen, Caillan Shanghai Jiao Tong Univ.

Abstract: The increasing applications of cyber-physical systems (CPSs) wit-
ness the fact that high-level situation awareness tasks can be accomplished
with cooperative sensing, data processing, communication and control. Dis-
tributed estimation is a key process bridging the gap between the wealth of
distributed information captured and the understanding of a situation of phys-
ical systems. In this talk, the speaker will present its evaluation and case
study from system perspective by considering network topology, distributed
estimation and consensus strategy.

MS-Th-E-42-2 16:30–17:00
Consensus-based Distributed Filter Design and Convergence Analysis in Sensor Networks
Zhang, Ya Southeast Univ.

Abstract: This paper studies the distributed filtering problem of heterogeneous
sensor networks. The communications among sensors and the sensing links
are unreliable and randomly switching. Based on Kalman filtering algorithm
and weighted average strategy, a sub-optimal filtering algorithm is proposed.
The statistical convergence properties of estimation error covariances are in-
vestigated and a necessary and sufficient convergence condition is provided
based on LMIs.
Abstract: We will introduce an inexact alternating direction algorithm with variable stepsize for solving separable convex optimization. This algorithm generalizes the Bregman operator splitting algorithm with variable stepsize (BOSVS) to the multiblock case and allows to solve the convex subproblems to an adaptive accuracy. Global convergence and some preliminary numerical results will be discussed in this talk.

MS-Th-E-44 16:00–18:30 VIP2-1
Pseudo-Differential Operators in Industries and Technologies - Part II of IV
For Part 1, see MS-Th-D-44
For Part 3, see MS-Fr-D-44
For Part 4, see MS-Fr-E-44
Organizer: Wong, M.W., York Univ.
Abstract: Pseudo-differential operators, first appeared in 1960s in the paper by Joseph J. Kohn and Louis Nirenberg in the Communications on Pure and Applied Mathematics, have been used in the explicit descriptions of solutions of Partial Differential Equations. Since wavelet transform and related transforms came to the fore and became understood by scientists and engineers in the physical sciences, biomedical sciences, atmospheric sciences and geological sciences in the context of time-space-frequency representations, pseudo-differential operators and their variants such as Weyl transforms and noncommutative quantization with operator-valued symbols have become instrumental in signal and image analysis in the role of filters. Extensions of classical pseudo-differential operators to Weyl transforms and pseudo-differential operators to H-type groups can be thought of as noncommutative quantization. The aim of this minisymposium is to provide a platform for dialogs on several developments of pseudo-differential operators in some areas of industries and technologies such as information, communication and signals.

► MS-Th-E-44-1 16:00–16:30
Modulation Spaces, Harmonic Analysis and Pseudo-differential Operators
Toff, Joachim
Department of mathematics, Linnaeus Univ.
Abstract: We present recent results on composition, continuity and Schatten-von Neumann (SvN) properties for pseudodifferential operators (PsDOs) on modulation spaces. We present certain conditions in order for the Weyl product should be continuous on modulation spaces. We also present appropriate conditions on modulation space symbols in order for the PsDOs should be SvN of certain degree in $(0,\infty)$. We use the results to deduce SvN properties of PsDOs with symbols in $H^s\otimes\mathbb{R}$.

► MS-Th-E-44-2 16:30–17:00
MRI Texture Heterogeneity Correlates with Tissue Pathology in Multiple Sclerosis
Zhang, Yunyan
Univ. of Calgary
Moore, Wayne
Univ. of British Columbia
Laube, Corrine
Univ. of British Columbia
Bjarnason, Thor
Univ. of British Columbia
Kozlowski, Piotr
Univ. of British Columbia
Traboussy, Anthony
Univ. of British Columbia
Li, David
Univ. of British Columbia
Abstract: Mathematical calculation of the texture in MR images demonstrates promise to detect subtle changes in tissue structure but is subject to pathological validation. Here we imaged 10 postmortem brain samples with multiple sclerosis and computed the local texture of brain areas with different severity of pathology determined by histological staining. We show that MRI texture heterogeneity correlates strongly with tissue pathology and may be a new measure of injury and repair in multiple sclerosis patients.

► MS-Th-E-44-3 17:00–17:30
A Frame of Discrete Orthogonal Stockwell Transform
Berra, Michele
Univ. of Turin
Abstract: We define a new frame on $L^2 (\mathbb{R})$ using the so-called DOST basis using a particular classes of windows that includes the Gaussian characterizing also the dual window. We also generalize this frame in the framework of the alpha-modulation spaces. Finally, we test the numerical efficiency of the proposed frame.

► MS-Th-E-44-4 17:30–18:00
Time-Frequency Methods Applied to Images
Cohen, Leon
City Univ. of NY
Abstract: Over the past 30 years time-frequency methods have been generalized to apply to images. Instead of time/frequency one considers position/spatial-frequency. One seeks a formulation where we can study the local properties of images. We review the concepts that have been developed in formulating joint spatial/spatial-frequency distributions and discuss the mathematical and physical ideas that have lead to both insight and practical methods to understand and manipulate images.

► MS-Th-E-44-5 18:00–18:30
Thresholding-based Image Denoising Using Discrete Orthoromonal S-Transform
Sun, Fongrong
Shandong Univ.
Babyn, Paul
Univ. of Saskatchewan
Zhu, Hongmei
York Univ.
Abstract: S-transform is an effective time-frequency analysis technique that can provide simultaneous time and frequency distribution information similar to the wavelet transform. We introduce the ideas of wavelet transform-based image denoising into S-transform domain and propose the thresholding-based image denoising using discrete orthonomal S-transform. Simulations illustrated the favorable application performance of the method, while its successful implementation in myocardial contrast echocardiography image denoising and the spatial-temporal denoising for fluoroscopy sequences demonstrated its application prospects.

Abstract:

Optimization Methods for Inverse Problems - Part III of V
For Part 1, see MS-Th-BC-45
For Part 2, see MS-Th-D-45
For Part 4, see MS-Fr-D-45
For Part 5, see MS-Fr-E-45
Organizer: LI, XIN, AMSS
Organizer: WANG, YANFEI
The Inst. of Geology & Geophysics, CAS
Abstract: In this minisymposium, inverse problems arisen from various areas such as geoscience and petroleum engineering, related optimization models like L1 norm regularization, and advanced optimization methods for solving these models such as first order methods, subspace methods, alternating direction method of multipliers and distributed optimization approaches are discussed.

► MS-Th-E-45-1 16:00–16:30
Synchrontron-based Computerized Tomography on Microscopic Imaging in Shale Structure Analysis
WANG, YANFEI
The Inst. of Geology & Geophysics, CAS
Abstract: X-ray computerized tomography based on synchrontron radiation, as a non-destructive technique, become an important tool and can be applied to the study of morphology, microstructure, transport properties and fracturing of shale. Two scientific issues rose: one is how to generate high level reconstructed image data using SR-CT, another is how to use these CT image data to analyzing compositional microstructures. We study sparse regularization methods for reconstruction of image and microstructure prediction using SR-CT data.

► MS-Th-E-45-2 16:30–17:00
Linearized Primal-Dual Based Methods for $L^2$-TV-Based Regularization Model of Some Linear Inverse Problems
Tian, WenYi
Hong Kong Baptist Univ.
Abstract: This paper considers the optimization model with $L^2$ and total variation regularization terms to approximate solutions to some linear inverse problems. The model is reformulated as a saddle-point problem with consistent finite element discretization. A linearized primal-dual scheme is proposed to iteratively solve the discretized problem. Then we analyze the convergence and establish the convergence rate both in ergodic and nonergodic sense. Finally, the efficiency of the proposed method is verified in several numerical examples.

► MS-Th-E-45-3 17:00–17:30
On the Proximal Alternating Direction Method of Multipliers
Chen, Caihua
Nanjing Univ.
Abstract: In this talk, we consider the use of the proximal alternating direction method of multipliers to solve linearly constrained separable programming problems. We first review and develop some convergence and complexity analysis results of the algorithm for convex programming. We also discuss some variants of PADMM, including the inertial PADMM and Bregman ADMM, for convex programming and extend the algorithm to solve some specific nonconvex programming problems.

► MS-Th-E-45-4 17:30–18:00
Approximation Algorithms for Mixed Binary Nonconvex Quadratically Constrained Quadratic Programs
Abstract: Motivated by applications in wireless communications, this talk focuses on linear conic relaxation techniques and approximation algorithms for some mixed binary quadratically constrained quadratic programs and analyzes their approximation performance. The approximation ratios or bounds which are independent of dimensions are all established for these problems. In some cases, the ratio are tight up to a constant factor. The effectiveness of the proposed algorithms are demonstrated via numerical experiments.

Motivated by applications in wireless communications, this talk focuses on linear conic relaxation techniques and approximation algorithms for some mixed binary quadratically constrained quadratic programs and analyzes their approximation performance. The approximation ratios or bounds which are independent of dimensions are all established for these problems. In some cases, the ratio are tight up to a constant factor. The effectiveness of the proposed algorithms are demonstrated via numerical experiments.
modelled by a quadratic map of the inlet concentration. Pressure and flow rate distributions in the network are analyzed, then concentration distribution is governed by systems of coupled quadratic maps. In the continuum the systems become the Burgers equation or its variable-coefficient variant, with no-flux boundary conditions. For one network the initial and boundary val-
ue problem is exactly solvable via Cole-Hopf transformation. It is proved that the solution component becomes concentrated on one side of a transition layer corresponding to a stationary shock regardless of initial concentration distri-
bution. Another network behaves similarly. MEMS circuits based on the idea are constructed to separate almost pure hydrogen from mixture using thermal diffusion.

**Thermodynamically Consistent Modelling and Computations for Two-phase Flows**

Guo, Zhenlin
Univ. of California Irvine

**Abstract:** We present a novel phase-field model to study the two-phase flows with thermocapillary effects which allow for the different properties (densities, viscosities and heat conductivities) of each component. The model equations are derived under the thermodynamic framework and the compatibility with the laws of thermodynamics is achieved for the first time. In addition, im-
portant modelling properties Onsager reciprocal relations and Galilean invari-
ance have been verified as well. To investigate this model numerically, we
provide for the first time, an energy law preserving continuous finite elemen-
tical scheme. To implement the numerical methods more efficiently, we design an adaptive mesh that can automatically adjust to resolve the relevant scales of the phase-field model, ensuring accuracy while minimizing computational cost. Some numerical examples are computed using a continuous finite ele-
ment method, where the results are compared to the corresponding analytical solutions as validations for our model.

**MS-Th-E-48** 16:00–18:00 212B

**Image restoration: new algorithms and new applications - Part I of III**

For Part 2, see **MS-Fr-D-49**

For Part 3, see **MS-Fr-E-48**

Organizer: Sgallari, Fiorella
Univ. of Bologna
Organizer: Chan, Raymond
The Chinese Univ. of Hong Kong

**Abstract:** The field of digital image restoration is concerned with the recon-
struction or estimation of uncorrupted images from noisy, blurred ones. This blurring may be caused by optical distortions, object motion during imaging, or atmospheric turbulence. There are existing or potential applications of im-
age restoration in many scientific and engineering fields, e.g., aerial imaging, remote sensing electron microscopy, and medical imaging. From these arise some real challenging problems related to image reconstruction/restoration that open the way to some new fundamental scientific questions closely relat-
ed with the world we interact with and Mathematics has become one of the
main driving forces of the modern development of image restoration.

The purpose of this mini-symposium is to gather the leading researchers in the areas of image restoration/reconstruction to present a series of talks that will expose the current state of knowledge in the algorithmic and application field. Our goal is also to establish connections between different techniques, talk about important issues in the emerging application fields and generate novel ideas for future development.

**Illusory Shapes via Corner Fusion**

Kang, Sung Ha
Georgia Tech

**Abstract:** We propose a method for constructing illusory shapes from convex
comers. Corner bases are fused together by elastica energy to construct both
ground and background occluded shapes. Robust num-
erical schemes are developed, and several generic examples will be presented.

**Multigrid Regularization Method for Image Deblurring with Arbitrary Boundary Conditions**

Donatelli, Marco
Univ. of Insubria
Buccini, Alessandro
Univ. of Insubria

**Abstract:** We consider the image deblurring problem. We propose a multi-
resolution representation of the point spread function to allow the method to be
independent of the structure of the blurring matrix. The grid transfer op-
erator is a linear B-spline used also for a post-smoothing denoising at each
corner level. The effectiveness of the method is further improved using as a
smoother a non-stationary preconditioning regularization method recently pro-
presented in the literature and adding the nonnegative constraint.

**Convex Image Denoising via Non-Convex Regularization**

Morigi, Serena
Sgallari, Fiorella
Univ. of Bologna
Univ. of Bologna

**Abstract:** Natural image statistics motivate the use of non-convex non-smooth regularizations over convex regularizations for restoring images. However, they are rarely used in practice due to the challenge to find a good minimizer. We propose a Convex Non-Convex (CNC) denoising variational model and an efficient minimization algorithm based on the ADMM approach. We provide theoretical convergence conditions for both the CNC model and the optimization sub-problems arising in the ADMM-based procedure, such that convergence is guaranteed.

**Constrained TVp-L2 Model for Image Restoration**

Sgallari, Fiorella
Morigi, Serena
Univ. of Bologna
Univ. of Bologna

**Abstract:** TV model for image restoration can be formulated as a MAP esti-
mator which uses a half-Laplacian image-independent prior favoring sparse image gradients. We propose a generalization of the TV prior based on a half-Generalized Gaussian Distribution with parameter p and an automatic estimation of it to fit images gradient distribution. The restored image is com-
puted by an ADMM procedure. A novel result in multivariate proximal calculus is presented. Numerical examples show the efficiency of the approach.

**Mathematical modeling of infectious diseases - Part I of II**

For Part 2, see **MS-Fr-D-49**

Organizer: Wang, Xueying
Washington State Univ.

**Abstract:** Mathematical modeling plays an important role in understanding the spread and control of infectious diseases in populations. Mathematical mod-
elers have been increasingly used to guide public health policy decisions and
explore questions in infectious disease control. This minisymposium will bring
together researchers employing a variety of mathematical techniques to study
relevant phenomena of infectious diseases.

**Revisiting the Cholera Outbreaks of John Snow's Time**

Tien, Joe
The Ohio State Univ.

**Abstract:** John Snow's celebrated investigations of cholera in 19th century
London proved a seminal step in establishing the germ theory of disease. In
fact there is still more to learn from the cholera outbreaks of John Snow's time.
In this talk, we will examine cholera data from the Bills of Mortality of London,
and see how interesting patterns in the data together with simple mathemati-
cal modeling lead to the reconstruction of an ancient cholera genome.

**Mathematical Modeling and Analysis of Cholera Epidemics**

Wang, Xueying
Washington State Univ.

**Abstract:** In this work, we propose novel epidemic models for cholera dynam-
ics. First, we develop a generalized ODE model by incorporating a general
formula of cholera transmission pathways and intrinsic bacteria growth; we then analyze the local and global dynamics of this model. Secondly, we
extend the ODE model to PDE models with inclusion of the bacterial and
human diffusion and bacterial convection. We investigate the traveling wave solutions and disease threshold dynamics of PDE models.

**Modeling Cholera on Community Networks**

Shuai, Zhisheng
Univ. of Central Florida

**Abstract:** Cholera is an infectious disease that can be transmitted to humans
directly by person-to-person contact or indirectly through ingestion of con-
taminated water. Basic cholera models that include both direct and indirect
transmission and assume homogeneous mixing in the host population are reviewed. Detailed models that incorporate spatial heterogeneity and math-
ematical tools from graph theory are applied to understand cholera dynam-
ics on community networks. Joint work with Marisa Eisenberg, Joseph Tien,
Pauline van den Driessche.

**Basic Reproduction Numbers for Non-homogeneous Epidemic Models**

Wang, Jin
Univ. of Tennessee at Chattanooga

**Abstract:** The basic reproduction number, commonly denoted R0, is of fun-
damental importance in epidemic models. Although threshold dynamics as-
sociated with R0 have been well established for autonomous systems repre-
senting homogeneous environments, the analysis and computation of R0 for
non-homogeneous epidemic models remain a challenge. Here we discuss
R0 for time periodic and spatially heterogeneous models, representing two typical types of non-homogeneity. We present efficient methods to compute R0, and demonstrate the application through non-trivial examples.

**MS-Th-E-50**

Mathematical and Numerical Aspects of Electronic Structure Theory - Part III of V

For Part 1, see MS-Th-BC-50

For Part 2, see MS-Th-D-50

For Part 4, see MS-Fr-D-50

For Part 5, see MS-Fr-E-50

Organizer: Lin, Lim
Univ. of California at Berkeley
Organizer: Lu, Jianfeng
Duke Univ.

Abstract: Electronic structure theory and first principle calculations are among the most challenging and computationally demanding science and engineering problems. This minisymposium aims at presenting and discussing new developments of mathematical analysis, and numerical methods for achieving ever higher level of accuracy and efficiency in electronic structure theory. This includes ground state and excited state density functional theory calculations, waveform methods, together with some of their applications in computational materials science and quantum chemistry. We propose to bring together experts on electronic structure theory, which include not only mathematicians, but also physicists working actively in the field.

**MS-Th-E-50-1**

Efficient Spectral-element Methods for Electronic Schrodinger Equation
Shen, Jie
Purdue Univ.

Abstract: We present efficient spectral-element methods, based on Legendre and Laguerre polynomials, for direct approximation of the electronic Schrodinger equation in one spatial dimension. A spectral-element approach is used to treat the singularity in nucleus-electron Coulomb potential, and with the help of Slater determinant, we construct special basis functions to obey the antisymmetric property of the fermionic wavefunctions. Numerical tests are presented to show the efficiency and accuracy of the proposed methods.

**MS-Th-E-50-2**

Numeric Atom-centered Orbital Based All-electron Electronic Structure Theory for Accurate, Large Simulations
Blum, Volker
Duke Univ.

Abstract: We describe recent methodological progress and applications of electronic structure theory methods implemented in a numeric atom-centered orbital framework (FHI-aims). This basis choice enables simulations of materials and molecules (periodic and non-periodic) from light to numerically converged accuracy, for DFT including hybrid functionals and many-body perturbation theory. Recent developments include a massively parallel dense eigenvalue solver "ELPA" and a localized "resolution of identity" that enables exact-exchange for hybrid DFT up to thousands of atoms.

**MS-Th-E-50-3**

Hierarchical Tensors and Tensor Networks for Quantum Chemistry
Schneider, Reinhold
Inst. for Mathematics

Abstract: n tensor product approximation, Hierarchical Tucker tensor format (Hackbusch) and Tensor Trains (TT) (Tyrtyshnikov) have been introduced recently offering stable and robust approximation by a low order cost. If \( V = \bigotimes_{i=1}^{d} C_i \), these formats are equivalent to tree tensor networks states and matrix product states (MPS) originally introduced for the treatment of quantum spin systems. Considering the electronic Schrödinger equation, we use an occupation number labeling of Slater determinants, and show that the discrete Fock space becomes isometric to d-fold tensor product of a a two-dimensional Hilbert space. We use hierarchical tensor representation, which are equivalent to tree tensor networks, in particularly in the form of matrix product states. For the computation of an approximate ground solution this problem can be casted into an optimization problem constraint by the discrete Fock space becomes isometric to d-fold tensor product of a a two-dimensional Hilbert space. We use hierarchical tensor representation, which are equivalent to tree tensor networks, in particularly in the form of matrix product states. For the computation of an approximate ground solution this problem can be casted into an optimization problem constraint by the discrete Fock space becomes isometric to d-fold tensor product of a a two-dimensional Hilbert space. %We use hierarchical tensor representation, which are equivalent to tree tensor networks, in particularly in the form of matrix product states. For the computation of an approximate ground solution this problem can be casted into an optimization problem constraint by the discrete Fock space becomes isometric to d-fold tensor product of a a two-dimensional Hilbert space. %We use hierarchical tensor representation, which are equivalent to tree tensor networks, in particularly in the form of matrix product states. For the computation of an approximate ground solution this problem can be casted into an optimization problem constraint by the discrete Fock space becomes isometric to d-fold tensor product of a a two-dimensional Hilbert space.
Analysis of Fecal Microbiota Transplantation in the Treatment of Clostridium Difficile Infection
Mio, Washington Florida State Univ.

Abstract: Fecal microbiota transplantation (FMT) shows a high success rate in the treatment of Clostridium difficile infection (CDI). However, the mechanism by which CDI is resolved through FMT is not well understood. We present a multiscale approach to analysis of data in networks and Riemannian manifolds that combined with metagenomic sequencing let us develop a CDI biomarker that accounts for bacterial interactions and also is effective in monitoring the effects of FMT on CDI.

MS-Th-E-52 16:00–18:00 212A
Recent Development of Mathematical Models in Computational Biology - Part III of V
For Part 1, see MS-Th-BC-52
For Part 2, see MS-Th-D-52
For Part 4, see MS-Fr-D-52
For Part 5, see MS-Fr-E-52
Organizer: Zhang, Lei Peking Univ.
Organizer: Ge, Hao Peking Univ.
Organizer: Lei, Jinzhi Tsinghua Univ.

Abstract: One of the central problems in biology is to understand the design principles of complex biological systems. Mathematical and computational models of biological processes can be characterized both by their level of biological detail and by their mathematical complexity. In this minisymposium, we focus on recent findings of computational models and methods to gain insights of the complexity of cellular life and efficiently analyze the experimental observations. Topics of interests include stem cells, developmental patterning, gene regulatory networks, neuron networks, uncertainty quantification of biological data, etc.

► MS-Th-E-52-1 16:00–16:30
Transition Paths of Metastable Bio-chemical Reacting Systems
Liu, Di Michigan State Univ.

Abstract: Based on the framework of transition path theory (TPT), we extended the probability current between two adjacent reacting states to single reacting states as well as reacting trajectories, thereby give the definition of transition state (TS) as states with maximum velocity strength. Simple examples have shown the success of this approach.

► MS-Th-E-52-2 16:30–17:00
Cycle Symmetries and Circulation Fluctuations for Markov Processes with Cycle Structure
Jiang, Da-Quan Peking Univ.

Abstract: For a recurrent Markov chain, we prove several equalities which characterize the symmetry of the forming times of cycles. The equalities are then applied to prove that the sample circulations satisfy a large deviation principle. The rate function has an interesting symmetry, which implies the Gallavotti-Cohen type fluctuation theorem of the sample net circulations. We also obtain other fluctuation theorems for sample circulations. Similar results hold for diffusion processes on the circle.

► MS-Th-E-52-3 17:00–17:30
Stem Cell Regeneration: from Model to Simulation
Lei, Jinzhi Tsinghua Univ.

Abstract: This talk presents the modelling of stem cell regeneration through the multi-scale model with cross talk between genetic and epigenetic regulation. Numerical scheme to study the model with GPU is also introduced to simulate the long-term regeneration of a group of stem cells with modifications of histone modification in each cell cycle.

► MS-Th-E-52-4 17:30–18:00
A Model for Clonal Expansion in Blood Generation
Chou, Tom UCLA

Abstract: We develop a mechanistic model for how labelled stem cells generate peripheral blood in the hematopoietic system. We model clones in three pools: the progenitor cell pool in the bone marrow, the peripheral blood pool, and the sampled blood. The model includes regulatory interactions through a phenomenological carrying capacity in the bone marrow. Our results are fit to longitudinal data on rhesus macaques, and show that two combinations of parameters determine the observed clone-size distributions.

Stochastic modelling, control and optimization in finance II
Organizer: Ludkovski, Mike UC Santa Barbara
Organizer: Leung, Tim Columbia Univ.
Organizer: Li, Lingwei The Chinese Univ. of Hong Kong
Organizer: Chen, Nan The Chinese Univ. of Hong Kong

Abstract: This minisymposium will explore applications of stochastic control to utility maximization problems, including new developments motivated by models from behavioral finance and risk measures.

► MS-Th-E-53-1 16:00–16:30
Asymptotic Methods for Portfolio Optimization Problems
Hu, Ruimeng Univ. of California, Santa Barbara
Fouque, Jean-Pierre Univ. of California, Santa Barbara

Abstract: We revisit the portfolio optimization problems under stochastic volatility models, and using asymptotic methods with respect to volatility time scales. In the case of one factor and power utility, the problem is linearized and well-understood. However, the problem with general utility is still open. Here we address the case of general utility and prove asymptotically the optimality of the zeroth order strategy within a class of Markovian feedback control.

► MS-Th-E-53-2 16:30–17:00
Empirical Pricing Kernel: A Revisit
Xie, Jinming The Chinese Univ. of Hong Kong
Li, Duan The Chinese Univ. of Hong Kong

Abstract: We revisit the empirical pricing kernels (EPK) estimated from index option and index prices. Using a much longer sample, we find that the EPKs consistently demonstrate oscillating patterns. These oscillating patterns provide a nonlaboratorial evidence for the Friedman and Savage three-piece utility function, under which the utility function is convex with moderate wealth levels, which further confirms our finding that the EPK is increasing in a subinterval with small magnitude of losses and gains.

► MS-Th-E-53-3 17:00–17:30
The Ross Recovery Theorem and Log Optimal Portfolio
Wang, Yiwei The Chinese Univ. of Hong Kong
Chen, Nan The Chinese Univ. of Hong Kong

Abstract: We set up a framework that relates Ross recovery theorem with stochastic portfolio theory and obtain the recovery result from the long term perspective, particularly from the log optimal portfolio theory.

Modeling and Simulations of Complex Biological Systems - Part II of IV
For Part 1, see MS-Th-D-54
For Part 3, see MS-Fr-D-54
For Part 4, see MS-Fr-E-54
Organizer: Liu, Xinfeng Univ. of South Carolina
Organizer: Ju, Lili Univ. of South Carolina

Abstract: This mini-symposium aims to bring together researchers focusing on using modeling and numerical approach to study complex biological systems including (but not limited to) cell signaling pathways, complex bio-fluids, biofilms, cell polarization, developmental and cell biology, and stem cells, etc. Such complex biological systems in general consist of multiple interacting components that exhibit complicated temporal and spatial dynamics. Furthermore, feedback, nonlinearities and multiple time and length scales often make such systems extremely difficult to describe, model or predict. The invited speakers will discuss the challenges of modeling such complex systems, introduce new computational techniques to simulate them and, where possible, present novel analytical techniques to extract meaningful information.

► MS-Th-E-54 16:00–18:00
A New Approach to Feedback for Robust Signalization Frederic Y. M. Wan, Frederic Y. M. Wan Department of Mathematics University of California, Irvine Irvine, CA 92697-3875 USA

Abstract: The patterning of many developing tissues is orchestrated by gradients of morphogens through an elaborate set of regulatory interactions. Such interactions are thought to make gradients robust – i.e. resistant to changes in response to genetic or environmental perturbations. Just how this might be done is a major unanswered question. Empirical evidence of feedback regulating signaling gradients has been reported in the literature. The present paper undertakes a different approach to the role of feedback in robust signaling gradients and, therewith robust biological developments. This talk presents a new approach to feedback mechanisms that would lead to robust development.
The research is supported in part by NIH Grants R01 - GM067247 and P50 - GM076516. The R01 was awarded through the Joint NSF/ NIGMS Initiative to Support Research in the Area of Mathematical Biology.

**MS-Th-E-54-2 16:30–17:00**

**A Mechnochemical Model for Cell Polarity by Coupling A Reaction Diffusion System with Membrane Tension**

Zhang, Lei  
Peking Univ.

**Abstract:** Development and regeneration require plant and animal cells to make decisions based on their locations. In this talk, I will introduce a hybrid model for cell polarity by coupling a reaction diffusion system with membrane tension. Simulations demonstrate that membrane tension affects the spatial profile of Rac-GTP’s distribution, the polarization time and the sensitivity to attractant. Our model can first explain results of aspiration-release experiment and the pseudopod-neck-cell body morphology severing experiment.

**MS-Th-E-54-3 17:00–17:30**

**Stem Cells and Regeneration: Feedback, Niche, and Epigenetic Regulation**

Nie, Qing  
Univ. of California, Irvine

**Abstract:** In developing and renewing tissues, terminally differentiated cell types are typically specified through the actions of multistage cell lineages. Such lineages commonly include a stem cell and multiple progenitor cell stages, which ultimately give rise to terminally differentiated cells. In this talk, I will present several modeling frameworks with different complexity on multistage cell lineages driven by stem cells, which account for diffusive signaling molecules, regulatory networks, individual cells, mechanics, and evolution. Questions of our interest include role offeedbacks in regeneration, stem cell niche for tissue spatial organization, crosstalk between epigenetic and genetic regulations. In several cases, we will also present direct comparisons between our modeling outputs and some existing and new in vivo and in vitro data.

**MS-Th-E-55 16:00–18:00**

**Wavelength Methods for Inverse Problems Modelling Real World Systems - Part II of IV**

For Part 1, see MS-Th-D-55  
For Part 2, see MS-Fr-D-55  
For Part 3, see MS-Fr-E-55  
For Part 4, see MS-Fr-E-56

**Organizer:** Majumdar, Apala  
Univ. of Bath

**Organizer:** Wang, Changyou  
Purdue Univ.

**Organizer:** Zhang, Pingwen  
Peking Univ.

**Abstract:** We prove regularity properties and determine bounds for local minimizers to an energy derived from Maier-Saupe theory that is used to characterize order in nematic liquid crystal materials.
a function of the shell’s aspect ratio and temperature and prove that the radial hedgehog solution is the unique global energy minimizer for this boundary-value problem, for sufficiently low temperatures. This is joint work with Giacomo Canevari, Duwan Henao, Adriano Pisante and Mythily Ramaswamy.

**On the Behaviour of Smectic Liquid Crystals Subject to Small Perturbations**

**Snow, Ben**  
Univ. of Strathclyde

**Abstract:** After a brief review of Stewart’s dynamic theory for smectic A (SmA) liquid crystals (with relevant elastic energy density given by De Vita & Stewart), results will be presented regarding the behaviour of SmA subjected to small perturbations in the form of a shear wave incident at the interface between a sample of SmA and an isotropic solid, and a disturbance to a known steady flow pattern in SmA in the presence of an obstacle.

**Superstructures from Liquid Crystal Colloids**

**Ravnik, Miha**  
Univ. of Ljubljana

**Abstract:** Liquid crystal colloids are interesting for a variety of mechanisms that can be used to create complex optical and photonic structures. Here, we present selected liquid crystal colloidal structures, as recently achieved by numerical modelling and experiments. Central to the structures are complex conformations of topological defects. More specifically, we show 2D and 3D colloidal crystals, Penrose P1 tiling with quasicrystalline and surface conditioned structures from multiple length scales.

**Schedules: Thursday Sessions**

- **MS-Th-E-57-4**  
  17:30–18:00  
  On the Behaviour of Smectic Liquid Crystals Subject to Small Perturbations  
  **Snow, Ben**  
  Univ. of Strathclyde

- **MS-Th-E-56-5**  
  18:00–18:30  
  Superstructures from Liquid Crystal Colloids  
  **Ravnik, Miha**  
  Univ. of Ljubljana

**Abstract:** We discuss high-order methods inspired by the multi-step Adams methods for systems of fractional differential equations. The schemes are designed to be unconditionally stable and convergent in $L_\infty$-norm by the energy method. (2) A fourth-order difference approximation is derived for the fractional sub-diffusion equation. It is proved that the difference scheme is unconditionally stable and convergent in $L_2$ norm.

**Theoretical and numerical studies of phase field model - Part II of IV**

**Organizer:** Wang, Zengjian  
Univ. of Massachusetts Dartmouth

- **MS-Th-E-58-1**  
  16:00–16:30  
  Numerical Simulation of Two-phase Fluid Systems Governed by A Diffuse Interface Model Equipped with Van Der Waals Equation of State  
  **Hesthaven, Jan**  
  EPFL

**Abstract:** We consider multi-component two-phase systems modeled by a diffuse interface model equipped with van der Waals equation of state (EOS). We propose an efficient numerical solution of the modeling system, focusing on discrete energy stability, local mass conservation and numerical accuracy. Our algorithm consists of a finite volume-based method for spatial discretization and a convex splitting-based semi-implicit marching scheme for temporal discretization, which is proved to be unconditionally energy stable under certain conditions.

**Convergence of Discontinuous Galerkin Methods for the Allen-Cahn and Cahn-Hilliard Equations and Their Sharp Interface Limits**

**Feng, Xiaobing**  
The Univ. of Tennessee

**Abstract:** This talk is concerned with theoretical aspects of discontinuous Galerkin (DG) finite element methods for two best known phase field models, namely, the Allen-Cahn and Cahn-Hilliard equations. The focuses of the talk will be on discussing the recent developments on establishing the convergence of the numerical interfaces to the sharp interface limits of the both
phase field models, namely, the mean curvature flow and the Hele-Shaw flow, as both the numerical mesh parameters and the phase field parameter tend to zero, and to present the main ideas for establishing those results, as well as to discuss possible generalizations of the ideas and results to other related phase field models. This is a joint work with Yukan Li of the University of Tennessee at Knoxville, and Yulong Xing of the the University of Tennessee at Knoxville and the Oak Ridge National Laboratory (ORNL).

**MS-Th-E-59-4** 17:30–18:00

Isotropic-nematic Interface in the Framework of Landau-de Gennes Theory

Wang, Wei

Zhejiang Univ.

Abstract: Isotropic and nematic are two important phases for liquid crystals materials. In this talk, we will discuss the isotropic-nematic problem in the framework of Landau-de Gennes theory. Specifically, we will discuss the stability of uniaxial interface profile and derive the sharp interface model for the hydrodynamics of isotropic-nematic two-phase flow by using the matched asymptotic expansion method.

**MS-Th-E-59-5** 18:00–18:30

A Second Order Accurate in Time Unconditionally Stable, Uniquely Solvable Scheme for Cahn-Hilliard-Navier-Stokes System

Wang, Xiaoming

Florida State Univ.

Abstract: Cahn-Hilliard-Navier-Stokes system is one of the well established diffuse interface models for two phase flows. We present a second order in time accurate, unconditionally stable, and uniquely solvable numerical scheme for this system. The algorithm combines the idea for pressure projection for the momentum equations and convex splitting for the phase field equation. Our numerical experiments confirm the theoretical findings. This is a joint work with Daolzi Han.

**MS-Th-E-59-6** 16:00–18:00

Energy-Driven Pattern Formation - Part II of IV

For Part 1, see MS-Th-D-59

For Part 3, see MS-Fr-D-59

For Part 4, see MS-Fr-E-59

Organizer: Kohn, Robert

New York Univ.

Abstract: Energy-driven pattern formation examines how energy minimization leads to the formation of defects and microstructure in a variety of physical systems. Examples include the wrinkling of a stretched elastic membrane, the twinning produced by martensitic phase transformation, and the defects seen in liquid crystals. In these and many other examples, the physics is modeled by a nonconvex variational problem regularized by a higher-order term with a small coefficient, and energy-driven pattern formation can be studied by considering the limiting behavior of minimizers as the small parameter tends to zero. Another recurrent theme is the use of ansatz-free bounds to identify and explore the features of energy-minimizing configurations. A third recurrent theme is dynamics, since the patterns of interest are sometimes transient states of steepest-descent processes.

**MS-Th-E-59-9** 16:00–16:30

Chiral Skyrmions: New Phases in Condensed Matter

Melcher, Christoph

RWTH Aachen Univ.

Abstract: Chiral symmetry breaking described by Lifshitz invariants gives rise to a class of topological solitons, the so-called chiral skyrmions. This form of chirality occurs in various condensed matter systems including ferromagnets and liquid crystals. We shall discuss the stabilization of isolated chiral skyrmions and skyrmion lattices emerging as new phases in appropriate parameter regimes.

**MS-Th-E-59-2** 16:30–17:00

The Energy Scaling Law of A Thin Film Bonded to A Compliant Substrate, and the Wrinkling of A Floating Elastic Sheet.

Nguyen, Hoai-Minh

Ecole Polytechnique Federale de Lausanne EPFL

Abstract: This talk is on the energy scaling law of thin films. Two problems are discussed: 1) the compliance of a thin film to a substrate where a hererringbone pattern is “optimal”; 2) the wrinkling of a floating elastic film where a cascade pattern achieves the law. Ansatz-free proofs showing that no pattern can achieve a better law are mentioned. The proofs use some non-standard interpolation inequalities. This is joint work with Bob Kohn.

**MS-Th-E-59-3** 17:00–17:30

Low Density Phases in A Uniformly Charged Liquid

Knuepfer, Hans

Univ. of Heidelberg

Abstract: We consider a macroscopic limit for the Ohta-Kawasaki energy, used to described phase separation for diblock-copolymers. We first investigate existence and shape of minimizers of the energy with prescribed volume (of the one phase) in the full space setting. We then consider the situation of periodic configurations with prescribed density. We show that in a certain regime, the energy Gamma-converges to a homogenized problem. This is joint work with C. Muratov und M. Novaga.

**MS-Th-E-59-4** 17:30–18:00

Metastability and Access to Ground States in A Class of Variational Models for Self-Assembly

Choksi, Rustum

McGill Univ.

Abstract: We consider a class of non-convex variational models for self-assembly, focusing on metastability and access to a ground state. We explore a simple strategy for assessing whether or not a particular computed metastable state is a global minimizer. The method is based upon finding a “suitable” global quadratic lower bound to the free energy. This is joint work with D. Shirkooff (NJIT) and J.C. Nave (McGill).

**MS-Th-E-60** 16:00–18:00

Mathematical methods in biomedical applications - Part I of III

For Part 2, see MS-Fr-D-60

For Part 3, see MS-Fr-E-60

Organizer: Amigo, Jose

Universidad Miguel Hernandez

Organizer: Liang, X. San

Nanjing Inst. of Meteorology

Organizer: Small, Michael

Univ. of Western Australia

Abstract: Mathematics is being successfully applied to a number of important topics in biology and medicine like biofluids, data analysis, drug design and discovery, epidemiology, evolution, genetics, image processing, immunology, medical instrumentation, neuroscience, plant growth, population dynamics (including ecology and microbiology), tumor propagation, virus dynamics, etc. The list of tools include virtually the whole applied mathematics. To cite just the most familiar ones: discrete dynamical systems, ordinary and time-delay differential equations, graph and network theory, integral transforms, numerical and computational mathematics, partial and stochastic differential equations, statistics, probability, and time series analysis. All this research has contributed and is increasingly contributing both to a better understanding of complex biological phenomena and to find practical ways of action. On the wake, new branches of applied mathematics have emerged, e.g., mathematical biology, theoretical biology, and computational neuroscience. But today, more important consequence is the improvement in health care and life quality that results from, say, early and better diagnoses, more efficient drugs, plague control, or biotechnological know-how, all of which owe much to the mathematical research.

This being the case, the scope of the minisymposium hereby proposed is to give researchers the opportunity to share their latest applications of mathematical methods to biology and medicine in a multi- and interdisciplinary environment. The topics addressed have been intentionally left open with the objective of having a broader participation. Thus, researchers in computational neuroscience can benefit very much from a network-based approach or time series analysis. Researchers in deterministic models can get further inspiration from stochastic methods or fractional analysis. Moreover, specialists in one particular field can learn new, possibly unexpected applications of their technical skills or hear about other approaches.

With this scope in mind, the organizers of this minisymposium have invited a reduced number of experts who work on applications of mathematics to medicine and biology. Their theoretical backgrounds cover mainly nonlinear dynamics, computational neuroscience, time series analysis, network theory, and partial differential equations, thus a representative blend of current research. Specially important are the actual and potential applications to the biomedical industry of topics such as complex fluids, drug discovery, computational methods and information analysis, all of them included in the minisymposium. For instance, the parametric study of the flow in ventricular catheters for the treatment of hydrocephalus presented in one of the communications, has led new designs which are patent pending. If approved, this minisymposium will be certainly a great place to create synergies in an area of mathematics which has scientific interest, applications to the biomedical industry, and social impact.

**MS-Th-E-60-1** 16:00–16:30

Parametric Study of the Flow in Ventricular Catheters

Amigo, Jose

Universidad Miguel Hernandez

Galarza, Marcelo

Universidad Miguel Hernandez

Gimenez, Angel

MIGUEL HERNANDEZ Univ.

PELLICER, OLGA MIGUEL HERNANDEZ Univ.

Valero, Jose

Univ. Miguel Hernandez of Elche

Abstract: Hydrocephalus is a medical condition characterized by an abnormal accumulation of cerebrospinal fluid in the brain ventricles. A catheter is
inserted in one of the ventricles and then connected to an external valve to drain the excess of fluid. To uniformize the flow pattern, we have carried out a parametric study of the cerebrospinal fluid flow via numerical catheter models. As a result we formulate some basic principles for ventricular catheter design.

Self-organization of Interacting Agents and Applications to Population Dynamics

Escudero, Carlos Universidad Autonoma de Madrid

Abstract: We study the stochastic process of two-species coagulation as a model for population dynamics. Our approach consists in direct numerical simulations to describe this process at the microscopic level as well as the rigorous analysis of kinetic equations that describe it at the mesoscopic level. The conclusions of both analyses are put in the context of social interactions of insects.

Comparing Structural and Functional Clusters for Dynamic Network Data

Xu, Xiaoke Dalian Nationalities Univ.

Abstract: In social networks and biological networks, a structural cluster (community) refers to the occurrence of groups of nodes in a network that are more densely connected internally than with the rest of the network. In this study, we proposed a technique for the detection of functional clusters in discrete event data. The novel method can be used to detect functional clusters for dynamic network data (such as neural spike data and short message communication data).

Cardio-respiratory Coordination During Sleep

Abstract: Obstructive apnoeas and hypopnoeas (AHE) are defined by reduced ventilation which is caused by obstructions of the upper airways during sleep. In order to characterise the autonomic regulation during AHE, we concentrate on the mutual influence of the cardiac and respiratory oscillations on their respective onsets, the cardio-respiratory coordination (CRC). We find that the occurrence of CRC is significantly more frequent during AHE than in normal respiration and is more frequent after these events.

Stochastic differential equation

Chi: Karthikeyan, Shanmugasundaram Periyar Univ.

Abstract: This paper is concerned with the relative controllability for a class of control systems governed by nonlinear stochastic systems with multiple delays in state. Sufficient conditions for relative controllability are established by using the Banach fixed point principle. An example is provided to illustrate the application of the result.

Stochastic Fuzzy Differential Equations - A Tool for Stochastic Systems with Imprecise Values

Malinowski, Marek T. Univ. of Zielona Gora

Abstract: To handle dynamics of systems operating in random and vague/fuzzy environment, we propose to consider stochastic fuzzy differential equations. This constitutes a new branch of research in modeling uncertain phenomena. We examine equations whose solutions have increasing and decreasing fuzziness. The existence and uniqueness of solutions is investigated. Also, stability properties of solutions are established. Several examples are studied to indicate applicability of the theory introduced in modeling population growth, stock price, short-term interest rate.

Determining Transmission Eigenvalues of Anisotropic Inhomogeneous Media from Far Field Data

Peters, Stefan AG inverse problems, Univ. Bremen

Abstract: We characterize interior transmission eigenvalues of penetrable anisotropic acoustic scattering objects by a technique known as inside-outside duality. Under certain conditions on the anisotropic material coefficients of the scatterer, the inside-outside duality allows to rigorously characterize interior transmission eigenvalues from multi-frequency far field data. This theoretical characterization moreover allows to derive a simple numerical algorithm for the approximation of interior transmission eigenvalues.

Path Integration Methods for Weak Solutions of Stochastic Differential Equations

Chen, Linghua Norwegian Univ. of Sci. & Tech.

Abstract: The numerical path integration method is used to approximate the evolution of the probability density of the solution process of stochastic differential equations, driven by either traditional white noise or more general Levy type noise. In this paper we firstly analyze the close connection between the discretized path integration operators and their corresponding integro-differential operators. Under rather standard assumptions, convergence results are proved that the iteration of discretized operation approximates the semi-groups generated by the original continuous equations. Next we look at the realization of the path integration operator on a digital computer, and demonstrate the convergence of the algorithm. Various examples are presented and compared with other numerical methods. We conclude that the path integration method gives rather satisfactory results, and it copes with a quite wide family of problems arisen from different fields.

Regularity of Solutions of Stochastic Tidal Dynamics Equation with Additive Noise

Suvintha, Murugan Bharathiar Univ., Coimbatore

Abstract: In this work we consider the stochastic analogue of tidal dynamics equation developed by Marchuk and Kagan (1984). The tidal dynamics model is a coupled system relating the horizontal flow to the surface height of the ocean. The randomness is assumed to be Gaussian noise of additive type. We analyze the regularity of solutions of the stochastic tidal dynamics equation with randomness being considered for both the equations. Existence of strong solutions to the system is established by using Gelerkin approximation and local monotonicity argument introduced by Minty and Browder (1963). The uniqueness of solution is observed to be pathwise and the regularity of solution is discussed by using an equivalent Sobolev norm obtained by means of Fourier transform. It is concluded that the regularity of the strong solution could be improved with suitable assumptions on the initial data and external forces acting on the system.

The Schrodinger Model and Its Applications

David, Darlington S. Y. William V. S. Tubman Univ.

Ben, Christian Univ. of Liberia

Fatigun, Adetona Univ. of Ado Ekiti

Abstract: In this paper, the Schrodinger model was investigated. Our results show that the time-independent operators correspond to the observables of the quantum system. Also, from the Schrodinger model, it was proven that the model can be used to represent physical quantities such as quantum energy, quanta momentum and harmonic oscillator. Our results also show that operators are very useful tools for the representation of the eigenfunctions of the harmonic oscillator. Eigenfunctions can also be orthogonal basic of unit vector in an n-dimensional vector space that is obtained by solving the Schrodinger equation.
accelerated expansion is modified gravity. The present work reports study on
the interacting Ricci dark energy in a modified gravity theory named f(R, T)
gravity. In the specific model \( f(R, T) = \mu R + \nu T \) we have observed a
tquotum-like behavior of the equation of state parameter and a transition from
matter dominated to dark energy density has been observed through fraction
density evolution. The statefinder parameters reveal that the model interpo-
lates between dust and LCDM phases of the universe.

**Abstract:** A wormhole is a hypothetical path to connect different regions
of the universe. This path can be regarded as a tunnel or bridge from which the
observer may traverse easily. In general relativity, the exotic matter (which
violates the energy conditions) constitutes basic ingredient to develop math-
ematical structure of wormhole. The violation of null energy condition is the
necessary tool to form wormhole solutions which also allow two way travel.
The search for a realistic source which provides this violation (while normal
matter may satisfy the energy conditions) has gained a lot of interest now-a-
days. This search introduced modified theories of gravity in wormhole sce-
nario. In f(T) gravity, the effective energy momentum tensor is responsible for
the corresponding violation while normal matter threads wormhole solutions.

**Abstract:** The calculations are carried out for the vibrational states that correspond
to energy levels calculation of excited vibrational states for different molecules.
The calculations are carried out for the vibrational states that correspond to
three- to seven-fold vibrational excitations. Perturbation series diverge in the
case of strong resonance interactions. Nevertheless, considering vibrational
energy of each excited state not as a real number, but as a complex function
and applying corresponding analytical functions theory, we were able not only
to get the exact value of energy, but to find the reason of divergence, and to
choose the best summation technique. Our summation technique is based on
high-order Pade-Hermite approximations. Further research shows that series
behavior completely depends on the singularities of complex energy function
inside unit circle. This analysis helped us to make the first exact definition of
resonance interaction and to develop a unique technique for vibrational en-
ergy spectrum calculations avoiding resonances.

**Abstract:** fringe value or ‘inner works’ of CDS prices using analytical solutions if available. Finally, the survival/default
dependence level and allows for recovery from credit events. The model is ap-
plied to compute Credit Value Adjustment for a CDS contract with wrong-way
risk. By choosing a stochastic square root jump-diffusion (SSRJD) process to
be the default independent process and combining with a contingent shift,
our approach results in a two-dimensional partial integro-differential equation
(PIDE) for survival probability, price of credit default swaps (CDS) and credit
value adjustment (CVA). We also discusses the finite scheme and its efficiency
and accuracy is analysed with examples of survival/default probabilities and
CDS prices using analytical solutions if available. Finally, the survival/default
probabilities, CDS prices and CVA are compared to the results of previous contagion models.

**Stochastic Volatility Double Jump-diffusions Model: the Importance of Distribution Type of Jump Amplitude**

SuN, Youfa
Guangdong Univ. of Tech.

**Abstract:** This research examines if there exists an ideal distribution for jump amplitude in the sense that with this distribution, the stochastic volatility double jump-diffusions (SVJJ) model would potentially have a superior option market fit. We provide a general methodology for pricing vanilla options via a Fast Fourier transform series expansion method, in the setting of Heston’s SJJV model that may allow a range of jump amplitude distributions. Example applications include the normal distribution, the exponential distribution and the asymmetric double exponential distribution, for the reason of analytical tractability for options and economical interpretation. An illustrative example examines the implications of HSVJJ model in capturing option “smirks”. This example highlights the impacts on implied volatility surface of various jump amplitude distributions, through both extensive model calibrations and carefully designed implied-volatility impacting experiments.

**Fuzzy Reliability Analysis of A Fire Pump System with Components Following Different Membership Functions**

Komal, Komal
H.N.B. Garhwal Univ., Srinagar(Garhwal), Uttarakhand

**Abstract:** Reliability plays a crucial role to enhance the performance of any complex industrial system constituted by number of repairable components following different types of failures/repairs. Data uncertainty due to various practical constraints is always influence the system reliability and consequently make a challenge for decision maker to extract some concrete decisions for enhancing system performance. System components’ failure/repair data uncertainty and their different types of patterns increase the difficulty of system analysts to analyse and enhance the system performance. To overcome these problems, this paper presents a novel approach in which different types of fuzzy membership functions are used to incorporate different types of uncertainties and Two (weakest t-norm) based approximate fuzzy arithmetic operations are adopted for fuzzy reliability analysis of complex repairable systems. Proposed approach has been applied to analyse the reliability of a fire pump system and the computed results are compared with traditional and existing fuzzy lambda-tau(FLT) approaches.

**Study of Einstein Theory of Gravitation for G\&#246;del Type Solution**

Pandey, S.
Motilal Nehru National Inst. of Tech. Allahabad

**Abstract:** In this paper, we have studied higher order theory of gravity which is based on conformal non-invariance of gravitational wave equations. These waves are inevitable consequences of Einstein theory which are non-conformally invariant unlike electromagnetic waves which are conformally invariant. We study these field equations by considering its solutions in heterogeneous space-time of G\&#246;del type and compare its result with Einstein field equation with cosmological constant.

**Second Order Slip Effects on Entropy Generation of MHD Nanofluid Flow over A Stretching Surface with Thermal Radiation Effect**

A.K., Abdul Hakeem
Sri Ramakrishna Mission Vidyalya CAS B., Ganga
Providence College for Women, Coonoor

**Abstract:** The aim of the present paper is to analyze the second order slip effects on entropy generation of an incompressible, viscous and electrically conducting water based nanofluid boundary layer flow over a stretching surface with thermal radiation effect. A system of governing non-linear partial differential equations is transformed to ordinary differential equations with help of Lie group transformation. The analytical results are derived in terms of Kummer’s function and the numerical results are obtained by shooting method. The entropy generation is calculated using the entropy relation by substituting the velocity and temperature fields obtained from the momentum and energy equations. The effects of pertinent physical parameters on entropy generation, skin friction coefficient and the reduced Nusselt number are discussed. A comparative analysis of present results with previously published results is given.

**Inexact Tensor-free Chebyshev-Halley Class**

Eustaquio, Rodrigo
Federal Technological Univ. of Parana

**Abstract:** This work introduces a class of methods for solving nonlinear systems. This new class can be seen as a generalization of the Chebyshev-Halley class. It is known that the methods latter class could have cubic convergence rate, that means, higher order convergence rate than Newton’s method. However, Chebyshev-Halley class methods are computationally expensive, requiring second-order derivatives information. The new class of methods, named the inexact tensor-free Chebyshev-Halley class, does not calculate second-order derivatives and finds the next iterate by approximately solving two linear systems. In addition to giving a proof of the convergence of these new methods, it is shown that, depending on reasonable assumption, the methods of this class can have superlinear, quadratic, superquadratic or cubic convergence rates. Numerical evidence that demonstrates significant improvement when utilizing the proposed inexact tensor-free methods, is presented.
of two different iterative procedures used in our results have better rate of convergence than other existing iterative procedures.

**CP-Th-E-65-3** 16:40–17:00
Existence of Solutions of Fractional Differential Equations with Non Instantaneous Impulses
Annamalai, Anguraj
PSG College of Arts & Sci.,

Abstract: We consider a new class of Fractional Integro-differential equations with non instantaneous impulses. We establish an existence theorem for abstract fractional integro-differential equations with initial conditions under non instantaneous impulsive moments. The results are obtained by using the fixed point theorem for condensing map and resolvent operator.

**CP-Th-E-65-4** 17:00–17:20
On the Existence of Boundary Value Problems for First-order Fuzzy Delay Differential Equations
Hongzhou, Wang
Beijing Inst. of Tech.

Abstract: In this paper, we consider existence of solutions to first-order fuzzy delay differential equation with two-boundary point value condition. Firstly, we study a class of linear fuzzy differential equation with boundary value condition \( x(0) = x(T) \), where \( a \in \mathbb{R} \). Some necessary conditions are provided with \( x \) in different intervals. Based on these results and upper and lower solutions method, we obtain some existence results about first-order nonlinear differential equation with the same boundary value condition.

**CP-Th-E-65-5** 17:20–17:40
Sharp Interface Model for Solid-state Dewetting Problems with Weakly Anisotropic Surface Energies
Wang, Yan
National Univ. of Singapore

Abstract: Based on an energy variational approach, we propose a sharp interface model for simulating solid-state dewetting of thin films with (weakly) anisotropic surface energies. The morphology evolution of thin films is governed by surface diffusion and contact line migration. For the contact line migration, we introduce a relaxation kinetics with a finite contact line mobility by energy gradient flow method. We implement the mathematical model in an explicit finite-difference scheme with cubic spline interpolation for evolving marker points. Following validation of the mathematical and numerical approaches, we simulate the evolution of thin-film islands, semi-infinite films, and films with holes. The numerical results capture many of the complexities associated with solid-state dewetting experiments.

**CP-Th-E-65-6** 17:40–18:00
Plane Waves at the Interface of Two Dissimilar Thermo-viscoelastic Half-spaces with Voids
Bhagwan, Jai
Government College for Women, Tosham (Bhiwani)

Tomar, Sushil Kumar
Panjab Univ., Chandigarh

Abstract: Refraction and transmission phenomena of plane waves striking obliquely at the plane interface between two dissimilar thermo-viscoelastic half-spaces with voids have been investigated. Two problems have been considered: (a) when a set of coupled dilatational waves is made incidence at the interface; (b) when a shear wave is made incidence at the interface. The theory of thermo-viscoelastic material with voids developed by Iesan (2011) has been employed for mathematical treatment. Potential method has been adopted to solve the equations of motion for two-dimensional problem. The equations giving the amplitude and energy ratios corresponding to various reflected and transmitted waves have been presented in closed form. Numerical computations have been performed for a specific model to study the dependence of various amplitude and energy ratios on the angle of incidence. Effects of various parameters on the amplitude ratios have been investigated and the corresponding results are depicted graphically.

**CP-Th-E-65-7** 18:00–18:20
Wavelet-Based FDTD and Tunable High Resolution Estimator for Calculation of Band Structures in Two-Dimensional Phononic Crystals
Yan, Zhizhong
Beijing Inst. of Tech.

Abstract: This paper discusses the wavelet-based Finite Difference Time Domain (FDTD) method and a tunable high resolution estimator with a specific problem of sound wave propagation through phononic crystals. If the band structures of a phononic crystal are calculated by the traditional FDTD method combined with the fast Fourier transform (FFT), some disadvantages, such as time consuming and the numerical instability of FDTD iterations are encountered. Moreover, good frequency estimation can only be ensured by the post-processing of sufficiently long time series. In this paper, a wavelet-based FDTD and a tunable high resolution estimator based on a bank of filters are proposed to overcome these difficulties. Numerical results for two-dimensional phononic crystal show that, the wavelet-based FDTD method improves the efficiency of the time stepping algorithm and the stability of iterations, and tunable high resolution estimator shows the advantages over the FFT-based spectral estimation.

**MS-Th-E-66** 16:00–18:00
VIP4-3
Theory and applications of Painleve type equations - Part II of II
For Part 1, see MS-Th-D-66

Organizer: Takenawa, Tomoyuki
Tokyo Univ. of Marine Sci. & Tech.

Organizer: Dzhemay, Anton
Univ. of Northern Colorado

Abstract: Last few decades have seen major developments in the theory of differential Painleve equations. Their solutions, called Painleve transcendents, are nonlinear special function that are playing an increasingly important role in many nonlinear problems in Mathematical Physics in areas such as Integrable Systems, Random Matrices, and others. Recently a lot of progress has been made in understanding the discrete analogues of Painleve equations and their connections to Algebraic Geometry and Representation Theory. The purpose of this minisumposium is to bring together researchers working in this active area to discuss recent advances in the theory and their applications to other fields.

**MS-Th-E-66-1** 16:00–16:30
Lax Pairs of Discrete Painleve Equations Arising from the Integer Lattice
Nakazono, Nobutaka
The Univ. of Sydney

Shi, Yang
The University of Sydney

Joshi, Nalini
The Univ. of Sydney

Abstract: Construction of the Lax pairs of the ordinary difference equations called discrete Painleve equations from those of the partial difference equations called ABS equations via the periodic type reduction are well investigated. In this talk we will show new method to obtain the Lax pairs of discrete Painleve equations from the integer lattice associated with ABS equation.

**MS-Th-E-66-2** 16:30–17:00
Symmetry and Combinatorics of Discrete Integrable Systems
Shi, Yang
the university of Sydney

Joshi, Nalini
The Univ. of Sydney

Nakazono, Nobutaka
The Univ. of Sydney

Abstract: Symmetry plays a central role in the study of integrable systems. Using the tools from representation theory of affine Weyl groups, we uncover various properties and relations between the different discrete integrable systems. In particular, the objects fundamental to this work are the polytopes (higher dimensional generalization of Polygons) associated with the symmetry groups, of which interesting geometric and combinatorial aspects will be discussed.

**MS-Th-E-66-3** 17:00–17:30
Exact WKBA Analysis for the Second Painleve Equation
Iwaki, Kohei
Research Inst. for Mathematical Sci.

Abstract: We analyze the second Painleve equation (P2) via the exact WKBA analysis. In particular, we discuss connection problems for non-linear or parametric Stokes phenomena for a WKB-type formal solution of P2.

**MS-Th-E-66-4** 17:30–18:00
A Bilateral Extension of the Ramanujan Entire Function
Morita, Takeshi
Osaka Univ.

Abstract: In this talk, we give a bilateral extension of the “Ramanujan entire function” and study the connection problem on the \( q \)-difference equations which satisfied by the extended Ramanujan entire function. We also introduce the multi-sum type \( q \)-Borel-Laplace transformations to study the connection problems.

**SL-Th-1** 19:00–20:00
Special Lecture
Ballroom C

Chair: Cook, L. Pamela

**SL-Th-1** 19:00–20:00
Predicting Population Extinction, Disease Outbreaks and Species Invasions Using Branching Processes
Allen, Linda J. S.
Texas Tech University

Abstract:
Friday, August 14, 2015

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**IL-Fr-1** 8:30–9:30 Table A
Invited Lecture

Chair: Esteban, Maria

**Abstract:**
Approximate likelihoods

Reid, Nancy
University of Toronto

Abstract: In complex models likelihood functions may be difficult to compute, or depend on assumptions about high order dependencies that may be difficult to verify. A number of methods have been devised to compute inference functions either meant to approximate the true likelihood function, or to provide inferential summaries that balance statistical efficiency with ease of computation. Examples include variational approximations, composite likelihood, quasi-likelihood, indirect inference, and Laplace-type approximations. This talk will survey various approximations to likelihood and likelihood inference, with a view to identifying common themes and outstanding problems.

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**IL-Fr-2** 8:30–9:30 Ballroom B
Invited Lecture

Chair: Cuminato, Jose A.

**Abstract:**
On Lagrangian Decomposition for Energy Optimization

Sagastizábal, Claudia
Instituto Nacional de Matemática Pura e Aplicada

Abstract: Real-life optimization problems often depend on data subject to unknown variations that can be due to imprecise measurements or to the stochastic nature of the data itself. When decisions need to be taken with high precision, it is important to employ methods that are reliable when subject to data variability. For complex problems such as those arising in the energy sector, advanced nonsmooth optimization techniques combined with Lagrangian decomposition provide a satisfactory answer to such concerns. We review recent approaches, including those referred to as having on-demand accuracy, for different Lagrangian functions. Throughout, the main concepts are illustrated by a simple example on optimal power management.

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**IL-Fr-3** 8:30–9:30 Ballroom C
Invited Lecture

Chair: Kang, Hyeonbae

**Abstract:**
Mathematical models and methods for noninvasive bioimpedance imaging

Seo, Jin Keun
Yonsei University

Abstract: In complex models likelihood functions may be difficult to compute, or depend on assumptions about high order dependencies that may be difficult to verify. A number of methods have been devised to compute inference functions either meant to approximate the true likelihood function, or to provide inferential summaries that balance statistical efficiency with ease of computation. Examples include variational approximations, composite likelihood, quasi-likelihood, indirect inference, and Laplace-type approximations. This talk will survey various approximations to likelihood and likelihood inference, with a view to identifying common themes and outstanding problems.

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**IL-Fr-4** 10:00–11:00 Ballroom A
Invited Lecture

Chair: Zhang, Pingwen

**Abstract:**
Applied Mathematics for Business Decision Making: The Next Frontiers

Kempf, Karl
Intel Corporation

Abstract: Humans have been making decisions for hundreds of thousand of years. Over those years situations have become much more complex and therefore the decisions much more difficult. This is especially true in today’s business world where the difference between a good decision and a bad decision can be worth billions of dollars. On the one hand, applied mathematicians have developed a variety of powerful tools and techniques to support good decision making. This power has been magnified many times over by the invention and continuous improvement of the digital computer. On the other hand, the legacy of hundreds of thousands of years of human decision making before the advent of computers is intuition. As most humans faced with decisions recognize, sometimes intuition is helpful and sometimes it is misleading. This paper provides a rudimentary background on the rise of both intuition and analytics. It then provides quantitative data on the shortcomings of intuitive decision making and the benefits of decision making aided by analytics drawn from 25 years of work directed at improving business decision making at Intel Corporation. Finally it identifies the next frontier in applied mathematics for decision making in business as the beneficial merger of intuition and analytics. A few encouraging examples are displayed to help quantify the power of analytics guiding intuition and intuition guiding analytics.

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**IL-Fr-5** 10:00–11:00 Ballroom B
Invited Lecture

Chair: Gao, Xiaoshan

**Abstract:**
Correlations: From Classical to Quantum

Luo, Shunlong
Academy of Mathematics and Systems Science, CAS

Abstract: The concept of correlations permeates our world in a profound and ubiquitous way. The gist of science is to classify and quantify correlations, and to reveal relations between different correlations. Correlations are many faceted and constitute basic resources that can be measured, manipulated, and utilized. With the advent of quantum information theory, which concerns the general study of information processing capability of quantum systems and ushers a new vista full of challenging mathematical problems and marvellous physical potentialities, correlations are playing an increasingly instrumental and significant role in the description and exploitation of nature. In this talk, we present an overview of some quantitative and informational aspects of correlations in both classical and quantum regimes, with focus on the interplay between classical and quantum, and their implications for quantum foundations and applications. We discuss classification and quantification of correlations, touch upon various topics such as classical correlations, quantum discord, quantum steering, quantum entanglement, and quantum nonlocality. Coexistence of correlations, including marginal problem and monogamy of correlations, is put in the context of setting fundamental constraints to physical laws, and is linked to Bohr’s complementary principle and Heisenberg’s uncertainty relations. We speculate that an informational approach to science via correlations may shed light on, and reconcile the tension between, quantum mechanics, which has unprecedented predictive power in microscopic world, and relativity theory, which has equally unprecedented predictive power for cosmological phenomena.

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**IL-Fr-6** 10:00–11:00 Ballroom C
Invited Lecture

Chair: Treffethen, Lloyd N.

**Abstract:**
Formal series and numerical integrators: some history and some new techniques

Serna, Jesús Sanz
Universidad de Valladolid

Abstract: This paper provides a brief history of B-series and the associated Butcher group and presents the new theory of word series and extended word series. B-series (Hairer and Wanner 1976) are formal series of functions parameterized by rooted trees. They greatly simplify the study of Runge-Kutta schemes and other numerical integrators. We examine the problems that led to the introduction of B-series and survey a number of more recent developments, including applications outside numerical mathematics. Word series (series of functions parameterized by words from an alphabet) provide in some cases a very convenient alternative to B-series. Associated with word series is a group G of coefficients with a composition rule simpler than the corresponding rule in the Butcher group. From a more mathematical point of view, integrators, like Runge-Kutta schemes, that are affine equivariant are represented by elements of the Butcher group, integrators that are equivariant with respect to arbitrary changes of variables are represented by elements of the word group G.

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**IL-Fr-7** 11:10–12:10 Ballroom A
Invited Lecture

Chair: Fonseca, Irene

**Abstract:**
TBA
We study the Lie algebra of infinitesimal symmetries of a system of differential equations in telecommunications, such as solitary wave. Homological algebra has the reputation of being the theory of abstract notions and lengthy complex constructions. Generalized morphism is a computer friendly notion which turns many of these constructions into simple abstract formulas, easily implementable on a computer. I will demonstrate two applications of constructive spectral sequences.

**MS-Fr-D-01-1**
**A Note on Aubin-Lions-Dubinskii Lemmas**
Chen, Xiqiu
Beijing Univ. of Posts & Telecommunications
Abstract: Strong compactness results for families of functions in seminormed nonnegative cones in the spirit of the Aubin-Lions-Dubinski lemma are proven, refining some recent results in the literature. The first theorem sharpens slightly a result of Dubinski (1965) for seminormed cones. The second theorem applies to piecewise constant functions in time and sharpens slightly the results of Dreher and Juengel (2012) and Chen and Liu (2012). An application is given, which is useful in the study of porous-medium or fast-diffusion type equations.

**MS-Fr-D-01-2**
**Water-mark Scheme of LDPC in High Speed Optical Communication**
Zhang, Wenbo
Beijing Univ. of Posts & Telecommunications
Abstract: LDPC is a FEC algorithm used in high speed communications, since it allows the noise threshold to be set very close to Shannon limit. BP algorithm is a decoding algorithm for LDPC which can provide excellent results and can be practically implemented. In this talk, the water mark LDPC (WMLDPC) scheme, which is a new scheme involving channel information, is introduced. Simulations show that performance of WMLDPC scheme is much better than that of traditional scheme.

**EM-Fr-D-02-2**
**A Renormalisation Operator on Multivariable Meromorphic Functions**
Paycha, Sylvie
Univ. of Potsdam
Abstract: The Rota-Baxter operator given by the projection of meromorphic functions in one variable to their holomorphic part is generalised to a projection map on germs of meromorphic functions in several variables with linear poles. This generalised Rota-Baxter type decomposition uses in an essential way the differential algebra structure on germs of meromorphic functions and serves as a renormalisation map. This is joint work with Li Guo and Bin Zhang.

**EM-Fr-D-02-3**
**Picard-Vessiot Theory and Infinitesimal Symmetries of Linear Differential Equations**
Blazquez Sanz, David
Universidad Nacional de Colombia - Medellin
Abstract: We study the Lie algebra of infinitesimal symmetries of a system...
of linear ordinary differential equations. We show the interplay between the Galois group and the Lie algebra of symmetries. We show that it suffices to study vertical symmetries whose components are polynomials in the unknown functions. Such symmetries are solutions of some associated equations. In particular, the existence of rational symmetries constrains the Galois group of the equation.

Abstract: As a generalization of the Picard-Vessiot theories for differential and difference equations we propose a non-commutative Picard-Vessiot theory for linear functional equations over a constant base field. Non-commutativity appears in three forms: The operators can have non-symmetrical product rules (skew-deformations for instance). The underlying rings are not necessarily commutative. Instead of affine group schemes as Galois groups possibly non-commutative Hopf algebras appear.

Non-commutative Picard-Vessiot Theory over Constants
Heiderich, Florian National Research Univ. Higher School of Economics

Abstract: The equation with state-dependent delay does not satisfy the standard comparison principle. We construct a proper wave profile set such that the comparison principle is applicable. By fixed point theorem and the theory of asymptotic spreading, we present the existence and nonexistence of traveling wave solutions.

Traveling Wave Solutions of a Diffusion Equation with State-Dependent Delay
Lin, Zhigui Yangzhou University

Abstract: In this talk, we first propose a time-periodic reaction-diffusion epidemic model which incorporates simple demographic structure and the latent period of infectious disease. Then we introduce the basic reproduction number $R_0$ for this model and prove that the sign of $R_0-1$ determines the local stability of the disease-free periodic solution. By using the comparison arguments and persistence theory, we further show that the disease-free periodic solution is globally attractive if $R_0-1$, while there is an endemic individuals are obtained. Furthermore, the uniform persistence, extinction $R_f$, reaction-diffusion epidemic model is introduced by means of establishing the traveling wave solutions.

A Reaction-Diffusion SIS Epidemic Model in an Almost Periodic Environment
Wang, Bin-Guo School of Mathematics & Statistics, Lanzhou Univ.

Abstract: Given a point cloud $u$ and a corresponding persistence diagram $v$, we apply continuation to the persistence diagrams to find a new point cloud $u$ (close to $u$), that have a prescribed persistence diagram $v$ (close to $v$). We present the details and the algorithms to perform the continuation as well as some results.

Threshold Dynamics of a Time Periodic Reaction-diffusion Epidemic Model with Latent Period
Wang, Zhi-Cheng Lanzhou Univ.

Abstract: In this talk, we first propose a time-periodic reaction-diffusion epidemic model which incorporates simple demographic structure and the latent period of infectious disease. Then we introduce the basic reproduction number $R_0$ for this model and prove that the sign of $R_0-1$ determines the local stability of the disease-free periodic solution. By using the comparison arguments and persistence theory, we further show that the disease-free periodic solution is globally attractive if $R_0-1$, while there is an endemic individuals are obtained. Furthermore, the uniform persistence, extinction $R_f$, reaction-diffusion epidemic model is introduced by means of establishing the traveling wave solutions.
Auszlander-Reiten quiver of $A_n$ encodes the permissible row and column operations that one can perform on this matrix.

**Efficient Persistent Homology Computations**

Wagner, Hubert

IST Austria

**Abstract:** I will discuss practical efficiency of persistent homology computations. I present a number of techniques implemented in the PHAT library. In particular, a specialized data-structure, called BTree, designed to efficiently handle complex addition. A comprehensive benchmark will demonstrate the practical impact of the described optimizations. This will also show what types and sizes of data can be efficiently handled by the current generation of software.

Joint work with Uli Bauer, Michael Kerber and Jan Reininghaus.

**Geometric Understanding of Data in 3D and Higher - Part II of III**

For Part 1, see MS-Th-E-05

For Part 3, see MS-Fr-E-05


Organizer: Zhao, Hongkai UC Irvine

**Abstract:** Rapid development of data acquisition technology stimulates research on developing new computational tools for analyzing and processing data to make more effective decisions. In many problems, coherent structures of data allow us to model data as a low dimension manifold in a high dimension space. More recently, there has been increasing interests in using geometric based method to analyze and infer underlying structures from the given data. This minisymposium aims to bring together people from different research groups with common interest. We hope that this symposium can propel further collaborations and developments in this field.

**A Novel Geometric Multiscale Approach to Structured Dictionary Learning on High Dimensional Data**

Chen, Guangliang

San Jose State Univ.

**Abstract:** Many real data sets have high ambient dimensions, but they are often intrinsically low-dimensional. We exploit such an assumption for efficiently representing high-dimensional data by using an adaptive, sparsifying dictionary. We construct the dictionary directly from the data based on a novel geometric multi-resolution analysis and we will show that it also relates to dictionary learning on the Grassmannian. In this talk, we present our constructions and associated advantages and demonstrate applications to image processing.

**Understanding Data from Incomplete Distance Information via Solutions of Geometric PDEs.**

Lai, Rongjie

Rensselaer Polytechnic Inst.

**Abstract:** To have global understanding of data from local or incomplete set of pairwise distance is an important problem that has many applications such as 3D modeling, sensor network etc. In this talk, we will discuss our recent work of solving geometric differential equations based on data from incomplete distance. We will also demonstrate applications of this method for reconstruction and understanding distance data based on solutions of differential equations.

**Data Analysis Tools for Large-scale Computer Vision and Multi-media Information Retrieval**

Bronstein, Alexander

Tel Aviv Univ.

**Abstract:** The rapid growth of the amounts of produced and consumed visual and multi-media information challenges existing tools and practices used in the organization, search, and analysis of such data. I will address problems in large-scale computer vision such as content-based retrieval, image-based localization, and 3D reconstruction of large scenes from collections of images, and show the construction of several geometric tools attempting to tackle these challenges.

**Fast Multiscale Optimal Transport for Point Clouds in High Dimensions**

Maggioni, Mauro

Duke Univ.

**Abstract:** We describe a novel algorithm for computing optimal transportation distances and corresponding plans between point clouds in high-dimensions, with assumptions on the geometry of the point cloud, in particular low intrinsic dimensionality. These distances are widely used in shape analysis, computer vision, and image retrieval tasks, and many other applications. We verify empirically that the algorithms scale linearly in the number of points, both in terms of computational complexity and memory usage.

**Data-driven methods for quantifying uncertainty of multiscale dynamical systems - Part III of IV**

For Part 1, see MS-Th-D-06

For Part 2, see MS-Th-E-06

For Part 4, see MS-Fr-E-06

Organizer: Harlim, John The Pennsylvania State Univ.

Organizer: Sapsis, Theodoros MIT

Organizer: Giannakis, Dimitrios New York Univ.

**Abstract:** A major challenge in contemporary applied science is to design efficient models for predicting dynamical behavior resulting from complex interaction of multiple scale processes. This task, implicitly, requires one to account for uncertainties of the models due to initial conditions, boundary conditions, model errors, and observation errors. A promising interdisciplinary approach to address such issue is with a data-driven statistical methods that combine ideas from dynamical systems theory, stochastic processes, statistics, and data analysis. This special session aims to bring together researchers from across the spectrum of disciplines related to data-driven methods to discuss the development and application of emerging ideas and techniques for these important and difficult practical issues.

**Towards Optimal Control of Gliders for Velocity Field Assimilation**

Moore, Richard

New Jersey Inst. of Tech.

**Abstract:** Autonomous vehicles, or gliders, offer flexible platforms for the collection of physical oceanography data, and are being deployed in a number of projects of scientific interest around the world. The gliders have a small capacity for locomotion but are strongly advected by a noisy velocity field that they infer through direct and indirect measurement. We discuss the viability and computational efficiency of optimal control techniques to improve the efficiency of the velocity field assimilation.

**Uncertainty Quantification (and Sensitivity!) in Fluid Dynamics and Control**

Brunton, Steven

Univ. of Washington

**Abstract:** Fluid systems are characterized by high-dimensional, nonlinear dynamics, although they often evolve on low-dimensional attractors. The behavior of these attractors are particularly relevant for feedback flow control. In this talk, I will discuss the role of uncertainty quantification in understanding the sensitivity of fluid flows to disturbances and actuation. This will encompass recent advances in data-driven modeling, including the dynamic mode decomposition (DMD), the finite-time Lyapunov exponent (FTLE), and generalized polynomial chaos (gPC).

**Statistical Learning for Model Reduction with ATLAS**

Maggioni, Mauro

Duke Univ.

Crosskey, Miles

Duke Univ.

Weare, Jonathan

Univ. of Chicago

**Abstract:** We discuss ATLAS, a statistical learning framework for model reduction of high-dimensional dynamical systems with few intrinsic degrees of freedom. The algorithm is highly parallelizable and it has shown to solve initial and final trajectories of the system (treated as a black-box), and learns from these short paths an ensemble of accurate local reduced models. It then pastes them together to create a global model, which is guaranteed to be accurate for large times. We present several examples.

**Timescale Separation and Forecasting with Dynamics-adapted Kernels**

Giannakis, Dimitrios

New York Univ.

**Abstract:** We discuss kernel methods for extracting intrinsic timescales of dynamical systems and nonparametric forecasting. These so-called cone kernels utilize the time ordering of the data to approximate the generator of the dynamics operating in the phase-space manifold. The associated kernel eigenfunctions provide dimension reduction coordinates which favor slow intrinsic timescales of the dynamics. We present applications in spatiotemporal decomposition and nonparametric forecasting of toy dynamical systems and comprehensive climate models.
Abstract:
Inverse problems in wave propagation have played a fundamental role in diverse scientific areas such as radar and sonar, geophysical exploration, medical imaging, near-field optical microscopy, and nano-optics. Due to the complexity of material properties and uncertainty in physical models and parameters, precise modeling and accurate computing present challenging and significant mathematical and computational questions, and remain the subject matter of much ongoing research.

The minisymposium aims to recent mathematical and computational studies of inverse problems in various wave propagation models, including acoustic, electromagnetic, optical, elasticity, and quantum wave propagation. It seeks to bring together leading researchers in these fields to present recent developments, promote exchange of ideas, and discuss new directions including treatment of multi-frequency and near-field data, and multi-wave imaging. The talks will cover all the aspects of inverse scattering problems like asymptotic techniques, sensitivity analysis, numerical computation, and wave propagation in complex and random media.

MS Fr D-09-1
13:30–14:00
A Direct Imaging Method for Inverse Obstacle Scattering from Phaseless Far-Field Data
Zhang, Bo
Acad. of Mathematics & Sys. Sci., CAS

Abstract:
In this talk, we consider the inverse problem of reconstructing acoustic obstacles from phaseless far-field data in inverse obstacle scattering. We propose a direct imaging algorithm for reconstruction of an acoustic obstacle, using only phaseless far-field data. Our algorithm does not need to know the type of boundary conditions on the obstacle in advance and is capable to reconstruct multiple obstacles with different boundary conditions and even with different scales. Numerical examples are also provided illustrating that the reconstruction algorithm is stable, accurate and robust to noise. This is a joint work with Haiven Zhang.

MS Fr D-08-2
14:00–14:30
Inverse Transport and Acousto-optic Imaging
Schotland, John
Univ. of Michigan

Abstract:
A method to reconstruct the optical properties of a highly-scattering medium from acousto-optic measurements is proposed. The method is based on the solution to an inverse problem for the Helmholtz equation, with and without internal data. A stability estimate and a direct reconstruction procedure are described.

MS Fr D-08-3
14:30–15:00
An Efficient Neumann Series-based Algorithm for Thermoacoustic and Photoacoustic Tomography with Variable Sound Speed
Zhao, Hongkai
UC Irvine

Abstract:
We present an efficient algorithm for reconstructing an unknown source in Thermoacoustic and Photoacoustic Tomography based on the recent advances in understanding the theoretical nature of the problem. We work with variable sound speeds that might be also discontinuous across some surface. The latter problem arises in brain imaging. The algorithm development is based on an explicit formula in the form of a Neumann series.

MS Fr D-08-4
15:00–15:30
Determining the Waveguide Conductivity in A Hyperbolic Equation from A Single Measurement on the Lateral Boundary
Bellina, Larisa
Chalmers Univ. of Tech. & Gothenburg Univ.

Cristolof, Michel
Aix-Marseille Univ., Institut de Mathematiques

Li, Shumin
Univ. of Sci. & Tech. of China

Ninimaki, Kati
Royal Inst. of Tech.

Soccorsi, Eric
Aix-Marseille Univ.

Abstract:
We consider the multidimensional inverse problem of determining the coefficient in the principal part of a hyperbolic equation in an infinite cylindrical domain, from a single boundary observation of the solution. We prove a H2#24;#26;#22;haracter stability with the aid of a Carleman estimate specifically designed for hyperbolic waveguides. The coefficient in the principal part is assumed to depend on x only or both x and t. We further provide some numerical simulations.

MS Fr D-09
13:30–15:30
Mathematical Modeling and the analysis in dissipative systems - Part I of II
For Part 2, see MS Fr E-09
Organizer: ET, SHIN-ICHIRO
Hokkaido Univ.
Organizer: Nagayama, Masaharu
Hokkaido Univ.

Abstract:
In this minisymposium, we aim to merge mathematical modeling and the theoretical analysis for phenomena arising in dissipative systems including chemical reactions and biological systems by introducing from each field both of models for real phenomena and techniques for nonlinear differential equations. As mathematical models, we deal with nonlinear parabolic equations of gas dynamics with gravity and shallow water equations with Coriolis forces. The schemes are capable of exactly preserving steady-state solutions expressed in terms of a nonlocal equilibrium variable. A crucial step in the construction of the schemes is a well balanced piecewise linear reconstruction of equilibrium combined with a well-balanced evolution in time.

MS Fr D-07-2
14:00–14:30
Central-Upwind Schemes for Systems of Balance Laws
Chertock, Alina
North Carolina State Univ.

Abstract:
I will describe Riemann-problem-solver-free central-upwind schemes for the shallow water equations. It has recently been noted by Berthon et al. and Morales et al. that the widely used hydrostatic reconstruction method (HR) due to Audusse et al. converges slowly for some downhill flows. In this paper, we propose a one-line change of the intermediate bottom height in the HR method which cures this imperfection. The new choice of the intermediate bottom is motivated by a subtle splitting of the source term at the wet-dry front. After proving positivity, well-balancing and an entropy inequality, we demonstrate the impact of the new HR method by numerical experiments for some downhill flows.

MS Fr D-07-3
14:30–15:00
Asymptotic Preserving Schemes for Singular Limit Flows
Lukacova, Maria
Univ. of Mainz, Inst. of Matematicks

Abstract:
In the present talk we will describe new asymptotic preserving schemes to some singular limit flows that arise in geophysics. The main idea is to split a fully nonlinear system in the stiff linear part, governing fast waves, and a nonstiff nonlinear part, describing slow motions. IMEX type time discretization and specific FV-type space discretization yield to time-space asymptotic accurate schemes, which can be proven theoretically and shown experimentally.

MS Fr D-07-4
15:00–15:30
Central-Upwind Schemes for Shallow Water Models
Kurganov, Alexander
Tulane Univ.

Abstract:
I will describe Riemann-problem-solver-free central-upwind schemes for the Saint-Venant system and related shallow water models. The main difficulties are to preserve a delicate balance between the flux and source terms and to ensure positivity of the computed water depth (and/or other quantities, which are supposed to remain nonnegative). I will present a general approach of designing well-balanced positivity preserving central-upwind schemes and illustrate their performance on a number of shallow water models.
equations of reaction-diffusion types and higher dimensional ODEs. Through the interaction between modeling and mathematical techniques, many joint works with researchers from both fields are expected.

**MS-Fr-D-09-1** 13:30–14:00
The Collective Motion of Camphor Papers in A Cylindrical Channel
Nagayama, Masaharu  
Hokkaido Univ.
Abstract: Billiard and jamming like motions of camphor papers placed over water have recently been observed in cylindrical channels. We investigate the mechanisms of these motions by constructing a mathematical model for the camphor system. In particular, we study the motion of two camphor papers by means of numerical simulation and mathematical analysis. As a result of our investigations, we have uncovered various morphologies of the camphor paper motions.

**MS-Fr-D-09-2** 14:00–14:30
Reaction-advection-diffusion Equations with Free Boundaries
Lou, Bendong  
Tongji Univ.
Abstract: In this talk we consider reaction-advection-diffusion equations in one dimension, with two free boundaries satisfying the Stefan conditions. The model is used to describe the population dynamics in advective environments. We study the influence of the advection coefficient on the long time behavior of the solutions. Among others, we find that a solution may converges to a traveling wave with tadpole-like profile.

**MS-Fr-D-10-1** 13:30–14:00
A Mathematical Model of Planar Cell Polarity
Akiyama, Masakazu  
Research Inst. for Electronics Sci., Hokkaido Univ.
Abstract: Many cells within epithelial tissues display polarity along a particular axis. This axis is perpendicular to the tissue plane and apicobasal axis of the cell. This phenomenon is called “planar cell polarity, PCP”, and is a common phenomenon found in many multicellular organisms. In this talk, we will introduce our mathematical model and simulation result. Despite of our model is very simple formulation, it can reproduce various aspects of the PCP.

**MS-Fr-D-10-2** 14:00–14:30
Stochastic Homogenization on Manifolds
Li, Xue-Mei  
The Univ. of Warwick
Abstract: We consider a family of stochastic differential equations on manifolds with a small parameter epsilon and study the convergence of their slow motions.

**MS-Fr-D-10-3** 14:30–15:00
Stochastic Dynamics: Advances and Perspectives
Duan, Jinqiao  
Illinois Inst. of Tech
Abstract: Dynamical systems arising in engineering and science are often subject to random influences (“noise”). To understand dynamics under uncertainty, topological, geometric and analytical approaches are taken to examine the quantities that carry dynamical information and the structures that act as dynamical skeletons. The speaker will present an overview of available theoretical and numerical techniques for investigating stochastic dynamical systems, highlighting some delicate and profound impact of noise on dynamics. Then, he will focus on understanding stochastic dynamics by examining “escape probability”, in the context of prototypical examples in biophysical and physical settings.

**MS-Fr-D-10-4** 15:00–15:30
Metastability in Stochastic Burgers Equation
Chen, Xiaopeng  
Shantou Univ.
Abstract: The stochastic center manifold is considered for the stochastic Burgers equation with initial value problem. Then the metastability in the stochastic Burgers equation is described by the stochastic center manifold.

**MS-Fr-D-11** 13:30–15:30
206B
Matrix computations using structures and other innovative techniques - Part III of III
For Part 1, see MS-Th-D-11  
For Part 2, see MS-Th-E-11
Organizer: Xia, Jianlin  
Purdue Univ.  
Organizer: Chen, Jie  
IBM Thomas J. Watson Research Center
Abstract: This minisymposium is concerned with a wide range of innovative matrix computation techniques, including structures, randomization, splitting preconditioning, etc. The techniques make it feasible to develop new and reliable direct or iterative solutions. In particular, certain block or hierarchical structures can be used to obtain effective preconditioners or nearly linear complexity direct solvers for challenging numerical problems. Interesting applications to imaging, PDE/Integral equation optimizations, optimization, parallel computing, and engineering simulations will also be shown.

**MS-Fr-D-11-1** 13:30–14:00
On Convergence of AVMM for Solving Equality-Constraint Quadratic Programming Problems
Bai, Zhong-Zhi  
Chinese Acad. of Sci.
Abstract: We discuss unique solvability of the equality-constraint quadratic programming problem, establish a class of preconditioned alternating variable minimization with multiplier (PAVMM) methods for iteratively computing its solution, and demonstrate asymptotic convergence property of these PAVMM methods. We also discuss an algebraic derivation of the PAVMM method by making use of matrix splitting.

**MS-Fr-D-11-2** 14:00–14:30
Krylov and Saunders Subspace Methods
Choi, Sou-Cheng  
NORC at the Univ. of Chicago
Abstract: Large-scale linear systems, linear least-squares problems, and eigenvalue problems are pervasive in science and engineering applications. For high-performance computing, we establish a suite of Krylov and Saunders subspace methods, MINRES-QLP and GMRES-URV, for solving these problems that neither suffer hard breakdowns nor evade singular square matrices or linear operators. For linear systems and least-squares problems, by leveraging rank-revealing matrix factorizations, our methods minimize both solution and residual norms of a sequence of subproblems whose

**MS-Fr-D-11-3** 14:30–15:00
Preconditioners for Weighted Toeplitz Least Squares Problems
Pan, Jianyu  
East China Normal Univ.
Abstract: We will talk about the fast algorithms for solving weighted Toeplitz regularized least squares problems. Based on augmented system formulation, we develop a new HSS preconditioner. The advantage of the proposed preconditioner is that the blurring matrix, weighting matrix, and regularization matrix can be decoupled so that the resulting preconditioner is not expensive to apply. The spectrum distribution and choice of parameters are discussed in details. Numerical results are reported to demonstrate the performance.
Abstract:

We consider the Hankel determinants associated with the singularly perturbed Laguerre weight \( w(x) = x^\alpha e^{-x} \), \( x \in (0, \infty) \), \( t > 0 \) and \( \alpha > 0 \). When the matrix size \( n \to \infty \), we obtain an asymptotic formula for the Hankel determinants, valid uniformly for \( t \in (0, d) \), \( d > 0 \) fixed. A particular Painlevé III transcendent is involved in the approximation, as well as in the large-\( n \) asymptotics of the leading coefficients and recurrence coefficients for the corresponding perturbed Laguerre polynomials.

Numerics for classical applications of Riemann-Hilbert problems

Olver, Sheehan The Univ. of Sydney

Abstract: We overview several classical problems that can be reduced to Riemann-Hilbert problems and solved numerically, falling into three categories: integral representations, differential equations and inverse spectral problems.

Asymptotics of Discrete Orthogonal Polynomials

Zhao, Yuqiu Sun Yat-sen Univ.

Abstract: We develop the Riemann-Hilbert method to study the asymptotics of two types of orthogonal polynomials. The first type of orthogonality is on infinite nodes with an accumulation point. To illustrate our method, we consider the Tricomi-Carlitz polynomials. Another type of orthogonality is characterized by small scale heterogeneities or fast scale random fluctuations, and are thus difficult for analysis and expensive for computation. We hope this minisymposium will strengthen the connections among people in the relevant areas and stimulate future research.

No Blow-up in Some Variational Wave Systems in Liquid Crystals

Zheng, Xuyi The Pennsylvania State Univ.

Abstract: We consider a full nonlinear variational wave system modeling nematic liquid crystals, which has spay, twist and bend capabilities. If the spay and bend coefficients are equal, we show that the solutions to initial value problems do not develop spontaneous singularities in time. The talk is based on joint work with Jingchi Huang.

Asymptotic Expansions for the First Painlevé Transcendent

Li, Yanqian Hong Kong Baptist Univ.

Abstract: The asymptotic expansions of the first Painlevé transcendent is well studied in the literature, and they are involved in the problem of connection formulas. In this talk, we shall review the existing results, and establish a new asymptotic expansion for the osculatory case. Our result is based on techniques from singular perturbation problems with resonance.

Effective dynamics of stochastic partial differential equations - Part II of III

For Part 1, see MS-Th-E-14

For Part 3, see MS-Fr-E-14

Organizer: Wang, Wei Nanjing Univ.

Abstract: Effective dynamical reduction for stochastic partial differential equations is desirable. The simplified system provide an effective model to be applied to understand the large scale spatio-temporal dynamics. For one dimensional systems with small data, a well-posedness theory of entropy weak solutions is well known. Analysis in several space dimension, however, remains an enormous challenge. In this minisymposium, recent results in the theory and numerical analysis of hyperbolic problems will be presented. A variety of computational techniques, including finite volume, finite element, spectral, WENO, and discontinuous Galerkin methods, will be represented.

A Fast Explicit Operator Splitting Method for Modified Buckley-Leverett Equations

Wang, Ying Univ. of Oklahoma

Kao, Chiu-Yen Claremont McKenna College

Kurganov, Alexander Tulane Univ.

Abstract: In this talk, I will discuss a fast explicit operator splitting method to solve the modified Buckley-Leverett equations which include a third-order mixed derivatives term resulting from the dynamic effects in the pressure difference between the two phases. The method splits the original equation into two equations, one with a nonlinear convective term and the other one with high-order linear terms so that appropriate numerical methods can be applied to each of the splitting equations.

Element Discretization

MIN, MISUN Argonne National Laboratory

Abstract: SPDEs arise naturally modeling multiscale systems under random influences. We consider macroscopic dynamics of microscopic systems described by SPDEs and characterized by small scale heterogeneities or fast scale random fluctuations, and are thus difficult for analysis and expensive for
numerical simulation. Effective models are desirable as they capture crucial dynamical features of the original systems but are more amenable for analysis and computation. The speaker presents recent advances and results in effective modeling for SPDEs.

**MS-Fr-D-14-2**

**On the Eigenfunctions of the Complex Ornstein-Uhlenbeck Operators and Applications**

Liu, Yong  
Peking Univ.

Abstract: In this talk, we show that the complex Hermite polynomials are the eigenfunctions of complex Ornstein-Uhlenbeck operators, and obtain a product formula of Hermite polynomials. Using this formula, we give the relation between real Wiener-Ito chaos and the complex Wiener-Ito chaos (or: multiple integrals). As an application, we prove the fourth moment theorem or say: the Nualart-Peccati criterion) for the complex Wiener-Ito multiple integrals. This is a joint work with Yong Chen

**MS-Fr-D-14-3**

**Identification of the Point Sources in Some Stochastic Wave Equations**

Guanglin, Rang  
Wuhan Univ.

Abstract: We introduce and study a type of (one dimensional) wave equations with noisy points sources. We study the existence and uniqueness problem of the equations. Then, we assume that the locations of point sources are unknown but we can observe the solution at some other location continuously in time. We propose an estimator to identify the point source locations and prove the convergence of our estimator.

**MS-Fr-D-14-4**

**Slow foliation of a slow - fast stochastic evolutionary system**

Chen, Guanggan  
Sichuan Normal Univ.

Abstract: This work is concerned with the dynamics of a slow - fast stochastic evolutionary system quantified with a scale parameter. A slow invariant foliation is established for this system. It is shown that the slow foliation converges to a critical foliation in probability distribution, as the scale parameter tends to zero. Furthermore, the geometric structure of the slow foliation is investigated.

**MS-Fr-D-15**

**PDEs and applications: theory and computation - Part III of IV**

For Part 1, see **MS-Th-D-15**  
For Part 2, see **MS-Th-E-15**  
For Part 4, see **MS-Fr-E-15**  

Organizer: Wang, Ying  
Univ. of Oklahoma
Organizer: Nie, Hua  
Shaanxi Normal Univ.

Abstract: Partial differential equations (PDEs) have been widely used in the mathematical modeling of physical and biological phenomena, including mixed type equations. Many problems of an applied nature reduce to finding specific solutions and properties of PDEs of elliptic, parabolic, or of mixed type; in particular, problems of plane transonic flow of a compressible medium, and problems in the theory of envelopes. In this mini-symposium, recent results in the theory and computation of PDEs and their applications will be presented. The goal of this mini-symposium is to provide a platform for the world experts in the area of PDEs, both theory and computation, to report the recent progresses, exchange ideas and build up collaborative works. We anticipate that our speakers will have expertise in a wide-ranging array of topics, possibly including: (i) qualitative and quantitative properties enjoyed by solutions to nonlinear partial differential equations of elliptic, parabolic, or of mixed type, (ii) numerical schemes derived for various types of PDEs, (iii) physical and biology modeling involving nonlinear partial differential equations of elliptic, parabolic, or of mixed type.

**MS-Fr-D-15-1**

**Interplay of Dissipation and Dispersion in Two-phase Flow**

Wang, Ying  
Univ. of Oklahoma

Abstract: In this talk, I will introduce the modified Buckley-Leverett (MBL) equation describing two-phase flow in porous media. The MBL equation differs from the classical Buckley-Leverett (BL) equation by including a diffusive-dispersive combination. The dispersive term is a third order effect in the pressure difference between the two phases. I will show that the solution of the finite interval [0,L] boundary value problem converges to that of the half-line [0, infinity) boundary value problem as L tends to zero. Furthermore, the geometric structure of the slow foliation is established for this system. It is shown that the slow foliation converges to a critical foliation in probability distribution, as the scale parameter tends to zero. Furthermore, the geometric structure of the slow foliation is investigated.

**MS-Fr-D-15-2**

**Steady-state Biharmonic for the Activator-depleted Substrate Model**

Wang, Yan-e  
Shaanxi Normal Univ.

Abstract: This paper concerns an activator-depleted substrate system in a bounded domain. Under no-flux boundary conditions, asymptotic stability properties of positive constant steady states are discussed firstly. Then, the steady state bifurcations with a one-dimensional kernel and a two-dimensional kernel are intensively studied in R^1. The main tools adopted here include stability theory, bifurcation theory, the techniques of space decomposition and implication function theory. Finally, we illustrate our results with numerical simulations.

**MS-Fr-D-15-3**

**Fundamental Solutions for A Class of Homogeneous Fractional Elliptic Equations**

Cao, Yi  
Shaanxi Normal Univ.

Abstract: We consider a class of elliptic non-local equations with homogeneous kernel (k(x,y)) in this paper. If the kernel k(x,y)=1, then we obtain the fractional Laplace equation. By constructing a super(sub) solution, we give the existence of a unique fundamental solutions, which is bounded on one side. A Liouville-type result demonstrate that the fundamental solution is the unique nontrivial solution that are bounded on one side in a neighborhood of the origin.

**MS-Fr-D-15-4**

**Geometrical Singular Perturbation Methods and Application to A Generalized KdV-mKdV Equation**

Du, Zengji  
Jiangsu normal Univ.

Abstract: This talk deals with a generalized KdV-mKdV equation . By employing the geometrical singular perturbation theory and the linear chain trick, we establish the existence result of solitary wave solutions when the average delay is sufficiently small, for a special convolution kernel.

**MS-Fr-D-16**

**System of Conservation Laws and Related Models - Part III of IV**

For Part 1, see **MS-Th-D-16**  
For Part 2, see **MS-Th-E-16**  
For Part 4, see **MS-Fr-E-16**  

Organizer: Li, Yachun  
Shanghai Jiao Tong Univ.
Organizer: Wang, Weike  
Shanghai Jiao Tong Univ.
Organizer: Wang, Yaguang  
Shanghai Jiaotong Univ.
Organizer: Xie, Chunjiang  
Shanghai Jiao Tong Universit


**MS-Fr-D-16-1**

**Steady Transonic Shocks in Compressible Euler Flows**

Yuan, Hairong  
Department of Mathematics, East China Normal Univ.

Abstract: I will introduce the physical phenomena of transonic shocks, and review some progresses on the mathematical studies of related boundary value problems of the steady compressible Euler equations. The talk is based upon joint works with many collaborators.

**MS-Fr-D-16-2**

**Rarefaction Waves for Collisional Fluid Plasmas**

Duan, Renjun  
The Chinese Univ. of Hong Kong

Abstract: The motion of collisional fluid plasmas is often governed by the compressible Navier-Stokes-Poisson system. In the talk, we are concerned with the large time behaviour of the system in the case when the electric potential takes distinct far-field data. For that, we mainly present the construction of rarefaction waves in terms of the quasineutral Euler system, and then use the energy method to show that the profile is time-asymptotically stable under small perturbation.

**MS-Fr-D-16-3**

**Self-similar 2d Euler Solutions with Vorticity of Mixed Sign**

Elling, Volker  
Univ. of Michigan

Abstract: We construct a class of self-similar 2d incompressible Euler solutions that have initial vorticity of mixed sign. The regions of positive and negative vorticity form algebraic spirals.

**MS-Fr-D-16-4**

**Global Solutions to Some Gas-vauum Interface Problems of Compressible Fluids**

Luo, Tao  
Georgetown Univ.

Abstract: Some recent results will be presented on the global solutions to some gas-vauum interface problems of compressible fluids including inviscid...
flow with damping convergent to Barenblatt solutions (joint with Huihui Zeng) and viscous flows with self-gravitation convergent to Lane-Emden solutions (joint with Zhourup Xin & Huihui Zeng).

**MS-Fr-D-17**

**13:30–15:30**

**205B**

Singular limits in mathematical physics - Part V of V

For Part 1, see **MS-We-E-17**

For Part 2, see **MS-Th-BC-17**

For Part 3, see **MS-Th-D-17**

For Part 4, see **MS-Th-E-17**

Organizer: Chiang, Bin

Univ. of Surrey

Organizer: Ju, Qiangchang

Inst. of Applied Physics & Computational Mathematics (IAPCM)

Organizer: Jiang, Ning

Tsinghua Univ., Beijing

Abstract: This minisymposium will address recent advances in analytical and numerical studies of singular limits of multiscale physical models as certain parameters approach zero or infinity. It shall cover such areas as incompressible and fast rotating limits in fluid dynamics, hydrodynamical limits of complex fluid and kinetic models, and relaxations. The singular nature of these models makes it challenging to rigorously justify and quantify their limits and to numerically simulate them in a way consistent with theory. Novel techniques and results in partial differential equations, stochastic differential equations and numerical analysis will be discussed.

**MS-Fr-D-18**

**13:30–15:30**

**209B**

Mathematics and Optics - Part III of IV

For Part 1, see **MS-Th-D-18**

For Part 2, see **MS-Th-E-18**

For Part 4, see **MS-Fr-E-18**

Organizer: Santosa, Fadil

Inst. for Mathematics & its Applications

Organizer: Bao, Gang

Zhejiang Univ.

Organizer: Weinstein, Michael

Columbia Univ.

Abstract: The importance of optics and is summarized in the 2013 US National Academy of Sciences report “Optics and Photonics: Essential Technology for Our Nation”. Envisioned technologies which rely on optics include communications, imaging, sensing, and computing. What is clear from the report is that the Mathematical Sciences is poised to make significant contributions to the progress in technology. Indeed there is a growing research activity at the nexus of the Mathematical Sciences and the Optical Sciences. Together with advances in materials science and nano-structure fabrication, there is a growing role for mathematical tools, both computational and analytical.

The goal of this minisymposium is to highlight research in the mathematical sciences that deal with problems arising in optics and photonics. Topics that will be discussed in the sessions include optics in meta-materials, cloaking, photonic bandgap structures, design and control of optical devices, plasmonics, and nonlinear phenomena in optics. These topics will be emphasized during the Institute for Mathematics and its Applications (IMA) annual thematic program “Mathematics and Optics”, 2016-17. The minisymposium is an invitation to mathematical scientists to participate in the IMA program.

**MS-Fr-D-18-1**

**13:30–14:00**

Uniqueness and Stability Results for Inverse Scattering Problems by Minimum Far-field Measurements

Liu, Hongyu

Hong Kong Baptist University

Abstract: In this talk, the speaker will present several uniqueness and stability results in determining impenetrable obstacles by minimum acoustic or electromagnetic far-field measurements. The obstacles are of general polyhedral type, which may consist at the same time, both solid and crack-type components. In the general case, one can recover them by $N$ far-field measurements, where $N$ denotes the space dimensions. If there are no crack-type components presented, then only a single far-field measurement is needed.

**MS-Fr-D-18-2**

**14:00–14:30**

Multiscale Modeling and Computation of Nano Optical Responses

Liu, Di

Michigan State Univ.

Abstract: We introduce a new framework for the multiphysical modeling and multiscale computation of nano-optical responses. The semi-classical theory treats the evolution of the electromagnetic field and the motion of the charged particles self-consistently by coupling Maxwell equations with Quantum Mechanics. To overcome the numerical challenge of solving high dimensional many body Schrödinger equations involved, we adopt the Time Dependent Density Functional Theory (TD-CDFT). In the regime of linear responses, this leads to a linear system of equations determining the electromagnetic field as well as the current and electron densities simultaneously. A self-consistent multiscale method is proposed to deal with the well separated energy scales. Numerical examples are presented to illustrate the resonant condition.

**MS-Fr-D-18-3**

**14:30–15:00**

**ON TRANSFORMATION-OPTICS BASED INVISIBILITY**

Zhou, Ting

Northeastern Univ.

Abstract: I shall discuss the transformation optics based design of electromagnetic cloaking from the inverse problems point of view. In order to avoid the difficulty posed by the singular structure required for ideal cloaking, we study the regularized approximate cloaking. In particular, as it converges to the ideal cloaking interface. Some of them is of non-local pseudo-differential type.

**MS-Fr-D-18-4**

**Imaging with Metallic Nanoparticles**

Triki, Faouzi

Joseph Fourier Univ.

Abstract: In the talk we are interested in the reconstruction of a local change in the refractive index at the proximity of a nanoparticle surface. After introducing the biosensing model we analyze the uniqueness and stability of the inversion.

**MS-Fr-D-19**

**13:30–15:30**

**307B**

From individual interactions to collective behaviour in socio-economics and life sciences - Part I of II

For Part 2, see **MS-Fr-E-19**

Organizer: During, Bertram

Univ. of Sussex

Organizer: Wolfram, Marie-Therese

Radon Inst. for Computational & Applied Mathematics

Abstract: Complex, real-life systems in sociology, economics, and life sciences often consist of a large number of interacting individuals which may form patterns or develop a collective behaviour. The research on microscopic models of such systems and their kinetic, mean-field and hydrodynamic limits have recently gained a lot of momentum. The aim of the mini-symposium is to highlight recent advances on kinetic and PDE modelling in this area. The session focuses on applications such as congestion models, flocking, population dynamics as well as price and opinion formation.
Minisymposium on discontinuous Galerkin method: recent development and applications - Part II of II
13:30–15:30 309B
MS-Fr-D-21
Minisymposium on discontinuous Galerkin method: recent development and applications - Part VIII of VIII
For Part 1, see MS-Tu-D-21
For Part 2, see MS-Tu-E-21
For Part 3, see MS-We-D-21
For Part 4, see MS-We-E-21
For Part 5, see MS-Th-BC-21
For Part 6, see MS-Th-D-21
For Part 7, see MS-Th-E-21
Organizer: Xu, Yan
Univ. of Sci. & Tech. of China
Organizer: Shu, Chi-Wang
Brown Univ.
Abstract: Over the last few years, discontinuous Galerkin (DG) methods have found their way into the main stream of computational sciences and are now being successfully applied in almost all areas of natural sciences and engineering. The aim of this minisymposium is to present the most recent developments in the design and theoretical analysis of DG methods, and to discuss relevant issues related to the practical implementation and applications of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

Error Estimates on the Fully-discretize Local Discontinuous Galerkin Method
Zhang, Qiang
Nanjing Univ.
Abstract: In this talk we give two error estimates on the local discontinuous Galerkin method. One is the local error estimate when the layer boundary exists, and the other is the implicit-explicit time-updating. For both cases, we obtained the optimal error estimates in a suitable domain.

Error Analysis of Discontinuous Galerkin Schemes for Compressible Multiflow Flows
Gieslmann, Jan
Univ. of Stuttgart
Abstract: We consider semi-discrete local discontinuous Galerkin methods approximating a one-dimensional model for compressible multiphase flows of Korteweg type. We use the Korteweg (density gradient) terms in the energy to derive a modified relative entropy stability framework. We combine reconstruction techniques with the stability framework to derive a residual based posteriori error estimate and we use a discrete version of the stability frame work to prove an a priori error bound.

Analysis of the Local Discontinuous Galerkin Method for the Drift-diffusion Model of Semiconductor Devices
Liu, Yunlian
Shandong Univ.
Shu, Chi-Wang
Brown Univ.
Abstract: In this talk we consider both the semi-discrete and fully discrete local discontinuous Galerkin (LDG) schemes for the drift-diffusion (DD) model of one dimensional semiconductor devices. In the fully discrete scheme, we couple the implicit-explicit (IMEX) time discretization with the LDG spatial discretization, in order to allow larger time steps and to save computational resources and detectors. “filming” the object from many directions at the same time. However, new regularized inversion methods are needed for imaging based on such special type of data. A novel level-set type method is introduced for that purpose, enforcing continuity in space-time. Computational results are shown, including measured data.

Oracle-type Posterior Contraction Rates in Bayesian Inverse Problems
Lu, Shuai
School of Mathematical Sci., Fudan Univ.
Abstract: We discuss Bayesian inverse problems in Hilbert spaces. The focus is on a fast concentration of the posterior probability around the unknown true solution as expressed in the concept of posterior contraction rates.

On Minimisers for the Interaction Energy
Canizo, Jose A.
Universidad de Granada
Abstract: We consider a Cucker-Smale type system with reaction delays and multiplicative noise. We discuss relevant issues related to the practical implementation and applications of these methods. Topics include: theoretical aspects and numerical analysis of discontinuous Galerkin methods, non-linear problems, and applications. Particular emphasis will be given to applications coming from fluid dynamics, solid mechanics and kinetic theory.

Towards Dynamic High Resolution Photoacoustic Tomography
Lucka, Felix
UCL
Abstract: The acquisition time of current high-resolution 3D photoacoustic tomography devices limits their ability to image dynamic processes. The talk will demonstrate how to overcome this deficit by combining recent advances in spatio-temporal sub-sampling schemes, compressed sensing and inverse problems with the development of tailored data acquisition systems. Results for simulated and experimental data will be presented. Joint work with Marwa Betcke, Simon Arridge, Ben Cox, Nam Huynh, Edward Zhang and Paul Beard.

Dynamic X-ray Tomography with Level Set Regularization
Siltanen, Samuli
Univ. of Helsinki
Abstract: X-ray tomography recovers an attenuation function f from a set of line integrals of f. Moving objects can be imaged using several pairs of X-ray sources and detectors. “filming” the object from many directions at the same time. However, new regularized inversion methods are needed for imaging based on such special type of data. A novel level-set type method is introduced for that purpose, enforcing continuity in space-time. Computational results are shown, including measured data.

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cost. Optimal error estimates are obtained and a simulation is also performed to validate the analysis.

**MS-Fr-D-22-1** 13:30–14:00

**A Sign Preserving Third-Order WENO Reconstruction**

**Ray, Deep**

TIFR-Centre for Applicable Mathematics

**Organizer: Meng, Xiong**

Harbin Inst. of Tech. & Univ. of East Anglia

**Abstract:** We propose a third-order WENO reconstruction that satisfies the sign property i.e., the sign of the jump in the reconstructed states at an interface is the same as that of the original jump. It is introduced as an improvement over existing ENO schemes, which also satisfy this property. The proposed reconstruction gives satisfactory results when used with high-order entropy stable TeCNO schemes for conservation laws.

**MS-Fr-D-22-2** 14:00–14:30

**Recent Development and Applications of Weighted Essential-Non-oscillatory Methods**

**Wang, Rong**

South Univ. of Sci. & Tech. of China

**Organizer: Qiu, Jianxian**

Xiamen Univ.

**Organizer: Meng, Xiong**

Harbin Inst. of Tech. & Univ. of East Anglia

**Abstract:** We propose a third-order WENO reconstruction that satisfies the sign property i.e., the sign of the jump in the reconstructed states at an interface is the same as that of the original jump. It is introduced as an improvement over existing ENO schemes, which also satisfy this property. The proposed reconstruction gives satisfactory results when used with high-order entropy stable TeCNO schemes for conservation laws.

**MS-Fr-D-22-3** 14:30–15:00

**Boundary Extrapolation Techniques for Finite Difference WENO Schemes on Complex Geometries**

**Donat, Rosa**

Universitat de Valencia

**Mulet, Pep**

Univ. of Valencia

**Organizer: Qiu, Jianxian**

Xiamen Univ.

**Organizer: Meng, Xiong**

Harbin Inst. of Tech. & Univ. of East Anglia

**Abstract:** We introduce a new mapped weighted essentially non-oscillatory method for hyperbolic conservation laws by proposing a new family of mapping functions. When it is applied to classic WENO methods, it can achieve the optimal order of accuracy near critical points in smooth regions. We also consider the potential loss of accuracy when using the classic forms of smoothness indicators for WENO of order $k \leq 7$ due to roundoff errors.

**MS-Fr-D-22-4** 15:00–15:30

**High-order Finite Difference WENO Methods for Plasma Applications**

**Christlieb, Andrew**

Michigan State Univ.

**Organizer: Qiu, Jianxian**

Xiamen Univ.

**Organizer: Meng, Xiong**

Harbin Inst. of Tech. & Univ. of East Anglia

**Abstract:** We construct single-stage, single-step finite difference weighted essentially non-oscillatory (WENO) methods for hyperbolic plasma models. Our methods are constructed from the Picard integral formulation (PIF) of the PDE. We begin with time averaged fluxes, and then discretize the temporal integral with a Taylor series. Our focus is on the magnetohydrodynamics equations. To obtain divergence free magnetic fields at the discrete level, we construct a high-order single-stage unstaggered constrained transport method using a Hamilton Jacobi formulation.
For Part 4, see MS-Th-D-24
For Part 1, see MS-Th-D-24
For Part 2, see MS-Th-E-25
For Part 4, see MS-Fr-E-25
Organizer: Duan, Huoyan Collaborative Innovation Centre of Mathematics, School of Mathematics & Statistics, Wuhan Univ., Wuhan 430072, China
Organizer: Zheng, Weiying Chinese Acad. of Sci.

Abstract: In recent years, there arises a surge of numerical studies for electromagnetic problems in complex engineering systems, such as large power transformers, electrical machinery, magnetic fusion, etc. The mathematical models turn out to be nonlinear, multiscale, strongly singular, and coupled with multiple physical fields. It brings new challenges to researchers from both mathematical and engineering communities in developing practical mathematical models and effective and efficient numerical methods and solvers. This mini-symposium seeks to bring together researchers in both computational mathematics and electromagnetic engineering that involve the mathematical modeling, analysis, computation, and experimental validation for electromagnetic problems. The main theme will be focused on new efficient numerical methods and fast solvers for Maxwell’s equations and magnetohydrodynamic equations and will address their extensive applications to engineering problems. It will promote exchange of ideas and recent developments in mathematical modeling, numerical discretization, solvers and engineering practices of computational electromagnetism.

MS-Fr-D-24-1 13:30–14:00
Material Property Modeling under Extreme Excitations and Validation of Large-Scale Numerical Computation in Industry Applications
Cheng, Zhiguang R & D Center, Baoding Tianwei Group

Abstract: The working property modeling of electrical material under extreme excitations, probably involving DC-biasing and/or multi-harmonics source, and the validations of large-scale modeling and numerical computation are investigated based on engineering-oriented models, which are becoming increasingly challenging and important in industry applications.

MS-Fr-D-24-2 14:00–14:30
Analysis for An Exactly Divergence-Free Method for the Magnetic Induction Equations
Li, Fengyan Rensselaer Polytechnic Inst.

Abstract: Motivated by the developments of the numerical divergence-free treatments for ideal magnetohydrodynamics (MHD) equations, we analyze an exactly divergence-free method based on central discontinuous Galerkin methods for the magnetic induction equations. von Neumann analysis is carried out for numerical stability when the meshes are uniform and the velocity field is constant. In order to be able to handle more general cases, we also establish stability and error estimates through energy methods.

MS-Fr-D-24-3 14:30–15:00
Two-level Additive Preconditioners for Edge Element Discretizations of Time-Harmonic Maxwell Equations
Zhong, Liuqiang Shu, Shi South China Normal Univ. Xiangtan Univ.

Abstract: Two-level additive preconditioners are presented for edge element discretizations of time-harmonic Maxwell equations. It is shown that the generalized minimal residual (GMRES) method applied to the preconditioned system converges uniformly provided that the coarsest mesh size is reasonably small (but independent of the fine mesh size) and the parameter for the “coarse mesh” space solver is sufficiently large. Numerical experiments show the efficiency of the proposed approach.

MS-Fr-D-24-4 15:00–15:30
Fully discrete A-0 finite element method for Maxwell’s equations with nonlinear conductivity
Tong, Kang Communication Univ. of China

Abstract: This talk is referred to the study of a fully discrete A-0 finite element scheme to solve nonlinear Maxwell’s equations. The nonlinearity is due to a field-dependent conductivity with the power-law form $|E|^{p-1}, 0 < c < 1$. We design a nonlinear time-discrete scheme for approximation in suitable function spaces. We show the well-posedness of the problem, prove convergence for our semidiscrete scheme based on boundedness of the second derivative in the dual space. The convergence of the nonlinear term is based on the Minty-Browder technique. We also discuss the error estimate for the fully discretized problem and support the theoretical result by some numerical experiments.

MS-Fr-D-25 13:30–15:30
Emerging PDEs: Analysis and Computation - Part III of IV
For Part 1, see MS-Th-D-25
For Part 2, see MS-Th-E-25
For Part 4, see MS-Fr-E-25
Organizer: Chen, Zhiming University of Maryland Organizer: Nochetto, Ricardo AMSS, Chinese Acad. of Sci.
Organizer: Zhang, Chenzong University of Maryland, College Park Organizer: Gao, Zhiqiang Academy of Mathematics & Sys. Sci.

Abstract: Novel models in science and engineering are governed by nonlinear integro-differential equations with increasing complexity which demand innovative techniques in both analysis and computation, such as adaptivity, fast methods and preconditioning, and structure preserving algorithms. Areas of special interest include complex fluids and new materials, electromagnetism and wave propagation, uncertainty quantification, and fractional PDEs, among others. This minisymposium intends to gather about 16 world experts and young researchers in analysis and computation of PDE to discuss the most recent progress in this exciting field as well as future directions for research.

MS-Fr-D-25-1 13:30–14:00
Preasymptotic Error Analysis of Higher Order FEM and CIP-FEM for Helmholtz Equation with High Wave Number
Wu, Hajun Nanjing Univ.

Abstract: $H^1$- and $L^2$- error estimates with explicit dependence on the wave number $k$ are derived for the FEM and CIP-FEM. In particular, it is shown that if $k^{2\nu} h^{\frac{1}{2}}$ is sufficiently small, then the pollution error of both methods in $H^1$-norm are bounded by $O(k^{\nu} h^{
u+\frac{1}{2}})$, which coincides with the phase error of the FEM obtained by existing dispersion analyses on Cartesian grids.

MS-Fr-D-25-2 14:00–14:30
Semisical Computational Methods for Quantum Dynamics with Band-crossings
Jin, Shi University of Wisconsin-Madison & Shanghai Jiao Tong Univ.

Abstract: We develop semisical models and multiscale computational methods for quantum dynamics with non-adiabatic effects. Application of such methods include surface hopping, Schrodinger equation with periodic potentials, elastic and electromagnetic waves with polarizations, and graphene. We use the Wigner transform to derive these models. The key idea is to evolve the dynamics of the entire Wigner matrices, which contain important non-adiabatic terms, not just the diagonal projections corresponding to the eigenstates of the Hamiltonians. We also develop multiscale computational methods based on these models and numerical examples will be used to show the validity of these models in capturing the quantum transitions at the crossing-points.

MS-Fr-D-25-3 14:30–15:00
A rate of convergence for Monge-Ampere equation
Zhang, Wujun University of Maryland, College Park
Nochetto, Ricardo University of Maryland

Abstract: Monge-Ampére equation arises naturally from differential geometry, optimal transportation and other fields of science and engineering. In this talk, we shall review the viscosity solution of Monge-Ampére equation. We design a numerical approximation of Monge-Ampére equation by using its geometric interpretation. Applying this geometric interpretation and discrete Alexandrov estimate, we derive a rate of convergence to the viscosity solution for Monge-Ampére equations.

MS-Fr-D-25-4 15:00–15:30
Analysis and Computation of Discretized Coupled PDEs
Xu, Jinchao PKU and The Pennsylvania State Univ.

Abstract: I will report some recent works on structure-preserving and stable discretization of some multi-physics models and robust preconditioning methods for the resulting algebraic systems. In particular, judging from theoretical and/or numerical analysis of several mathematical models for magnetohydrodynamics (MHD) which involve the coupling of Navier-Stokes or Euler equations with Maxwell equations, I will argue that some more complicated models may be easier to simulate than some simplified models that have been often used in practice.

MS-Fr-D-26 13:30–15:30
Disturbance rejection control: problems, principles and methodologies
Xu, Jinchao Department of electrical & computer engineering, Cleveland State Univ.

Abstract: This mini-symposium gives a fresh perspective of the science of computational electromagnetism and its engineering applications. Part III of IV is presented, covering topics such as material property modeling, analysis for an exactly divergence-free method, and two-level additive preconditioners for edge element discretizations of time-harmonic Maxwell equations.
automatic control through the exposition of the root problems, the fundamental principles and the useful methodologies of disturbance rejection. The first speaker will take us back to the original challenge posed by J. Han on the model-based modern control paradigm, and demonstrate the significance and consequence of such challenge. This is followed by three speakers, each will address a unique aspect of disturbance rejection control, including the mathematical analysis, the design philosophy, and methodologies. We look to the past to understand where we come from, to grasp the fundamental problems, and we contemplate the future of control theory and applied mathematics with inspiration and anticipation.

**MS-Fr-D-26-1** 13:30–14:00  
**Disturbance Observation Based Control Theory with Applications to Mechatronic Systems**  
Shihua, Li  
Southeast Univ.  
Abstract: Disturbances always bring adverse effects on control systems. Compared with high gain control and integral control methods, disturbance estimation based control provides a different way to handle disturbances. Some new research developments are introduced. Nonlinearities, frictions, internal dynamics, time-varying parameters and external disturbances make control design of mechatronic systems challenging. By theoretical analysis and experimental results, it is shown that disturbance observation based control methods can efficiently improve precision and robustness for such systems.

**MS-Fr-D-26-2** 14:00–14:30  
**The Active Disturbance Rejection Control to Stabilization for Multi-Dimensional Wave Equation with Boundary Control Matched Disturbance**  
Bao-Zhu, Guo  
Acad. of Mathematics & Sys. Sci., Academia Sinica  
Abstract: In this paper we consider boundary stabilization for a multi-dimensional wave equation with boundary control matched disturbance that depends on both time and spatial variables. The active disturbance rejection control (ADRC) approach is adopted in investigation. All subsystems in the closed-loop are shown to be asymptotically stable. In particular, the time varying high gain is first time applied to a system described by the partial differential equation.

**MS-Fr-D-26-3** 14:30–15:00  
**On the Conception of Disturbance as Bedrock in Engineering Cybernetics**  
Gao, Zhiqiang  
Department of electrical & computer engineering, Cleveland State Univ.  
Abstract: Rather than external and state independent, disturbance is conceived by Qian Xuesen as uncertainties both internal and external to the system. Disturbance rejection is thus central to Engineering Cybernetics, founded by Qian Xuesen in 1954. This distinct conception forces us to see differently the fundamental problems, basic premises, and fundamental frameworks in control theory; it has also changed how control is practiced, evident in the latest product announcements of several industry giants in the West.

**MS-Fr-D-26-4** 15:00–15:30  
**Composite Hierarchical Anti-Disturbance Control: from Single to Multiple Disturbances**  
Guo, Lei  
Beihang Univ.  
Abstract: To sufficiently reduce conservatism and utilize the characteristic of disturbances themselves, we address the Composite Hierarchical Anti-Disturbance Control (CHADC) approach for multiple disturbance systems. CHADC is a “refined” anti-disturbance control including disturbance modelling and description, disturbance estimation and rejection in inner loop, and disturbance attenuation or other performance control in outer loop. Aerospace control examples are given to show the significance of CHADC.

**MS-Fr-D-27** 13:30–15:30  
Decoupling methods for multi-physics and multi-scale problems - Part VII of VIII  
For Part 1, see MS-Tu-E-27  
For Part 2, see MS-We-D-27  
For Part 3, see MS-We-E-27  
For Part 4, see MS-Th-BC-27  
For Part 5, see MS-Th-D-27  
For Part 6, see MS-Th-E-27  
For Part 8, see MS-Fr-E-27  
Organizer: He, Xiaoming  
Missouri Univ. of Sci. & Tech.  
Organizer: Xu, Xuejun  
Inst. of Computational Mathematics, AMSS, CAS  
Abstract: The inherent multi-physics and multi-scale features of many real-world problems accentuate the importance to develop efficient and stable numerical methods for the relevant PDEs, especially the decoupling methodology. Although great efforts have been made for solving these problems, many practical and analytical challenges remain to be solved. This mini-symposium intends to create a forum for junior and senior researchers from different fields to discuss recent advances on the decoupling methods for multi-physics and multi-scale problems with their applications.

**MS-Fr-D-27-1** 13:30–14:00  
A Cartesian Grid Method for the Nonlinear Poisson-Boltzmann Equations of Biophysics  
Ying, Wenjun  
Shanghai Jiao Tong Univ.  
Abstract: The nonlinear Poisson-Boltzmann equations of biophysics arise from multiphysics modelling of electrostatic potential in a solvated biomolecular system. The problem is a heterogeneous interface problem around complex geometry. This talk presents a Cartesian grid based boundary integral method to solve the problem. The method avoids generation of any unstructured body-fitted grids and uses fast elliptic solvers to solve discrete equations on the Cartesian grid.

**MS-Fr-D-27-2** 14:00–14:30  
Efficient Space Charge Solver in Particle Tracking Method for Beam Dynamics Simulations  
Kaman, Tunlin  
ETH Zurich  
Abstract: The quantitative and efficient evaluation of space charge effects in existing and future high intensity hadron accelerators are essential. For this purpose, we create an interface between the block-structured adaptive mesh refinement framework and pre-conditioned iterative solvers to solve Poisson’s equation for the electrostatic potential on bounded three-dimensional domains. We introduce a new adaptive multigrid technique for 3D space charge calculation on the multilevel grid hierarchy.

**MS-Fr-D-27-3** 14:30–15:00  
Multiscale Multiphysics Simulation Tool for Dusty Proto-planetary Disks  
Li, Shengtao  
Los Alamos National Laboratory  
Abstract: We present a numerical method and simulation tool for interaction between dusty disk and embedded proto-planets. The dusty disk is subject to fluid hydrodynamics equations and is solved via high-order high-resolution Godunov methods. The planet motions are solved as an N-body problem. The interaction between the disk and planets is carefully considered using an operator-split method. Several methods are proposed to bridge different time and length scales in this multi-physics problem.

**MS-Fr-D-28** 13:30–15:30  
Models and Statistical analysis of bio-medical big data  
Organizer: Li, Lei  
Chinese Acad. of Sci.  
Abstract: The modeling, computation and inference of biological and medical big data is a promise of making new discoveries in life sciences, and finding treatment and cure of complex diseases. Meanwhile the sophisticated structures and large scale of these big data also challenge the intelligence of human beings of this time. Applied mathematicians and statisticians’ expertise are valuable in this research area. In this session, four distinguished applied mathematicians and statisticians will present their research and views toward the bio-medical big data.

**MS-Fr-D-28-1** 13:30–14:00  
Big Data and Brain Science: Stepping into Patients’ World  
Feng, Jianfeng  
Fudan Univ.  
Abstract: Multi-modality image data has played a critical role in studying mental disorders in recent years: it can be used as a biomarker or serve as an endophenotype data to link genetic and environmental data. Using the largest imaging set in schizophrenia, we explored the origins of the disorders with a novel approach BWAS (brain-wide association study) and nonlinear associations. The approach allowed us to identify the roots of the disorders at different stages.

**MS-Fr-D-28-2** 14:00–14:30  
Inference of Markovian Properties of Molecular Sequences from NGS Data and Applications to Comparative Genomics  
Sun, Fengzhu  
Univ. of Southern California, Fudan Univ.  
Abstract: Markov chains (MC) have been widely used to model molecular sequences. We develop approximation theory for two widely used statistics related to MCs based on next generation sequence (NGS) reads. Surprisingly the traditional chi-square statistic does not follow chi-square distribution anymore, instead it has an approximate gamma distribution. We develop methods to estimate the order of the MC based on NGS reads. These results are used for alignment-free genome comparison and interesting results are obtained.

**MS-Fr-D-28-3** 14:30–15:00
CCLasso: Correlation Inference for Compositional Data Through Lasso
Deng, Minghua Peking Univ.
Abstract: Inferring the correlation relationship among members of microbial communities is of fundamental importance for genomic survey study. We propose a novel method called CCLasso based on least squares with L1 penalty to infer the correlation network for latent variables of compositional data from metagenomics data. An effective alternating direction algorithm from augmented Lagrangian method is used to solve the optimization problem. The new method outperforms existing methods, e.g. SparseCC, in edge recovery for compositional data.

BASE - A Statistical Inference of transcription factors’ effective regulation: notion and examples
Li, Lei Chinese Acad. of Sci.
Abstract: A typical problem in functional genomics is the identification of transcription factors (TFs) accounted for the profile of expression differences between two samples. We propose a statistical method, referred to as BASE (binding association with sorted expression), to infer transcription factors’ effective regulation from expression profiles with the help of TFs’ binding affinity data. It searches the maximum association between binding affinity profile of a TF and expression profile along the direction of sorted differentiation.

Numerical Homogenization and Multiscale Model Reduction Methods - Part IV of V
For Part 1, see MS-Th-BC-29
For Part 2, see MS-Th-D-29
For Part 3, see MS-Th-E-29
For Part 5, see MS-Fr-E-29
Organizer: Zhang, Lei Shanghai Jiao Tong Univ.
Organizer: Peterseim, Daniel Universität Bonn
Organizer: Jiang, Lijian Hunan Univ.
Organizer: Chuang, Eric The Chinese Univ. of Hong Kong
Abstract: Problems that transcend a variety of strongly coupled time and length scales are ubiquitous in modern science and engineering such as physics, biology, and materials. Those multiscale problems pose major mathematical challenges in terms of analysis, modeling and simulation. At the same time, advances in the development of multiscale mathematical methods coupled with continually increasing computing power have provided scientists with the unprecedented opportunity to study complex behavior and model systems over a wide range of scales. This minisymposium is aimed at presenting the state-of-the-art in multiscale modeling, simulation and analysis for the applications in science and engineering. It will focus on the developments and challenges in numerical multiscale methods and multiscale model reduction methods. The lectures will cover the following subjects: - Numerical homogenization methods, e.g. Generalized FEM, MsFEM, FEM-HMM, DG methods, Partition of Unity methods, multiscale domain decomposition etc. - Multiscale model reduction methods for stochastic systems, such as stochastic PDEs and random materials. - Multiscale methods for problems arising in composite materials and heterogeneous porous media. - Multiscale methods for eigenvalue problems, high frequency waves, and multiscale hyperbolic PDEs. - Multiscale modeling in various applications such as reservoir performance prediction, bio-motility, chemical vapor infiltration, etc.

Multiscale Modeling on Chemical Vapor Infiltration Process
Zhang, Chuanjun Soochow Univ.
Yue, Xingye Soochow Univ.
Abstract: Multiscale model was developed and analyzed to describe the isothermal chemical vapor infiltration (CVI) process in fabrication of the carbon fiber reinforced silicon carbide (C/SiC) composites by Yun Bai et al. Homogenization theory for the two stages of CVI process is established, which is the foundation of the multiscale algorithm. Some three dimensional simulations for the CVI process are presented.

Domain Decomposition and Preconditioners for Heterogeneous Media Using Optimal Local Basis Functions
Lipton, Robert LSU
Sinz, Paul Louisiana State Univ.
Abstract: We introduce a new multiscale preconditioner derived from optimal local approximation spaces [1,2]. The domain decomposition is given by a partition of unity. We provide convergence rates for the iterative method.

Optimal local approximation spaces for generalized finite element methods with application to multiscale problems."
MMS 2011 DOI:10.1137/100791051.

Machine computation using generalized multiscale finite element method (GMsFEM) method for solving these models. The lack of local conservation of the Darcy’s flux is overcome by an element-based postprocessing which only requires solving inexpensive set of linear systems that are an independent of each other. Numerical examples are presented.

Optimal Control of Multiphase Flow Models
Ginting, Victor Univ. of Wyoming
Abstract: Subsurface flow and transport are described by partial differential equations whose parameters vary over many length scales. We employ a recent work on the generalized multiscale finite element (GMsFEM) method for solving these models. The lack of local conservation of the Darcy’s flux is overcome by an element-based postprocessing which only requires solving inexpensive set of linear systems that are an independent of each other. Numerical examples are presented.

Numerical approaches in optimization with PDE constraints: recent progress and future challenges - Part VI of VII
For Part 1, see MS-We-D-30
For Part 2, see MS-We-E-30
For Part 3, see MS-Th-BC-30
For Part 4, see MS-Th-D-30
For Part 5, see MS-Th-E-30
For Part 7, see MS-Fr-E-30
Organizer: Yan, Ningning Chinese Acad. of Sci.
Organizer: Hinze, Michael Universität Hamburg
Abstract: The numerical treatment of optimization problems with PDE constraints is a very active field of mathematical research with great importance for many practical applications. To achieve further progress in this field of research, the development of tailored discretization techniques, adaptive approaches, and model order reduction methods has to be intertwined with the design of structure exploiting optimization algorithms in function space. This minisymposium covers mathematical research in PDE constrained optimization ranging from numerical analysis and adaptive concepts over algorithm design to the tailored treatment of optimization applications with PDE constraints. It thereby forms a platform and fair for the exchange of ideas among young researchers and leading experts in the field, and for fostering and extending international collaborations between research groups in the field.

Optimal Control of Multiphase Flow.
Banas, Lubomir Bielefeld Univ.
Abstract: We consider a distributed optimal control problem for incompressible multiphase flow. The flow is modeled by a system of Cahn-Hillard-Navier-Stokes equations with non-smooth free energy. We propose and analyze a fully-discrete finite element based numerical approximation of the problem. The discrete problem corresponds to a system of variational inequalities and is solved by an active-set type iterative algorithm. We present a number of computational experiments to demonstrate the performance the presented solution approach.

Optimal Control of Phase-field Models for Multiphase Flow.
Banas, Lubomir Bielefeld Univ.
Abstract: We consider a distributed optimal control problem for incompressible multiphase flow. The flow is modeled by a system of Cahn-Hillard-Navier-Stokes equations with non-smooth free energy. We propose and analyze a fully-discrete finite element based numerical approximation of the problem. The discrete problem corresponds to a system of variational inequalities and is solved by an active-set type iterative algorithm. We present a number of computational experiments to demonstrate the performance the presented solution approach.

Optimal Control problems for the coupled Cahn-Hillard/Navier-Stokes system with non-smooth homogeneous free energy density are consid- ered. Based on a suitable stationarity concept, a solver using the adaptive finite element method is discussed.
Stochastic FE for Optimal Control Governed by Elliptic PDE with Random Coefficients
LIU, Wenbin
Univ. of Kent

Abstract: Stochastic optimal control problems has been one of the new hot research topics in the recent years. In this talk we apply stochastic Galerkin finite element methods to the optimal control problems governed by some PDEs with some random coefficients. We firstly establish stochastic Galerkin finite element approximation scheme for them and derive the optimality conditions. We then derive the priori error estimates with optimal order. We then extend our study to state constrained cases.

MS-Fr-D-31 13:30–15:30
Advances on Mixed Finite Element Methods for Linear Elasticity - Part III of IV
For Part 1, see MS-Th-D-31
For Part 2, see MS-Th-E-31
For Part 4, see MS-Fr-E-31
Organizer: Hu, Jun
Organizer: Zhang, Zhongyou
Peking Univ.
Univ. of Delaware

Abstract: The elasticity equations are solved in many scientific and engineering problems where the stress is often more important than the displacement. In this sense, the classical Hellinger–Reissner mixed formulation of the elasticity equations, where the stress tensor is sought in a symmetric H-div space and the displacement in an L2 space, is a natural and important variational formulation for this problem. The approximation of displacement can be taken in the space of discontinuous piecewise polynomials of some degree, but the approximation of the symmetric stress tensor is a long-standing, challenging, and surprisingly hard problem. As a matter of fact, “four decades of searching for mixed finite elements for elasticity beginning in the 1960s did not yield any stable elements with polynomial shape functions” [D. N. Arnold, Proceedings of the International Congress of Mathematicians, Vol. I: Plenary Lectures and Ceremonies (2002), 137–157]. This minisymposium will gather about 16 world experts and young researchers to discuss the most recent advances in this challenging field as well as future directions for research.

MS-Fr-D-31-1 13:30–14:00
Multigrid Methods for Saddle Point Problems
Brenner, Susanne
Louisiana State Univ.

Abstract: In this talk we will present a general framework for the design and analysis of multigrid methods for saddle point problems arising from mixed finite element discretizations of elliptic boundary value problems. These multigrid methods are uniformly convergent in the energy norm on general polygonal domains where the elliptic boundary value problems in general do not have full elliptic regularity. Applications to Stokes, Lame, Darcy and related nonsymmetric systems will be discussed. This is joint work with Hengguang Li, Duk-Soon Oh and Li-Yeng Sung.

MS-Fr-D-31-2 14:00–14:30
A Reduced Local C^0 Discontinuous Galerkin Method for Kirchhoff Plates
Huang, Jianguo
Shanghai Jiao Tong Univ.

Abstract: We propose and analyze a reduced local C^0 discontinuous Galerkin method for Kirchhoff plate bending problems. The method can be viewed as the localization of Hellan-Herrmann-Johnson method, so we derive the well-posedness and a priori error estimates of the method. With the help of Zienkiewicz-Guzman-Neilan element space, the a posteriori error analysis is also developed. Numerical results are also provided. This is a joint work with Xuehai Huang from Wenzhou University.

MS-Fr-D-31-3 14:30–15:00
A Non-conforming Finite Element Discretization for Linear Biot’s Model in Poroelasticity: Convergence and Monotonicity
Gaspar, Francisco
Univ. of Zaragoza
Hu, Xiaozhe
Tufts Univ.
Rodrigo, Carmen
Univ. of Zaragoza
Zikatanov, Ludmil
The Pennsylvania State Univ.

Abstract: We consider the linear Biot’s model in poroelasticity discretized with nonconforming linear elements for the displacement field and piece-wise constant elements for the pressure field. We show convergence of a fully discrete scheme using implicit Euler method in time. We also discuss the issue related to the monotonicity of the discrete schemes, i.e. the presence of non-physical oscillations in the pressure approximations for low permeabilities and/or small time steps.

Stochastic FE for Optimal Control Governed by Elliptic PDE with Random Coefficients
LIU, Wenbin
Univ. of Kent

Abstract: Stochastic optimal control problems has been one of the new hot research topics in the recent years. In this talk we apply stochastic Galerkin finite element methods to the optimal control problems governed by some PDEs with some random coefficients. We firstly establish stochastic Galerkin finite element approximation scheme for them and derive the optimality conditions. We then derive the priori error estimates with optimal order. We then extend our study to state constrained cases.

MS-Fr-D-32 13:30–15:30
Structured-mesh methods for interface problems. - Part VII of VIII
For Part 1, see MS-Tu-E-32
For Part 2, see MS-We-D-32
For Part 3, see MS-We-E-32
For Part 4, see MS-Th-BC-32
For Part 5, see MS-Th-D-32
For Part 6, see MS-Th-E-32
For Part 8, see MS-Fr-E-32
Organizer: Chen, Huanzhen
College of Mathematical Sci. Shandong Normal Univ.

Abstract: In this talk we discuss the numerical simulation for the second-order interface elliptic problems with tensor diffusion coefficient (anisotropic flow case). By enforcing the jump condition into the finite element space involved the interface element, we construct the piecewise linear finite element space and capability of approximation. We develop the corresponding partially penalized immersed interface finite element method and prove its optimal order convergence.

MS-Fr-D-32-1 13:30–14:00
INTERFACE PROBLEMS: FROM ISOTROPY TO ANISOTROPY
Chen, Huanzhen
College of Mathematical Sci. Shandong Normal Univ.

Abstract: In this report, we proposed a partially penalty immersed interface finite element (PIFE) method for second order elliptic interface problem with non-homogeneous interface jump conditions. We add penalty terms to the general immersed interface formulation along the sides intersected with the interface. Then we prove the consistency and the solvability of the procedure. Theoretical analysis and numerical experiments show that PIFE method solution possesses optimal-order error estimates in the energy norm and L2 norm.

MS-Fr-D-32-2 14:00–14:30
A Partially Penalty Immersed Interface Finite Element Method for Elliptic Interface Problems with Nonhomogeneous Jump Conditions
Liu, Zhongyan
School of Mathematical Sci. Shandong Normal Univ.

Abstract: In this report, we proposed a partially penalized immersed interface finite element (PIFE) method for second order elliptic interface problem with non-homogeneous interface jump conditions. We add penalty terms to the general immersed interface formulation along the sides intersected with the interface. Then we prove the consistency and the solvability of the procedure. Theoretical analysis and numerical experiments show that PIFE method solution possesses optimal-order error estimates in the energy norm and L2 norm.

MS-Fr-D-32-3 14:30–15:00
An Iterative Immersed Finite Element Method for An Electric Potential Interface Problem Based on Given Surface Electric Quantity
He, Xiaoming
Missouri Univ. of Sci. & Tech.

Abstract: In plasma simulation, we often only know the total electric quantity on the surface of the object, not the charge density distribution on the surface which appears as the non-homogeneous flux jump condition in the usual interface problems. We propose an iterative method that employs the immersed finite element (IFE) method to solve the 2D interface problem for the potential field according to the given total electric quantity on the surface of the object.

MS-Fr-D-32-4 15:00–15:30
Second-order Partitioned Time Stepping Method for Fluid-fluid Interaction
Zheng, Haibiao
East China Normal Univ.

Abstract: We study a second-order partitioned time stepping method (BDF2-GA (AB2)) for fluid-fluid interaction. This is accomplished through explicit treating the top in velocities across the fluid-fluid interface by a geometric averaging of this data over the Adams-Bashforth formulation with the previous two time levels.
Mathematical and computational methods for coupling local and nonlocal models - Part III of IV

Organizer: D’Elia, Marta Sandia National Laboratories
Organizer: Seleson, Pablo Oak Ridge National Laboratory
Organizer: Bochev, Pavel Sandia Labs

Abstract: Nonlocal continuum and atomistic models are used in many scientific and engineering applications, where material dynamics depends on microstructure. The numerical solution of nonlocal models might be prohibitively expensive; therefore, concurrent multiscale methods have been proposed for efficient and accurate solutions of such systems. These methods employ nonlocal models in parts of the domain and use local, macroscopic, models elsewhere. A major challenge is to couple these models at interfaces or in overlapping regions. This minisymposium invites contributions on coupling local and nonlocal continuum models and concurrent multiscale methods for atomistic-to-continuum coupling. Related domain decomposition methods are also considered.

IDentify the EffecT of the Ghost Forces in Multiscale Coupling Methods

Ming, Pingbing Chinese Acad. of Sci., AMSS

Abstract: Ghost forces is the inconsistency issue arising from improperr interfacial conditions in multiscale coupling methods. We shall demonstrate the effect of ghost forces through a series of examples, which vary rom 1d to 3d, from static to dynamics, and from perfect crystals to systems with defects.

Concurrent Atomistic-continuum Simulation of Mechanical and Thermal Transport Behavior of Materials

Chen, Youngping Univ. of Florida

Abstract: A concurrent atomistic-continuum methodology will be presented. The statistical mechanics foundation and the coarse graining strategy of the method will be introduced. Simulation results of dislocation dynamics and phonon thermal transport will be presented.

A Posteriori Error Estimates for Quasicontinuum Methods

Lin, Ping Univ. of Dundee

Abstract: In the talk we will show a posteriori $W^{1,\infty}$ error estimate for a 1D complex-lattice quasicontinuum method. Numerical experiments will be presented to support the result of the analysis. We may also present a posteriori error estimate for a 2D atomistic-to-continuum coupling method at the end. The most part of the talk is based on a joint work with A. Abbudle and A.V. Shapeev.

Modeling Electrokinetic Flow by Lagrangian Particle-based Method

Pan, Wenzhao Pacific Northwest National Laboratory

Abstract: Recent applications in micro-/nano-transport and technology demand efficient and accurate computational modeling of multiphysical processes at the mesoscale. This work focuses on mathematical models and numerical schemes based on Lagrangian particle-based method that can effectively capture mesoscale multiphysics (hydrodynamics, electrostatics, and advection-diffusion) as well as the effect of thermal fluctuations. Specifically, we show simulation results on separation and mixing processes in micro-/nano-channel, electrokinetic flow through semi-permeable membranes, and diffusive reaction on biomolecules.

Analysis, Modeling, and Numerical Methods for High Frequency Waves - Part III of IV

For Part 1, see MS-Th-D-35
For Part 2, see MS-Th-E-35
For Part 4, see MS-Fr-E-35

Organizer: YANG, XU Univ. of California, Santa Barbara
Organizer: YING, LEXING Stanford Univ.
Organizer: HUANG, ZHONGYI Tsinghua Univ.
Organizer: RUNBORG, OLOF Department of Mathematics, KTH

Abstract: The development of modern techniques has been able to provide accuracy studies on the micro- and nano-scale physics. Under this small scale, the objects often appear as a form of waves, and present quantum properties. On the other hand, the observation is often made at macroscopic scale which is closely related to small-scale details, therefore it is necessary to consider problems at multiple scales. Propagation of high frequency waves is one such topic. The major challenge is that one usually needs to handle the disparity between the two length scales: the large domain size and the small wavelength. This means one has to work on a large computational domain that contains thousands to millions of wavelengths, and each of them needs to be resolved if direct numerical methods are applied. Therefore the
total number of grid points is huge, which usually leads to unaffordable computational cost. This minisymposium will focus on high-frequency waves and their applications in quantum mechanics and seismology. Topics on analysis, modeling and numerical methods will be discussed.

**MS-Fr-D-35-1 13:30–14:00**

**GAUSSIAN BEAM METHODS FOR THE HELMHOLTZ EQUATION**

Liu, Hailiang Iowa State Univ.
RUNBORG, OLOF Department of Mathematics, KTH

Abstract: We construct Gaussian beam approximations to solutions of the high frequency Helmholtz equation with a localized source. Under the assumption of nanotrapping rays we show error estimates between the exact outgoing solution and Gaussian beams in terms of the wave number k, both for single beams and superposition of beams. The main result is that the relative local L2 error in the beam approximations decay as $k^{-N/2}$ independent of dimension and presence of caustics.

**MS-Fr-D-35-2 14:00–14:30**

**The Hierarchical Poincaré–Steklov scheme: An accurate and efficient technique for variable media scattering and more**

Gillman, Adrianna Rice Univ.

Abstract: This talk presents a recently developed discretization technique that naturally comes with an efficient direct solver for time-harmonic scattering problems where there is a bounded region in which the wave speed varies smoothly in space. The method can solve problems 100 wavelengths in size to 9 digits of accuracy in a few minutes on a workstation. For each new incident wave the solution can be found in 3 seconds.

**MS-Fr-D-35-3 14:30–15:00**

**Scalability Up to P $N^{1/7}$ Nodes for the 2D Helmholtz Equation**

Demanet, Laurent MIT

Abstract: We present a solver for the 2D high-frequency Helmholtz equation in heterogeneous acoustic media, with online parallel complexity that scales optimally as O(NP), where N is the number of volume unknowns, and P is the number of processors, as long as $P = O(N^{1/7})$. The solver combines two ideas: polarized traces, and nested sweeps. It works well on standard geophysics community models. Joint work with Leo Zepeda.

**MS-Fr-D-35-4 15:00–15:30**

**Uncertainty Quantification for High Frequency Waves**

Motamed, Mohammad Univ. of New Mexico
RUNBORG, OLOF Department of Mathematics, KTH
TEMPONE, RAUL KING ABDULLAH Univ. Of Sci. & Tech.
Malenova, Gabriela Royal Inst. of Tech.

Abstract: We will analyze and compute high frequency wave propagation problems subject to stochastic uncertainty. We construct an optimal stochastic spectral algorithm, by employing Gaussian beam superposition in the deterministic space and collocation on sparse grids in the stochastic space. The developed algorithm will significantly accelerate the convergence of current Monte Carlo sampling methods for high frequency wave propagation problems. We present a stochastic regularity analysis and obtain uniform convergence rates.

**MS-Fr-D-36 13:30–15:30**

Advances in MCMC and related sampling methods for large-scale inverse problems - Part III of IV

For Part 1, see MS-Th-D-36
For Part 2, see MS-Th-E-36
For Part 4, see MS-Fr-E-36

Organizer: Bui-Thanh, Tan The Univ. of Texas at Austin
Organizer: Cui, Tiangang MIT Organizer: Marzouk, Youssef Massachusetts Inst. of Tech.

Abstract: Inverse problems convert indirect measurements into useful characterizations of the parameters of a physical system. Parameters are typically related to indirect measurements by a system of partial differential equations (PDEs), which are complicated and expensive to evaluate. Available indirect data are often limited, noisy, and subject to natural variation, while the unknown parameters of interest are often high dimensional, or infinite dimensional in principle. Solution of the inverse problem, along with prediction and uncertainty assessment, can be cast in a Bayesian setting and thus naturally tackled with Markov chain Monte Carlo (MCMC) and other posterior sampling methods. However, designing scalable and efficient sampling methods for high-dimensional inverse problems that involve expensive PDE evaluations poses a significant challenge. This mini-symposium presents recent advances in sampling approaches for large scale inverse problems.

**MS-Fr-D-36-1 13:30–14:00**

**A Randomized Likelihood Method for Data Reduction in Large-scale Inverse Problems**

Bui-Thanh, Tan The Univ. of Texas at Austin

Abstract: We develop innovative approach to address the big data challenge in large-scale inverse problems and UQ governed by expensive PDEs. We analyze our approach from both statistical theory and machine learning point of view. Theoretical and various numerical results will be presented to demonstrate the effectiveness of our approach.

**MS-Fr-D-36-2 14:00–14:30**

**Randomized MCMC Methods for Exploration of Large-scale High Dimensional Bayesian Inverse Problems**

WANG, KAINAN HALLIBURTON LANDMARK GRAPHICS
Bui-Thanh, Tan The Univ. of Texas at Austin

Abstract: Sampling techniques are important for large-scale high dimensional Bayesian inferences. However, general-purpose technique such as Markov chain Monte Carlo is intractable. We present an ensemble transform algorithm that is rooted from the optimal transportation theory. The method transforms the prior ensemble to posterior one via a sparse optimization. We develop methods to accelerate the computation of the transformation. Numerical results for large-scale Bayesian inverse problems governed by PDEs will be presented.

**MS-Fr-D-36-3 14:30–15:00**

**Sampling High-dimensional Distributions Using Linear Iterations**

Fox, Colin Univ. of Otago

Abstract: Sampling from a Gaussian distribution is essentially the same task as solving a linear system in the precision matrix, plus drawing normal random variables. In high-dimensional settings the iterative solvers are attractive, and correspond exactly to Gibbs samplers. It follows that polynomial acceleration may be applied to Gibbs sampling from Gaussians. For non-Gaussian distributions the linear iterations can provide proposal distributions for Metropolis-Hastings MCMC, with MALA and HMC algorithms being special cases.

**MS-Fr-D-36-4 15:00–15:30**

**A Randomized Likelihood Method for Data Reduction in Large-scale Inverse Problems**

Bui-Thanh, Tan The Univ. of Texas at Austin

Abstract: Inverse problems convert indirect measurements into useful characterizations of the parameters of a physical system. Parameters are typically related to indirect measurements by a system of partial differential equations (PDEs), which are complicated and expensive to evaluate. Available indirect data are often limited, noisy, and subject to natural variation, while the unknown parameters of interest are often high dimensional, or infinite dimensional in principle. Solution of the inverse problem, along with prediction and uncertainty assessment, can be cast in a Bayesian setting and thus naturally tackled with Markov chain Monte Carlo (MCMC) and other posterior sampling methods. However, designing scalable and efficient sampling methods for high-dimensional inverse problems that involve expensive PDE evaluations poses a significant challenge. This mini-symposium presents recent advances in sampling approaches for large scale inverse problems.

**MS-Fr-D-37-1 13:30–14:00**

**Secret Sharing Secure Against Active Adversaries with Applications to Cloud Security and Long-term Storage**

Morozov, Kirill Kyushu Univ.

Abstract: Secret sharing realizes splitting of the data into pieces (called “shares”) among a set of parties such that only designated subsets of them can reconstruct it. For cloud storage, this approach allows us to combine security and reliability. We present cheater-identifiable schemes and robust schemes with minimum share sizes (up to date) in different settings. Security is guaranteed even against an adversary with unlimited computing power, making these schemes particularly attractive for long-term security applications.

**MS-Fr-D-37-2 14:00–14:30**

**Developments in Computer Algebra Research and Collaboration with Industry**

Affine Invariant MCMC’s, the Way Forward or the Least We Should Ask For?

Christen, Andres CIMAT

Abstract: Affine invariant MCMC methods (eg. the ‘t-walk’ or the ‘emcee hammer’) are regularly used in some areas of Bayesian inference, although still not used extensively. We will mention a large number of multiscale nonlinear Inverse Problems examples in which these methods work as automatic, out of the box, MCMC samplers. We will explain what affine invariant MCMC is and why we believe are a very relevant alternative in designing working MCMC samplers.
MS-Fr-D-37-3
14:30–15:00
An Algorithm for Parametric Integer Programming
Takafumi, Shibuta
Kyushu Univ.
Abstract: Parametric integer programming (PIP) is an integer programming such that the right-hand-side vector contains parameters. PIP is important for compiler optimization problems. In this talk, we give a parametric version of algorithm for solving PIP based on Groebner bases of toric ideals. This is joint work with Norie Fu.

MS-Fr-D-38
13:30–15:30 302A
Control of partial differential equations - Part I of II
For Part 2, see MS-Fr-E-38
Organizer: Coron, Jean-Michel
Univ. Pierre et Marie Curie
Organizer: Alabau-Boussouira, Fatma
Universite de Lorraine, IECI UMR 7502
Abstract: This mini-symposium will present an overview of recent advances on the control of PDE's and stochastic PDE's, as well as their challenging applicative issues for the control of complex models in quantum mechanics, fluid mechanics, climatology, conservation laws... The first session will focus on the control of quantum systems, stochastic PDE's, hyperbolic systems and applied control problems. The second session will present different mathematical methods to solve control issues for degenerate parabolic or hypoelliptic PDE's, bang-bang control of parabolic questions, under-observed coupled hyperbolic systems and hierarchic control for coupled parabolic systems.

MS-Fr-D-38-1
13:30–14:00
Boundary Control of Open Channels : Application to the Meuse River
Bastin, Georges
Louvain Univ.
Coron, Jean-Michel
Univ. Pierre et Marie Curie
Abstract: In this communication we emphasize the main features that may occur in real live applications of boundary feedback control of systems represented by 1-D hyperbolic partial differential equations. The issue is presented through the specific case study of the control of navigable rivers with a particular focus on the Meuse river in Wallonia (south of Belgium) where the system is described by Saint-Venant equations and an important challenge is to regulate the water level.

MS-Fr-D-38-2
14:00–14:30
Control and Observation for Stochastic Hyperbolic Equations
Zhang, Xu
Sichuan Univ.
Abstract: In this talk, I will explain the main difficulty for the controllability of stochastic hyperbolic equations. I will also introduce some observability estimates for the same equations and applications.

MS-Fr-D-38-3
14:30–15:00
A Constructive Method to the Exact Boundary Controllability for 1-D Quasilinear Hyperbolic Systems
LI, Tatsien
Fudan Univ.
Abstract: In this talk we will present a simple and efficient constructive method with modular structure to the exact boundary controllability and the exact boundary controllability of nodal profile for general 1-D quasilinear hyperbolic systems with general nonlinear boundary conditions.

MS-Fr-D-38-4
15:00–15:30
Some Results on Boundary Control of 1-D Hyperbolic Systems with A Vanishing Characteristic Speed
Wang, Zhiqiang
Fudan Univ.
Abstract: In this talk, we will show some results on boundary control of 1-D hyperbolic systems with a vanishing characteristic speed. Different from the case without vanishing characteristic speeds, we prove non-controllability in finite time for a class of linear hyperbolic system. However, boundary controllability can be obtained for some kind of quasilinear hyperbolic systems thanks to the nonlinearity.

MS-Fr-D-39
13:30–15:30 302B
New methods and trend in the field of nonlinear filtering - Part I of II
For Part 2, see MS-Fr-E-39
Organizer: Luo, Xue
School of Mathematics & Sys. Sci., Beihang Univ., Beijing, P. R. China, 100191
Organizer: Yau, Stephen
Department of Mathematical Sci., Tsinghua Univ., Beijing, P. R. China, 100084
Abstract: We shall focus on various aspects of the nonlinear filtering (NLF), including the new methods and related fields. The general idea of NLF is to form some kind of “best estimate” for the true state of some system, given some potentially noisy observations, and either the system or the observation (or both) is nonlinear. The NLF has been widely used in many science and engineering disciplines, such as radar tracking problems, signal processing etc. There have been intensive research on new methods recently, including the particle filters, methods based on Duncan-Mortensen-Zakai equation, curvature Kalman filter and their variants. The scope of this mini symposium is to discuss all sorts of newly developed methods and the potential trend in the field of NLF.

MS-Fr-D-39-1
13:30–14:00
Particle Flow for Nonlinear Filters Inspired by Physics
Daum, Fred
Raytheon
Abstract: Our new nonlinear filter theory is many orders of magnitude faster than standard particle filters for the same accuracy, and it beats the extended Kalman filter accuracy by several orders of magnitude for difficult nonlinear problems. Our theory uses particle flow (like physics) to compute Bayes’ rule, rather than a pointwise multiply. We design the particle flow with the solution of a linear first order highly underdetermined PDE, like the Gauss law in electromagnetics.

MS-Fr-D-39-2
14:00–14:30
The Suboptimal Method for Nonlinear Filterings via Carleman Approach Using Hermite Polynomials
Luo, Xue
School of Mathematics & Sys. Sci., Beihang Univ., Beijing, P. R. China, 100191
Yau, Stephen
Department of Mathematical Sci., Tsinghua Univ., Beijing, P. R. China, 100084
Abstract: In this talk we will investigate a novel suboptimal method for nonlinear filtering by augmenting the original states with its probabilists’ Hermite polynomials. It is shown that the augmented states satisfy a bilinear system, of which a suboptimal filtering has been derived by Carravetta et al. (SIAM J. Control Optim., 2000). The accuracy of our method has been compared with the one via Carleman approach, developed in Germani, et. al. (IEEE Trans. Automat. Control, 2007).

MS-Fr-D-39-3
14:30–15:00
Continuous-Time Nonlinear Filtering, Feynman Path Integrals and Supersymmetry
Balaji, Bhashyam
Defence R&D Canada
Abstract: In this talk, it is shown that Feynman path integrals provide an elegant formulation and solution of the continuous-discrete and continuous-continuous nonlinear filtering problems. The major role played by the path integral techniques in modern theoretical physics and pure mathematics is reviewed, and the connection to Euclidean quantum mechanics identified. Some novel algorithms and illustrated with highly nontrivial problems. A new precise connection with supersymmetry is also identified and illustrated, and new research directions proposed.

MS-Fr-D-39-4
15:00–15:30
Sparse Grid Filtering of Nonlinear Dynamical Systems
Cheng, Yang
Mississippi State Univ.
John, Crassidis
Univ. at Buffalo, State Univ. of New York
Moriba, Jah
Air Force Research Laboratory
Abstract: The sparse grid filter is a nonlinear filter in which sparse grid quadratures are used to represent and compute the moments of random vectors. Many Gaussian filters, including the unscented Kalman filter and the cubature Kalman filter and their variants, are special cases of the sparse grid filter. Recent development of the sparse grid filter based on direct update of the quadrature points as well as a space object tracking application will be presented.

MS-Fr-D-40
13:30–15:30 303A
Stretching of slender viscous fibres
Organizer: Stokes, Yvonne
The Univ. of Adelaide
Abstract: The stretching (or drawing or spinning) of fluid threads has wide-ranging application including in the manufacture of optical fibres and optical...
Abstract: We investigate the motion of a slender axisymmetric highly viscous thread that is supported at its top by a fixed horizontal surface and extends downward under gravity. Using matched asymptotic expansions, we obtain solutions for the full initial-boundary-value problem and show how inertia ultimately must become important. The solution allows us to understand the parameters that control the practical achievability of a desired geometrical structure. This mini-symposium is focused on mathematical modelling to yield understanding of the important physics that governs fibre drawing, including initial geometry, draw ratio, temperature, pressurization of any internal air channels, gravity and rotation of the fibre. Mathematical modelling is crucial to solving the practically important inverse problem of determining the initial conditions and draw parameters to achieve a desired geometry for a given application. We will consider recent progress and future requirements.

MS-Fr-D-40-1 13:30–14:00
Forward and Inverse Modelling to Aid Fabrication of Fibres with Complex Geometry
Stokes, Yvonne The Univ. of Adelaide
Crowdy, Darren Imperial College London
Ebendoff-Heidepriem, Heike Univ. of Adelaide
Tronnolone, Hayden The Univ. of Adelaide
Chen, Michael Univ. of Adelaide
Buchak, Peter Imperial College London

Abstract: Slenderness of fibres has long been exploited to derive 1D models of extensional flows such as fibre drawing. Where modification of structure in the cross-section, e.g. by surface tension or pressure, is important, these must be coupled to 2D cross-plane models. We present recent progress that has been made in the context of fibre drawing and the extraction of fibre preforms, and discuss challenges that remain. Temperature is an important aspect of this that will be discussed.

MS-Fr-D-40-2 14:00–14:30
Geometrical Pore Models for Regularizing the Inverse Problem in Microstructured Optical Fibre Fabrication
Crowdy, Darren Imperial College London
Buchak, Peter Imperial College London
Stokes, Yvonne The Univ. of Adelaide
Ebendoff-Heidepriem, Heike Univ. of Adelaide
Chen, Michael Univ. of Adelaide

Abstract: In the fabrication process for microstructured optical fibres an important inverse problem is relevant: what is the preform shape that, after deformation due to surface tension, pressure effects and draw tension, will produce the desired fibre geometry. Here we present a hierarchy of "geometrical pore models" we have devised to describe multi-channel interactions during the fabrication process. Significantly, the same reduced models provide a regularization of the ill-posed inverse problem.

MS-Fr-D-40-3 14:30–15:00
Asymptotic Analysis of A Viscous Thread Extending under Gravity
Wylie, Jonathan City Univ. of Hong Kong
Huang, Huaxiong York Univ.
Miura, Robert New Jersey Inst. of Tech.

Abstract: We investigate the motion of a slender axisymmetric highly viscous thread that is supported at its top by a fixed horizontal surface and extends downward under gravity. Using matched asymptotic expansions, we obtain solutions for the full initial-boundary-value problem and show how inertia ultimately must become important. The solution allows us to understand the mechanisms that underlie highly persistent filaments.

MS-Fr-D-40-4 15:00–15:30
Magnetospinning of Nano and Microfibres
O’Kiely, Doireann Univ. of Oxford
Griffiths, Ian Univ. of Oxford

Abstract: We consider a novel method for the fabrication of nanofibres and microfibres called magnetospinning, where a magnetic-nanoparticle-laden viscous fluid is drawn using an external magnet. We derive a mathematical model that exploits the geometrical features of the system. This is validated with experiments and used to make predictions on the appropriate operating regimes for fibre manufacture.
Scheduling was originated 60 years ago, starting with solving $n/2/F/C_{\text{max}}$ problems by S. M. Johnson in 1954. Considering jobs or orders that might come from several customers who have different objectives or priority request(s), a two-agent scheduling problem was introduced 14 years ago by A. Agnetis et al in 2000. The two-agent scheduling problem breaks the limitation that all jobs must meet same criteria, instead, in a two-agent case, jobs coming from different agents may have different criteria. Scheduling with multiple agents has already received considerable attention in the literature. Various results on complexity analysis and algorithms have been developed with different objective functions and different machine settings for two agent settings. However, the existing researches do not give full play to agent’s initiative. All proposed heuristic algorithms are exquisitely designed and fine tuned to satisfy each agent’s constraints and goal. These are done by managers rather than agents. Agents are merely representing different job sets. However, in the literature of multi-agent systems (MAS), an agent is considered as an autonomous entity who can observe and act upon its environment, and direct its activity towards its goals. Agents can develop schedules using negotiation, competitive or other mechanisms rather than simple dispatching rule in heuristic and generate-and-test search strategy in meta-heuristic. Unfortunately, the two-agent scheduling research has largely ignored this autonomy property of agents focusing instead on optimizing schedules or analyzing complexity.

In the past 25 years, multi-agent system (MAS) is introduced into production scheduling to direct towards the support for scheduling agility rather than scheduling optimality and scheduling flexibility in the earlier research. However, the gap between current agent-based scheduling and initiative scheduling mainly reflects in these aspects: 1) independent agent for individual machine or job instead of a kind of machines or jobs according to the functional or physical decomposition approach; 2) open architecture to access to cloud manufacturing instead of closed architecture motivated by the manufacturing mode of real factory; 3) heterogenous agents instead of homogeneous agents; and 4) agent-centered scheduling mode instead of manager-centered scheduling mode. In addition, there lacks richer literature discussing how to realize the autonomous ability in the context of production scheduling.

With the high technology development of internet of things, cyber-physical system, and cloud computing, a platform is being realized where autonomous agents interact with each other to reach common objectives in the presence of real-time information, while simultaneously, each agent pursues individual goals. Hence, how to autonomously perform reactive, proactive, and social actions in its execution environment and act upon each other to generate schedule is a worthy question to explore, especially in a dynamic manufacturing environment. For example, in job shops, inevitable and unpredictable disturbances necessitate the revision of established schedules during manufacturing processes.

In this symposium, we discuss some evolving scenarios, models, solution techniques and future research of agent-based scheduling.
Kohn-Sham density functional theory. As the exact Jacobian of the KS equation could not be easily obtained, the application of classic Newton method is impractical. In this paper we propose several types of quasi-Newton methods for solving the KS equation by making use of the structure of the Jacobian. Theoretical convergence analysis of the proposed quasi-Newton method is given. Some numerical results experiments are also reported.

MS-Fr-D-44 13:30–15:30 VIP2-1
Pseudo-Differential Operators in Industries and Technologies - Part III of IV
For Part 1, see MS-Th-D-44
For Part 2, see MS-Th-E-44
For Part 4, see MS-Fr-E-44
Organizer: Wong, M.W. York Univ.
Abstract: Pseudo-differential operators, first appeared in 1960s in the paper by Joseph J. Kohn and Louis Nirenberg in the Communications on Pure and Applied Mathematics, have been used in the explicit descriptions of solutions of Partial Differential Equations. Since wavelet transform and related transforms came to the fore and became understood by scientists and engineers in the physical sciences, biomedical sciences, atmospheric sciences and geological sciences in the context of time-space -frequency representations, pseudo-differential operators and their variants such as Weyl transforms and noncommutative quantization with operator-valued symbols have become instrumental in signal and image analysis in the role of filters. Extensions of classical pseudo-differential operators to Weyl transforms and pseudo-differential operators to H-type groups can be thought of as noncommutative quantization. The aim of this minisymposium is to provide a platform for dialogs on several developments of pseudo-differential operators in some areas of industries and technologies such as information, communication and signals.

► MS-Fr-D-44-1 13:30–14:00
Advances in Queueing Models’ Research
Gupur, Geni Xinjiang Univ.
Abstract: On the basis of our research work, we introduce the dynamics for queueing models formulated by the supplementary variable technique. Firstly, we state our motivation, next we provide the main tools in functional analysis, queueing models formulated by the supplementary variable technique. Firstly, we introduce the asymptotic behavior of time-dependent solutions of queueing models. In addition, we discuss structure of time-dependent solutions of queueing models. We conclude this talk with some open problems.

► MS-Fr-D-44-2 14:00–14:30
Visualization of Complex-Valued Time-frequency Representations
Yan, Yusheng Beijing Inst. of Tech.
Zhu, Hongmei York Univ.
Abstract: Time-frequency analysis techniques are effective in detecting local signal structure and have been applied successfully in a wide range of fields. Different time-frequency analysis transforms yield different time-frequency spectra. However, visualizing a four-dimensional complex-valued time-frequency spectrum is not a trivial task. Here, we propose a new way to visualize such a complex-valued time-frequency spectrum in one graph. We show that the proposed visualization tool may facilitate better understanding of local signal behavior.

► MS-Fr-D-44-3 14:30–15:00
Pseudo-Differential Operators on Finite Abelian Groups
Wong, K. L. York Univ.
Molahajloo, Shahla Inst. for Advanced Studies in Basic Sci.
Abstract: We give the basic theory of pseudo-differential operators on finite abelian groups. In the case of a group with two elements, we give a criterion for invertibility of these operators and we also give a solution of the spectral invariance problem for these operators.

► MS-Fr-D-44-4 15:00–15:30
Phases of Modified Stockwell Transforms and Instantaneous Frequencies
Wong, M.W. York Univ.
Molahajloo, Shahla Inst. for Advanced Studies in Basic Sci.
Abstract: The phase of a signal is analyzed using the Stockwell transform. In particular, the relationships between the instantaneous frequencies of a signal in polar form and the phase of the corresponding Stockwell transform are given. The corresponding results using a reciprocal Morlet wavelet transform are given for comparisons.

Optimization Methods for Inverse Problems - Part IV of V
For Part 1, see MS-Th-BC-45
For Part 2, see MS-Th-D-45
For Part 3, see MS-Th-E-45
For Part 5, see MS-Fr-E-45
Organizer: LIU, XIN AMSS
Organizer: WANG, YANFEI The Inst. of Geology & Geophysics, CAS
Abstract: In this minisymposium, inverse problems arise from various areas such as geoscience and petroleum engineering, related optimization models like L1 norm regularization, and advanced optimization methods for solving these models such as first order methods, subspace methods, alternating direction method of multipliers and distributed optimization approaches are discussed.

► MS-Fr-D-45-1 13:30–14:00
A Matrix Framework Approach to Solve A High-Dimensional Inverse Problem
Wu, Leqin Jinan Univ.
Abstract: In this talk, we will introduce a method, which is based on a new matrix framework, to solve a high-dimensional inverse problem, or more specifically, the parameter estimation problem raised in the field of Gene Regulatory Networks (GRNs). Our method not only gives more fascinating theoretical properties, but also dramatically improves the numerical performance.

► MS-Fr-D-45-2 14:00–14:30
New Regularization Algorithm with Due Account Taken of Round-off Errors for Solving Multidimensional Ill-posed Problems
Lukyanenko, Dmitry Lomonosov Moscow State Univ.
Abstract: One of the most efficient ways of solving multidimensional ill-posed problems is using of parallel computing that helps us to process a huge amount of data. But the round-off errors that grow with increasing amount of computations can significantly affect the final result of calculations. Several recent results will be presented on the study of this problem. This work was supported by RFBR, project No. 14-01-31201, and by the Supercomputing Center of Lomonosov Moscow State University.

► MS-Fr-D-45-3 14:30–15:00
Regularized Optimization Method for Some Inverse Problems of Linear Diffusion Equations and Its Application in Numerical Differentiation
Wang, Zewen East China Inst. of Tech.
Ruan, Zhousheng School of Sci., East China Inst. of Tech.
Abstract: In this talk, we firstly present a regularized optimization method without iteration for some inverse problems of linear diffusion equation, such as inverse source problem of parabolic equation, the inverse problem of simultaneously determining both a space-dependent source and an initial value in the linear parabolic equations, etc. Then, we propose a PDEs-based numerical differentiation method based on the inverse source problems of diffusion equations.

► MS-Fr-D-45-4 15:00–15:30
Parameter Inversions for the Fractional Diffusion Equation Using the Optimal Perturbation Algorithm
Li, Gongsheng Shandong Univ. of Tech.
Abstract: In this talk, we consider parameters inversion problems in the time/space fractional diffusion equation using the optimal perturbation regularization algorithm with discrete additional data. We give three kinds of numerical inversions for the space-dependent diffusion coefficient, the fractional orders and/or the diffusion coefficient, and the linear source term respectively. Numerical simulations are presented, and discussions on the inversion algorithm are given too, including the finite-dimensional approximation, the regularization parameter, and data noises, etc.

Optimization Methods for Inverse Problems - Part IV of V
For Part 1, see MS-Th-BC-45
For Part 2, see MS-Th-D-45
For Part 3, see MS-Th-E-45
For Part 5, see MS-Fr-E-45
Organizer: YARMAN, Evren Schlumberger
Organizer: YARMAN, Evren Schlumberger
Abstract: Confidence in recovering earth’s properties requires good understanding of the underlying physics of wave propagation to synthetically generate data matching the measurements. This data matching problem, also known as full waveform inversion, requires three steps: (1) modeling: simulation of seismic wave propagation; (2) imaging (linearized inversion): reconstruction of the medium’s singularities by linearization of the forward modeling with respect to a known background; (3) inversion (non-linear inversion): updating the background model to match the measurements. This mini-sym-
Mathematics of Time-domain Seismic Imaging
Fomel, Sergey
The Univ. of Texas at Austin

Abstract: Time-domain imaging, which includes prestack time migration, as well as normal moveout, dip moveout, and stacking, is a workhorse of seismic data processing. Many of the transformations involved in time-domain imaging can be described as “images waves” with the help of specially constructed linear PDEs. Image wave PDEs include offset continuation, velocity com- pensation, and Gardner continuation. Gardner continuation transforms seismic reflection data to remove the dependence of moveouts on dip and curvature of reflectors.

Phase and Amplitude Tracking for Seismic Event Separation
Li, Yunye, Elita Demanet, Laurent
Massachusetts Inst. of Tech., MIT

Abstract: We propose a method for decomposing a seismic record into atomic events defined by a smooth phase and a smooth amplitude. The method uses an iterative refinement-expansion tracking scheme to minimize the highly nonconvex objective function. We demonstrate the proposed method on two synthetic records. An application of our method to frequency extrapolation is shown for the synthetic shot record from the shallow Marmousi model.

Model Reduction Approaches for Solution of Wave Equations for Multiple Frequencies
Saladi, Mikhail Druskin, Vladimir Remes, Rob
Schlumberger-Doll Research, Schlumberger-Doll Research, delt Univ. of Tech.

Abstract: We have developed a novel algorithm to solving Helmholtz equation for multiple frequencies. Our approach is based on model reduction techniques using Krylov and extended Krylov subspaces (EKS). Numerical examples on SEG/EAGE Salt model indicate that Krylov model reduction allows to obtain the solution for multiple frequencies at the cost of the BiCGStab iteration error for a single frequency. The EKS improves the convergence by providing more uniform error distribution for the entire range.

Image Reconstruction and Interpretation in Position Emission Tomography for Small Animals (micro-PET)
Garbarino, Sara
Department of Mathematics, Univ. of Genoa

Abstract: We consider applications like eddy current (EC) of metallic parts where the quality of the representation of the layers in the material degrades with the deepness of the layer. The goal is to recover anomalies (cracks) in the metal. Contemporary methods provide resolution that rapidly decay with the depth. Our method improves this decay by adapting the regularization parameters to the attenuation. The improvement is limited by the noise.

Mathematical modeling of infectious diseases - Part II of II
For Part I, see MS-Th-E-49

Organizer: Wang, Xueying
Washington State Univ.

Abstract: Mathematical modeling plays an important role in understanding the spread and control of infectious diseases in populations. Mathematical models have been increasingly used to guide public health policy decisions and explore questions in infectious disease control. This minisymposium will bring together researchers employing a variety of mathematical techniques to study relevant phenomena of infectious diseases.

A PDE System Modeling the Dengue Transmission with Nonlocal Infections and Crowding Effects
Feng-Bin, Wang
Chang Gung Univ.

Abstract: In this talk, I consider the influences of the spatial heterogeneity, crowding effect and non-local infection caused by the movements of the latent mosquitoes on the dynamics of dengue transmission. For this purpose, we modify an existing model to obtain a nonlocal and time-delayed reaction-diffusion system with the Neumann condition on the boundary. Then the basic reproduction number \( R_0 \) is defined for the model system, and it can be obtained explicitly when all model parameters are constants. Finally, we show that the global threshold dynamics of the model system can be determined by \( R_0 \).

Krylov Subspace Methods for Constrained Image Restoration
James, Nagy
Emory Univ.

Abstract: Iterative Krylov subspace methods play a central role in the regular- ization of image restoration problems. In this talk we consider hybrid schemes that can be used to effectively implement regularization, including determining regularization parameters. We also consider approaches to enforce sparsity and nonnegativete constraints, as well as approaches that can compensate for outliers, such as missing pixels.
Mathematical modeling of infectious diseases has affected disease control policy throughout the developed world. Policy goals vary with disease and setting, but preventing outbreaks is common. We use epidemiological models that incorporate various spatial and temporal heterogeneities to demonstrate how these heterogeneities may influence model predictions, particularly their implications for public health policymaking.

**Abstract:**
A general numerical framework of using adaptive finite element sizing on the motivation, the solitary wave solutions as well as the multi-hump waves. This includes ground state and excited state density functional theory calculations, wavefunction methods, together with some of their applications in computational materials science and quantum chemistry. We propose to develop ab initio electronic structure theory and first principle calculations among other parts of the spectrum of the operator.

**Mathematical and Numerical Aspects of Electronic Structure Theory - Part IV of V**

**For Part 1, see MS-Th-BC-50**

**For Part 2, see MS-Th-D-50**

**For Part 3, see MS-Th-E-50**

**For Part 5, see MS-Br-E-50**

**Organizer:** Lin, Lin
**Univ. of California at Berkeley**

**Organizer:** Lu, Jianfeng
**Duke Univ.**

**Abstract:**
Electronic structure theory and first principle calculations are among the most challenging and computationally demanding science and engineering problems. This minisymposium aims at presenting and discussing new developments of mathematical analysis, and numerical methods for achieving ever higher level of accuracy and efficiency in electronic structure theory. This includes ground state and excited state density functional theory calculations, wavefunction methods, together with some of their applications in computational materials science and quantum chemistry. We propose to bring together experts on electronic structure theory, which include not only mathematicians, but also physicists working actively in the field.

**Title:**
Nonlinear Spinor Field: Multi-hump Waves and the Stability

**Shao, Shihong**
**Peking Univ.**

**Abstract:** We first present a brief introduction to nonlinear spinor field, emphasizing on the motivation, the solitary wave solutions as well as the multi-hump waves. The upper bounds of the hump number in the charge, energy and momentum densities for the solitary waves are proved in theory. We then explore the relation between the multi-hump profile and the stability theoretically and numerically.

**Title:**
An Adaptive Finite Element Framework for Kohn-Sham/time-dependent Kohn-Sham Equation

**Bao, Gang**
**Zhejiang Univ.**

**Hu, Guanghui**
**Univ. of Macau**

**Liu, Di**
**Michigan State Univ.**

**Abstract:** A general numerical framework of using adaptive finite elements to solve Kohn-Sham and time-dependent Kohn-Sham equations is presented in this talk. The Kohn-Sham equation is linearized with the SCF iteration, and the derived eigenvalue system is solved with LOBPCG. With the use of the Crank-Nicolson method, the numerical method can be used to solve TDKS in the time domain. To improve the efficiency, the mesh adaptive methods are introduced. Numerical examples show the effectiveness of our method.

**Title:**
Rapid Iterative Diagonalization of Ill-conditioned Eigenvalue Problems in Electronic Structure Calculations

**Cai Yunfeng**
**Peking Univ.**

**Bai, Zhaojun**
**Univ. of California, Davis**

**Pask, John**
**LLNL**

**Abstract:**
This talk introduces a multiscale algorithm for stochastic simulation of reaction-diffusion processes. The algorithm is applicable to systems which include regions with a few molecules and regions with a large number of molecules. A domain of interest is divided into two subsets where continuous-time Markov chain models and stochastic partial differential equa-
Abstract:

For Part 1, see MS-Th-BC-52
For Part 2, see MS-Th-D-52
For Part 3, see MS-Th-E-52
For Part 5, see MS-Fr-E-52

Organizer: Zhang, Lei
Organizer: Ge, Hao
Organizer: Lei, Jinzhi

Peking Univ.

Tsinghua Univ.

Abstract: One of the central problems in biology is to understand the design principles of complex biological systems. Mathematical and computational models of biological processes can be characterized both by their level of biological detail and by their mathematical complexity. In this minisymposium, we focus on recent findings of computational models and methods to gain insights into the complexity of cellular life and efficiently analyze the experimental observations. Topics of interests include stem cells, developmental patterning, gene regulatory networks, neuron networks, uncertainty quantification of biological data, etc.

► MS-Fr-D-52-1

Energy Landscape Theory for the Biological System

Li, Tiejun

Peking Univ.

Abstract: The construction of the energy landscape for the biological system attracts much attention recent years. There are different proposals for this construction. We will try to give a detailed comparison for these different approaches from an applied mathematics point of view.

► MS-Fr-D-52-2

Clustering Analysis for Coarse Grain Models of Biomolecules

Zhou, Xiang

City Univ. of Hong Kong

Abstract: Coarse grained (CG) model of large biomolecule is important for the study of functional dynamics. Building CG model is to cluster full atoms into several sites in rational way. We define the dissimilarity between atoms from their MD simulated trajectories which includes both spatial structure and motion dynamics. K-means clustering method is applied and the selection of number of sites is based on minimizing clustering instability. Example of ATP-bound G-action is presented.

► MS-Fr-D-52-3

Reliability of Noise-Induced Spikes for Two Types of Threshold Dynamics

Kuske, Rachel

Univ. of British Columbia

Abstract: We study spike time reliability (STR) in neurons, driven by frozen copies of a stochastic, rather than constant, signal. For quiescence in uninhibited neurons, we compare smooth vs. discontinuous dependence of frequency on the applied current. Computational and geometrical approaches show how favorable time profiles combined with specific current increases improve STR. Analytical approximations for the phase difference density of two coupled stochastically forced oscillators complement our understanding of intrinsic vs. extrinsic noises in STR.

► MS-Fr-D-52-4

Multimodal Feedback in Lineage Control and Morphogenesis

Lowengrub, John

UC Irvine

Abstract: Feedback regulation of cell lineage progression plays an important role in tissue size control, but a role for such feedback in tissue morphogenesis is unexplored. Here we use mathematical modeling to show that positive and negative diffusible signals acting on stem and/or progenitor cells, lead to the appearance of bi-stable or bi-modal growth behaviors, ultrasensitivity to external growth cues, and the spontaneous emergence of self-organized budding and branching reminiscent of in vivo morphogenesis.

MS-Fr-D-53

3130–1530 212A

Recent Development of Mathematical Models in Computational Biology - Part IV of V

Organizer: Zhou, Xiang
Organizer: Fang, Yang
Organizer: Zhang, Lei

Chinese Acad. of Science

Fudan Univ.

Peking Univ.

Abstract: This minisymposium aims to bring together researchers focusing on using modeling and numerical approaches to study complex biological systems including (but not limited to) cell signaling pathways, complex bio-fluids, cell polarization, developmental and cell biology, stem, cells, and etc. Such complex biological systems in general consist of multiple interacting components that exhibit complicated temporal and spatial dynamics. Furthermore, feedback, nonlinearities and multiple time and length scales often make such systems extremely difficult to describe, model or predict. The invited speakers will discuss the challenges of modeling such complex systems, introduce new computational techniques to simulate them and, where possible, present novel analytical techniques to extract meaningful information.

► MS-Fr-D-53-1

Optimal Dividend, Capital Injection and Bankruptcy for An Insurer with Solvency Requirement

Zhou, Ming

Central Univ. of Finance & Economics

Abstract: We consider the optimal dividend problem in a Cramér-Lundberg model with capital injections, and a potential bankruptcy is allowed in this model. By maximizing the firm’s market value, we find that the optimal policy is to pay all surplus exceeding $d^*$ as dividends, and do capital injections when the surplus falls down solvency requirement, but declare bankruptcy when the surplus further drops down $-b^*$, at which the market value of the firm equals zero.

► MS-Fr-D-53-2

Composite Bernstein Copulas

Yang, Jingong

Peking Univ.

Abstract: Copula function has been widely used in insurance and finance for modeling inter-dependency between risks. Inspired by the Bernstein copula (BC) put forward by Sancetta and Satchell (2004), we introduce a new class of multivariate copulas, the composite Bernstein copula (CBC), generated from a composition of two copulas. This new class of copula functions is able to capture the tail dependence, and it has a reproduction property for the three important dependency structures: comonotonicity, countermonotonicity and independence. We introduce an estimation procedure based on the empirical composite Bernstein copula (ECBC) which incorporates both prior information and data into the estimation. A simulation study and an empirical study on financial data illustrate the advantages of the ECBC estimation method, especially in capturing the tail dependence. It is a joint work with Zhijin Chen, Fang Wang and Ruodu Wang.

Reference:


► MS-Fr-D-53-3

The Internal Stopping Time of A Merger for Two Insurance Companies

Liu, Bai

Nankai Univ.

Abstract: This paper is concerned with the optimal stopping time of a merger for two insurance companies under the condition that the merger will generate some synergy and create some costs. The objective is to maximize the sum of the two companies’ expected discounted value. Under different initial conditions, we split up the problem into three cases. Then, by using the optimal stopping theorem, we solve the problem separately and the value function and the optimal policy.

► MS-Fr-D-53-4


Zubelli, Jorge

IMPA

Abstract: Claim evaluation and risk management decisions require taking into account a large number of uncertain variables and volatile scenarios. They may include financial market investments as well as un hedgeable risks. Thus, risk neutral techniques are not suitable to this context. In this talk, we propose and discuss a variant of the hedged Monte-Carlo method of Potters et al. to tackle strategic and risk management decisions. This leads to interesting statistical and numerical analysis questions.

MS-Fr-D-54

3130–1530 V1P1-2

Modeling and Simulations of Complex Biological Systems - Part III of IV

For Part 1, see MS-Th-D-54
For Part 2, see MS-Th-E-54
For Part 4, see MS-Fr-E-54

Organizer: Liu, Xinfeng
Organizer: Ju, Lili
Organizer: Zhou, Ming

Univ. of South Carolina

Univ. of South Carolina

Central Univ. of Finance & Economics

Abstract: This mini-symposium aims to bring together researchers focusing on using modeling and numerical approaches to study complex biological systems including (but not limited to) cell signaling pathways, complex bio-fluids, cell polarization, developmental and cell biology, stem, cells, and etc. Such complex biological systems in general consist of multiple interacting components that exhibit complicated temporal and spatial dynamics. Furthermore, feedback, nonlinearities and multiple time and length scales often make such systems extremely difficult to describe, model or predict. The invited speakers will discuss the challenges of modeling such complex systems, introduce new computational techniques to simulate them and, where possible, present novel analytical techniques to extract meaningful information.

► MS-Fr-D-54-1

Single-step Implicit Integration Factor Methods for Advection-diffusion-reaction Equations

Abstract: These methods combine the advantages of explicit methods for simplicity and implicit methods for stability to achieve higher order of accuracy and mass conservation.
Abstract: In this paper, I shall present our work on developing single-step implicit integration factor (IIF) methods for solving stiff advection-diffusion-reaction equations. WENO schemes are applied to the nonlinear advection terms. Krylov subspace approximations are used for dealing with the computational challenge arising from the matrix exponentials in high dimensions. Both linear analysis and numerical experiments for the new method will be shown. This is a joint work with Tian Jiang at U. of Notre Dame.

Nonlinear Growth Kinetics of Breast Cancer Stem Cells: Implications for Cancer Stem Cell Targeted Therapy
Liu, Xinglong
Univ. of South Carolina

Abstract: We will introduce mathematical modeling for the dynamical interaction between cancer stem cells (CSCs) and non-stem cancer cells, and our findings reveal that two negative feedback loops are critical in controlling the balance between the population of CSCs and that of non-stem cancer cells. Furthermore, the model with negative feedback suggests that over-expression of the oncogene HER2 leads to an increase of CSCs by regulating the division mode or proliferation rate of CSCs.

Periodic Migration In A Physical Model of Cells on Micropatterns
Zhao, Yanxiang
The George Washington Univ.

Abstract: We extend a model for the morphology and dynamics of a crawling eukaryotic cell to describe cells on micropatterned substrates. This model couples cell morphology, adhesion, and cytoskeletal flow in response to active stresses induced by actin and myosin. Consistent with experimental results, simulated cells exhibit a broad range of behaviors, including steady motion, turning, bipedal motion, and periodic migration, in which the cell crawls persistently in one direction before reversing periodically.

An Energetic Variational Approach to Model Interaction of Multicomponent Biofilms with Fluid Flows
Xu, Zhihong
Univ. of Notre Dame

Abstract: A novel biofilm model is described which systemically couples bacterial, extracellular polymeric substances (EPS) and solvent phases in biofilm. This allows for studying contributions of rheology of individual phases to deformation of biofilm in response to fluid flow as well as interactions between different phases. The model is derived using energetic variational approach and phase-field method. Phase-field coupling is used to model structural changes of a biofilm. Model simulations are shown to be in qualitative agreement with experimental data.

Wavelet Methods for Inverse Problems Modelling Real World Systems - Part III of IV
MS-Fr-D-55 13:30–15:30
106
Organizer: Siddiqi, Prof., Abul
Organizer: Al-Lawati, M.A.
Sharda Univ., NCR
Sultan Qaboos Univ.

Abstract: In a direct problem an effect is determined by a cause while in an inverse problem cause is determined from an effect. In an image processing the direct problem is to find out how a given sharp photograph would look like when camera is incorrectly focused. A related inverse problem is to find sharp photographs from a given blurry image. Inventors of CAT and MRI were awarded Nobel Prize of Medicine and Physiology respectively in 1979 and 2003. Inverse problems typically involve certain quantities based on indirect measurements of these quantities. Seismic exploration, CAT, MRI, X-ray are examples of inverse problems. Bio metric identifiers are measurements from human body: examples are ear, face, facial thermogram, hand thermogram, hand vein, hand geometry, finger print, iris, retina, signature and voice. The direct and indirect problems of biometrics correspond to the analysis and synthesis of biometric information, respectively. Recognition of face is a direct problem while face reconstruction is an an inverse problem. Refinement of Fourier methods, called wavelet methods including curvelets, shearlets play important role for study of inverse problems occurring in above themes. The symposium is devoted to updated research on applications of wavelets to the above problems.
The Exit-time Problem for A Markov Jump Process

MS-Fr-D-57-3 14:30–15:00
Stochastic Solutions for Fractional Wave Equations
Sikorski, Alla
Michigan State Univ.
Abstract: A fractional wave equation replaces the second time derivative by a fractional derivative of order between one and two. In this paper, we show that the fractional wave equation governs a stochastic model for wave propagation, with deterministic time replaced by the inverse of a stable subordinator whose index is one half the order of the fractional time derivative.

Numerical and theoretical studies of phase field model - Part III of IV
For Part 1, see MS-Th-D-58
For Part 2, see MS-Th-E-58
For Part 4, see MS-Fr-E-58

MS-Th-D-58 13:30–15:30
Theoritical and numerical studies of phase field model - Part III of IV

For Part 1, see MS-Th-D-58
For Part 2, see MS-Th-E-58
For Part 4, see MS-Fr-E-58

Organizer: Wang, Qi
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: We propose a phase field model for the study of three-component immiscible flows with boundary. The model is a generalization of the two-component model. We first study certain consistency conditions for the forms of the bulk free energy and surface energy. We then develop an adaptive mesh refinement(AMR) technique to solve the system in order to improve the efficiency of the problem. Several numerical results are also given.

MS-Fr-D-58-3 14:30–15:00
Phase Field Methods with Energetic Variational Approaches
Liu, Chun
Penn State Univ.

Abstract: In this talk, I will discuss various phase field models with the general variational approaches. The focus is to relate these approaches to the existing results/theories for viscoelasticity.

MS-Fr-D-58-4 15:00–15:30
3D Numerical Simulation of Biofilm Hydrodynamics
Zhao, Jia
Univ. of South Carolina

Abstract: In this presentation, we will present a systematic study of biofilm hydrodynamics using a multiphase complex fluid model that accounts for quorum sensing, bacterial phenotypes and antimicrobial treatment. The model is essentially a phase field model with the phase boundary naturally defined by the concentration of biomass. 2nd order numerical methods are developed to simulate the hydrodynamics of biofilm system. 3D numerical results will be discussed.
We present in this talk some recent analytical and computational progress on understanding the nonexistence of minimizers to these variational problems, including in particular the singularly-perturbed two-well problem, including in particular the singularly-perturbed two-well problem. I shall discuss recent progress on understanding the nonexistence of minimizers to these variational problems. (joint work with Jacob Bedrosian.)

A Variational Perspective on the Blistering of a Compressed Thin Film on a Compliant Substrate
Kohn, Robert  
New York Univ.

Abstract: Complex blister patterns occur in elastic films as a consequence of compressive misfit. Blistering permits the film to expand locally, reducing the elastic energy. It is therefore natural to ask: what is the minimum energy achievable by blistering on a fixed area fraction of the substrate? I'll discuss this variational problem, which involves both the elastic deformation of the film and substrate and the geometry of the blistered region. (Joint work with Jacob Bedrosian.)

Nonexistence of Minimizers to Some Variational Principles with Nonlocal Repulsive Interactions
Lu, Jianfeng  
Duke Univ.

Abstract: Variational principles with competing attractive and repulsive interactions often arise from physical applications. In this talk, we will consider variational models with Coulomb repulsion coming from the theory of phase transition and electronic structure theory. We will present some recent progress on understanding the nonexistence of minimizers to these variational problems. (joint work with Felix Otto)

Coarsening Mechanism for Cahn-Hilliard Equation with Degenerate Diffusion Mobility
Du, Qiang  
Dai, Shibin  
NMSU

Abstract: We present in this talk some recent analytical and computational studies of the coarsening dynamics of a Cahn-Hilliard equation which is specified with a double-well potential and a degenerate mobility. Combining careful asymptotic analysis with effective computational schemes, we demonstrate that there is a strong dependence of the coarsening mechanism on specific forms of the potential and mobility functions.

Variational Modeling of Microstructure in Shape-memory Alloys
Conti, Sergio  
IAM, Univ. of Bonn

Abstract: Shape-memory alloys are a classical problem in the variational study of pattern formation in solids, both in the context of the theory of relaxation and in the study of singularly perturbed problems. I shall discuss recent progress on the singularly-perturbed two-well problem, including in particular the vectorial, geometrically nonlinear situation and the limit of low volume fraction.

Organizer: Kohn, Robert  
New York Univ.

Abstract: Energy-driven pattern formation examines how energy minimization leads to the formation of defects and microstructure in a variety of physical systems. Examples include the wrinkling of a stretched elastic membrane, the twinning produced by martensitic phase transformation, and the defects seen in liquid crystals. In these and many other examples, the physics is modeled by a nonconvex variational problem regularized by a higher-order term with a small coefficient, and energy-driven pattern formation can be studied by considering the limiting behavior of minimizers as the small parameter tends to zero. Another recurring theme is the use of ansatz-free bounds to identify and explore the features of energy-minimizing configurations. A third recurring theme is dynamics, since the patterns of interest are sometimes transient states of steepest-descent processes.

Model-based Approach to Drug Discovery
Small, Michael  
Univ. of Western Australia

Abstract: Mass spectrometry methodologies provide a massive amount of noisy data - within that mass of noisy data, biochemist wish to discover certain signatures corresponding to particular drug metabolites. These signatures can be characterised as a particular parameterised template within the data. Using minimum-description-length modelling methods we describe a new approach to identify potential drug locations and hence areas for further biochemical investigation. This method offers a new approach to the identifi-
cations of such deterministic signatures.

Abstract: Fractional analysis shows that changes in the memory of a nonlinear dynamical system lead to bifurcations. Biological systems with memory include the brain and also all organs' tissues which are viscoelastic and may be described by equations with time fractional derivative of order between zero and one. In this talk we make a review of possible applications of fractional calculus to biology and medicine based on recent publications.

Abstract:

In this work, we develop a mathematical model to study the effect of drug on the development of cancer including the quiescent compartment. The model is governed by a system of delay differential equations where the delay represents the time that the cancer cell takes to proliferate. Our analytical study of the stability shows that by considering the time delay as a parameter of bifurcation, it is possible to have stability switch and oscillations.

Nonlinear Dynamics in Fractional-Order Mathematical Model of Autoimmune Disease Psoriasis

Roy, Priti Kumar
Jadavpur Univ.

Psoriasis is one type of autoimmune chronic skin. We consider a mathematical model of Psoriasis involving T-Cells, Dendritic Cells, CD8+ T-Cells and Keratinocyte cell populations based on a set of FODEs. Our focus is how we can reduce the excess Keratinocytes, which is the causal effect of Psoriasis. From mathematical findings, we try to activate the suppressed memory, the inherited property of the cell-biological system, to decrease the surplus production of Keratinocyte cell population.

Forecasting the Incidence of Cancer

Mills, Terence
Loddon Mallee Integrated Cancer Service

Abstract: Approximately 30% of deaths in Australia are caused by malignant cancers. How do we deal with this group of diseases? There is widespread interest in this question in Australia. Planning for cancer services involves forecasting the incidence of cancer. These forecasts are based on mathematical models. My aim is to review the research literature on forecasting the incidence of cancer with a view to comparing models.

Convection Enhanced Macromolecular Nutrient Transport Through A Tumor Intertitial Space with Quadratically Varying Permeability

Dey, Bibaswan
Indian Inst. of Tech. Kharagpur
Raja Sekhar, G P
Indian Inst. of Tech. Kharagpur

Abstract: Extra-vascular transport of solute macromolecular nutrients and trans-vascular exchange between blood vessel and tumor interstitium inside a tumor (in vitro) are addressed. It is considered that the permeability of the interstitial space decreases quadratically with the radial distance towards the core. A general framework for transvascular and interstitial solute nutrient transport is discussed in a macroscopic view, where the modified Sterling law is used in order to describe transvascular nutrient transport. The interstitial fluid transport is modeled in the light of the mixture theory. The present model describes several dimensional analytical solution of hydrodynamic equations and an approximate analytical solution of advection-diffusion-reaction equation for describing the overall solute nutrient concentration within the interstitial space. Some criteria of the formation of necrosis within the tumor interstitium are discussed, when the nutrient metabolism kinetics of the tumor cells is first order in nature.

Galerkin Finite Element Method for Chemotaxis-Haptotaxis Cancer Invasion Model

Shangerganesh, Lingeshwaran
Indian Inst. of Sci.

Abstract: Cancer invasion of tissues is explained as system of partial differential equations using a wide range of continuum mathematical models. These models are used to explain the diverse growth of cancer cell dynamics and their interactions with the host tissue like extra cellular matrix. In this work, we propose a model to describe the evolutions of cancer cells density, extra cellular matrix (ECM) density and matrix degrading enzymes (MDE) concentration produced by cancer cells. In order to examine the interactions of cancer cells with ECM and MDE, we consider the reaction-diffusion system with chemotaxis and haptotaxis effect. In this work, the Galerkin finite element method will be presented for the numerical simulations of the cancer invasion model and we investigate the effects of haptotactic and chemotactic coefficients, diffusion coefficients of cancer cell density and matrix degrading enzymes, proliferation rate of cancer cells, remodeling rate of ECM.

A Reconstruction Algorithm for An Inverse Source Problem in Non-homogeneous Media

Chow, Shue-Sum
Brigham Young Univ.

Abstract: In many inverse source problems involving time harmonic wave propagation, the solution is improved if measurements based on many frequencies are used to recover the source. However, most of these results assumed the underlying medium is homogeneous. We propose an iterative reconstruction algorithm that allows one to recover the source term in non-homogeneous Helmholtz equation using boundary measurements for a range of frequencies, and discuss computational results in acoustic and elastic wave problems.

A Multiscale Butterfly Algorithm for Multidimensional Fourier Integral Operators

Li, Yingzhou
YING, LEXING Stanford Univ.

Abstract: This paper presents an efficient multiscale butterfly algorithm for computing Fourier integral operators (FIOs) of the form Ω(x) = ∫ f(x) a(x, ξ) e-2πiΦ(x, ξ) dξ, where a(x, ξ) is an amplitude function, and f(x) is a given input. The frequency domain is hierarchically decomposed into a union of Cartesian coronas. The integral kernel a(x, ξ) e-2πiΦ(x, ξ) in each corona satisfies a special low-rank property that enables the application of a butterfly algorithm on the Cartesian phase-space grid. This leads to an algorithm with quasi-linear operation complexity and linear memory complexity. Different from previous butterfly methods for the FIOs, this new approach is simple and reduces the computational cost by avoiding extra coordinate transformations. Numerical examples in two and three dimensions are provided to demonstrate the practical advantages of the new algorithm.

Butterfly Factorization

Li, Yingzhou
YING, LEXING Stanford Univ.

Abstract: The butterfly algorithm has been applied to accelerate an important class of matrix-vector multiplications. A matrix in this class enjoys a special low-rank property that the rank of any contiguous submatrix is only deter-
mined by the size of the submatrix. We refer to these matrices as butterfly matrices and present an efficient butterfly factorization method to represent them as a multiplication of data-sparse matrices. This butterfly factorization admits efficient algebraic operations, e.g., matrix-vector multiplication, matrix compression, etc. The factorization can be constructed efficiently in two cases: if a pre-existing code for the butterfly algorithm is available, or if arbitrary entries of the butterfly matrix can be computed on-the-fly. The application of the factorization is significantly faster than that of the butterfly algorithm as

**Abstract:** Image super-resolution is a process to enhance image resolution. It is widely used in medical imaging, satellite imaging, target recognition, etc. In this paper, we conduct continuous modeling and assume that the unknown image intensity function is defined on a continuous domain and belongs to a space with a redundant basis. We propose a new iterative model for single image super-resolution based on an observation: an image is consisted of smooth components and non-smooth components, and we use two classes of approximated Heaviside functions (AHFs) to represent them respectively. Due to sparsity of the non-smooth components, a L1 model is employed. In addition, we apply the proposed iterative model to image patches to reduce computation and storage. Comparisons with some existing competitive methods show the effectiveness of the proposed method.

**Abstract:** Fast GPU Implementation of Active Contours for High-throughput Medical Imaging

Prasath, Surya
Univ. of Missouri-Columbia

**Abstract:** Active contour method is based on a nonlinear minimization model and widely used for digital image segmentation. Nonlinear optimization combined with segmenting huge size of the images have hindered the progress of these algorithms for real time usage in medical diagnostics. Recently, globally convex version of traditional active contour models has paved the way for fast and efficient optimization procedures. Following the dual minimization of the total variation regularization, we derive efficient discretization schemes for active contour without edges model. By utilizing graphical processing unit (GPU) based implementation we obtained 20x faster results than using traditional computational methods. This enables us to utilize these algorithms for practical use in computationally demanding applications.
A new differential evolution variant is proposed to solve the network coding optimization problem becomes more and more important. In this paper, coding operation for information from different links. Therefore, network coding can reduce the data transmission time and improve the network performance.

Abstract:
Research on Network Coding Optimization Using Differential Evolution

A new combinatorial interpretation of convoluted Catalan numbers.

Abstract:
On A Mode-matching Analysis of 2D Flexible Waveguide Problems: Applications in Sound-structure Interaction

Abstract:
Modeling of Movie Scheduling - Outstanding Team Solution Paper

Abstract:
EM-Fr-D-67-7 16:00–18:10 311A
Discrete Moving Frames

Organizer: Chen, Xiaqing Beijing Univ. of Posts & Telecommunications
Abstract: The aim of this mini-symposium is to bring together specialists in the fields of mathematical problems in information technology, to intensify the mathematical research on three important research fields as follows. 1. Differential equations in telecommunications, such as, solitary wave. 2. Probability and Statistics in information technology. 3. Optimization and Scientific Computation in telecommunications.

Organizer: Liu, Wengjun Beijing Univ. of Posts & Telecommunications
Abstract: The propagation of optical solitons in optical fibers can be modeled by nonlinear Schrödinger equation (NLSE). The properties of solitons are presented, and the Hirota method is introduced. With the Hirota method, the bilinear forms for the NLSE are obtained, and the analytic one-soliton solution is derived.

Organizer: Zhang, Liying Beijing Univ. of Posts & Telecommunications
Abstract: Network coding can reduce the data transmission time and improves the throughput and transmission efficiency. However, network coding technique increases the complexity and overhead of network because of extra coding operation for information from different links. Therefore, network coding optimization problem becomes more and more important. In this paper, a new differential evolution variant is proposed to solve the network coding optimization problem based on simulated annealing and elitist parameter preserving strategy. Simulation experiments indicate its competitive performance based on various butterfly diagram network instances.

Organizer: Chun-Ming, Yuan AMSS, CAS
Abstract: In this talk, the concepts of binomial difference ideals and toric difference varieties are defined and their properties are proved. Four equivalent definitions for toric difference varieties are presented. Algorithms are given to check whether a given Laurent binomial difference ideal I is reflexive, prime, perfect, or toric, and in the negative case, to compute the reflexive and perfect
This is joint work with James Freitag and Tom Scanlon. The proof uses the construction of classical Chow dimension and degree. We establish their differential analogs for differential rational polynomials. Namely, Padé approaches which compare favourably to other applicable methods. In particular such as environmental studies, biology, chemistry, medicine, and ecological models that demonstrate good performance in solving PDEs that couple diffusion and reaction terms.

The purpose of this study was to investigate select numerical methods that demonstrate good performance in solving PDEs that couple diffusion and reaction terms. These types of equations have numerous fields of application such as environmental studies, biology, chemistry, medicine, and ecology. Our aim was to investigate and develop accurate and efficient approaches which compare favourably to other applicable methods. In particular, we investigated and adapted a relatively new class of methods based on rational polynomials. Namely, Padé time stepping (PTS), which is highly stable for the purposes of the present application and is associated with lower computational costs. Furthermore, PTS was optimized for our study to focus on reaction diffusion equations. Due to the rational form of PTS method, a local error control threshold (LECT) was proposed. Numerical runs were conducted to obtain the optimal LECT.

Abstract: This minisymposium is organized as follows. The first speaker Takenobu Nakamura (Tohoku University) will give a talk about applications of TDA into amorphous silica. His recent research shows two important new discoveries: (1) The dimensions of supports of persistence diagrams computed on alpha filtrations of atomic arrangements clearly distinguish crystal (0 dim), glass (1 dim), and liquid (2 dim) states, (2) The rings in the atomic arrangement of glass states possess a hierarchical structure. The second speaker Miro Kračmar (Rutgers University) will give a talk about applications of TDA to fluid dynamics and pattern formations appearing in Rayleigh-Benard convection. In this research, he transforms experimental or numerical data into a point cloud in the space of persistence diagrams. By choosing different metrics, one can interrogate the pattern locally or globally, which provides deeper insights into the dynamics of the processes of pattern formation. The third speaker Mohammad Saadatfar (Australian National University) will give a talk about applications of TDA into granular dynamics. He is an experimentalist of 3 dimensional granular systems, and recent his researches show some of the key geometric configurations of grains such as 5-rings to understand amorphous and crystal packing states. He also starts to apply TDA to study his experiments/numerical simulations. The fourth speaker Yuan Yao (Peking University) will give a talk about several methods for high dimensional data analysis. In particular, he will show some recent results on statistical ranking and combinatorial Hodge theory.
Abstract: Geometric methods for graph partitioning have been introduced in the past few years, with wide applications in clustering, community detection, and image analysis. In this talk, I’ll discuss a new graph partitioning method where the optimality criterion is given by the sum of the Beltrami energies of the partition components, a quantity which appears in the study of minimal surfaces.

MS-Fr-E-06-1 16:00–16:30
Predicting Chaotic Network Time Series with A Partial Model
Sauer, Timothy
George Mason Univ.
Abstract: Methods for forecasting time series are a critical aspect of the understanding and control of dynamical networks. When an explicit model of the system is unknown, nonparametric methods for prediction have been developed, based on concepts of attractor reconstruction pioneered by Takens and others. We consider how to make use of a subset of the system equations, if they are known, to improve the predictive capability of forecasting methods.

MS-Fr-E-06-2 16:30–17:00
On Anomalous Diffusion in Weakly Chaotic Deterministic Systems
Gottwald, Georg
Univ. of Sydney
Abstract: We present a universal view on diffusive behaviour in spatially extended systems and establish links between weak chaos and Levy processes. Furthermore, we establish stochastic limit systems driven by Levy noise from deterministic multi-scale systems driven by weakly chaotic fast dynamics. We then use these results to devise a method to construct one- and two-sided alpha-stable processes with specified parameter values. This is joint work with Ian Melbourne.

MS-Fr-E-06-3 17:00–17:30
Sampling Approaches to Non-Gaussian Data Assimilation
Sandu, Adrian
Virginia Tech
Abstract: Current operational ensemble-based filters like Ensemble Kalman Filter (EnKF), and Maximum Likelihood Ensemble Filter (MLEF), could fail in case of non-linear observations or non-Gaussian distributions. We discuss general data assimilation methods that work by sampling directly from the posterior distribution using a Hybrid Monte Carlo (HMC) approach. Numerical tests show the promise of the proposed filter and smoother.

MS-Fr-E-06-4 17:30–18:00
Quantification and Prediction of Rare Events in Nonlinear Water Waves
Sapsis, Theodosis
MIT
Abstract: The scope of this work is the development, application, and demonstration of probabilistic methods for the quantification and prediction of extreme events occurring in complex nonlinear systems involving water waves. We are interested to address two specific topics related to rare events in complex dynamical systems, namely (i) the Rare Event Prediction Problem and (ii) the Rare Event Quantification Problem.
Organizer: Alina, Chertock North Carolina State Univ. 
Organizer: Kurganov, Alexander Tulane Univ. 
Organizer: Lukacova, Maria Univ. of Mainz, Inst. of Mathematics 

Abstract: This minisymposium focuses on complex problems arising from geophysical flows and their numerical simulations. The models are typically governed by hyperbolic systems of conservation and balance laws, which are difficult to be solved numerically due to the presence of possibly singular geometric source terms, nonconservative exchange terms as well as multiscale phenomena in singular limit cases. These may lead to the loss of hyperbolicity, nonlinear resonance, very complicated wave structures as a result, of appearance of spurious oscillations and slow convergence of numerical methods. Therefore accurate modeling and development of robust, highly accurate and efficient numerical methods for these systems is a very important and challenging task. The organizers of the minisymposium are: Alina Chertock, Alex Kurganov and Maria Lukacova-Medvidova

**MS-Fr-E-07-1 16:00–18:00**

**Numerical Simulation of Shallow Water Equations on Sphere by the GRP Schemes**

Li, Jiequan Beijing Normal Univ. 

Abstract: We will talk about our recent contribution on the numerical simulation of atmospheric motion using the model of shallow water equations on the earth. The generalized Riemann problem (GRP) scheme is used to capture the effect of Coriolis force and preserve the well-balanced property. 

**MS-Fr-E-07-2 16:30–17:00**

**A Well-balanced Scheme for the Shallow-water Equations with Topography and Bottom Friction.**

Michel-Dansac, Victor Université de Nantes
Berthon, Christophe Université de Nantes
Foucher, Françoise Ecole Centrale de Nantes
Clain, Stephane Università di Milano

Abstract: We consider the shallow-water equations with topography and Manning friction source terms. This system admits strongly nonlinear steady states, which present particular challenges from a numerical point of view. We derive a well-balanced Godunov-type scheme for this model, i.e. a scheme able to exactly capture the stationary solutions. In addition, we establish that this scheme has robustness properties. Moreover, the derived numerical method turns out to be relevant in the approximation of wet/dry transitions. 

**MS-Fr-E-07-3 17:00–17:30**

**The New Semi-Implicit Runge-Kutta Methods and Their Applications in Shallow Water Equations with Friction Terms**

Wu, Tong Tulane Univ.

Abstract: We develop a family of second-order semi-implicit time integration methods for systems of ordinary differential equations (ODEs) with stiff damping term, which is capable of exactly preserving the steady states and maintaining the sign of the computed solution. We implement the proposed SSP-RK based semi-implicit methods on a system of ODEs arising from the semi-discretization of the shallow water equations with friction terms and achieve a remarkable agreement between the numerical results and experimental data.

**MS-Fr-E-07-4 17:30–18:00**

**On Hydrostatic Reconstruction (HR) Schemes for the Shallow Water Equation**

Nollé, Sebastien RWTH Aachen Univ.

Abstract: A key difficulty in the analysis and numerical approximation of the shallow water equations is the non-conservative product of measures. Solutions may be non-unique, and numerical schemes make an implicit decision about how to model the physics. We present a systematic derivation of HR schemes, including a new scheme which borrows its structure from the wet-dry front, and compares well with previous schemes. This is joint work with Guoxian Chen, Wuhan University.

**MS-Fr-E-08 16:00–18:00**

**Success Stories of Spanish Industrial Mathematics with Industry**

Organizer: Quintela, Peregrina Spanish Network for Mathematics & Industry; Univ. of Santiago de Compostela

Abstract: The minisymposium “Success Stories of Spanish Industrial Mathematics with Industry” will emphasize the importance of the mathematical methods and techniques in the resolution of industrial problems. To do that, it will be presented four success stories between Spanish research groups in Industrial Mathematics and companies. To show that Mathematical technology is present at all economic sectors, examples of collaborations has been selected in four different sectors which are: Environment, Space, Materials and Transport. Each speaker will explain the improvements to achieve a successful implementation in companies. The first project was conducted under contract with the Kaleido Ideas & Logistics Company. The objective was to determine a lashing solution for granite sheets during sea transport into containers complying with IMO standards for stowage and safety. The design is focused on the sheets packaging, the bundles location, and the slings necessary to tie them to the container, so that the cargo remains immobilized under adverse conditions of navigation. The second success case will present the strategy implemented in the Italian TEWS (Tsunami Early Warning System) concerning tsunami simulations using tsunami-HySEA model developed by EDANYA Group implemented on GPUs. This model takes into account the three phases of an earthquake generated tsunami: generation, propagation and coastal inundation, and combines finite difference and finite volume schemes, providing a complete simulation on the Mediterranean basin in less than five minutes of computational time. Most Earth satellites observation decouple the acquisition of a panchromatic (grayscale) image at high spatial resolution from the acquisition of a multispectral image at lower spatial resolution. The pansharping problem refers to the fusion process of inferring a high-resolution multispectral image from a high-resolution panchromatic image and a low-resolution multispectral one. To solve it, in the third talk, a functional model that incorporates a nonlocal regularization term and two fidelity terms will be proposed. Finally, the goal of the fourth success case will be to enable on-the-fly recommendations for technological conditions in polymerization processes. The focus is on algorithms for prediction of particle morphology development and polymer branching. The work has been done in collaboration with Basque Center for Macromolecular Design and Engineering (POLYMAT), a long term partner of the chemical companies Arkema, BASF and Solvay.

**MS-Fr-E-08-1 16:00–16:30**

**A New Mathematical Model for PanSharpening Satellite Images**

Coll Vicens, Bartomeu Univ. of Balearic Islands
Buades, Antoni universitat illes balears
Duran, Joan Univ. of Balearic Islands
Sbert, Catalonia Université de les Illes Balears

Abstract: Most Earth satellites observation decouple the acquisition of a panchromatic (grayscale) image at high spatial resolution from the acquisition of a multispectral image at lower spatial resolution. The pansharpening problem refers to the fusion process of inferring a high-resolution multispectral image from a high-resolution panchromatic image and a low-resolution multispectral one. To solve it, we propose a functional model that incorporates a nonlocal regularization term and two fidelity terms.

**MS-Fr-E-08-2 16:30–17:00**

**Numerical Simulation of Lashing Solutions for Containerized Transport of Granite Sheets**

Quintela, Peregrina Spanish Network for Mathematics & Industry; Univ. of Santiago de Compostela
Barral, Patricia Univ. of Santiago de Compostela
Rial, Angel Univ. of Santiago de Compostela

Abstract: A project conducted under the contract with the Kaleido Ideas & Logistics Company will be presented. The objective was to determine a lashing solution for granite sheets during sea transport into containers complying with IMO standards for stowage and safety. The design is focused on the sheets packaging, the bundles location, and the slings necessary to tie them to the container, so that the cargo remains immobilized under adverse conditions of navigation.

**MS-Fr-E-08-3 17:00–17:30**

**Mathematical Modelling of Polymers Particles Production**

Rusconi, Simone BCAM - Basque Center for Applied Mathematics
Akhmatskaya, Elena BCAM - Basque Center for Applied Mathematics
Dutkyh, Denis CNRS
Sokolovski, Dmitri Univ. of Basque Country
Asua, Jose M POLYMAT, Univ. of the Basque Country UPV/EHU

Abstract: We present the novel stochastic approach for polymers particles production modelling and numerical simulations amenable to high performance computing. The goal is to enable on-the-fly recommendations for technological conditions in polymerization processes. The focus is on algorithms for prediction of particle morphology development and polymer branching. The work has been done in collaboration with Basque Center for Macromolecular Design and Engineering (POLYMAT), a partner of a consortium of companies including some of the
Abstract:
In reaction-diffusion systems with a mass conservation property, conservation breaking dynamics works with researchers from both fields are expected.

The interaction between modeling and mathematical techniques, many joint field both of models for real phenomena and techniques for nonlinear differential equations. As mathematical models, we deal with nonlinear parabolic equations of reaction-diffusion types and higher dimensional ODEs. Through the interaction between modeling and mathematical techniques, many joint works with researchers from both fields are expected.

**MS-Fr-E-09-1 16:00–16:30**

**Conservation Breaking Dynamics in Reaction-diffusion Systems**

Kuwamura, Masataka
Kobe Univ.

**Abstract:** In reaction-diffusion systems with a mass conservation property, a spatial pattern induced by the diffusion-driven ( Turing type) instability can eventually approach a simple localized pattern after exhibiting long transient dynamics. This study investigated the perturbed reaction-diffusion systems of such conserved systems. The results provide interesting examples of spatio-temporal dynamics in reaction-diffusion systems. This work is based on a joint work with Prof. Yoshihisa Morita.

**MS-Fr-E-09-2 16:30–17:00**

**A Mathematical and Experimental Study on Jet Lag: Why is Eastbound Trip So Hard?**

Kori, Hiroshi
Ochanomizu Univ.

**Abstract:** I will report on a mathematical and experimental study on jet lag. After giving a short review of our experimental study, mathematical interpretation will be provided. Here, the body clock is described as periodically forced phase oscillators. I found that, using perturbation theory, periodic forcing generally has an effect of slowing down relaxation time for the phase advance of phase oscillators. I will report on a mathematical and experimental study on jet lag.

**MS-Fr-E-09-3 17:00–17:30**

**Mathematical Modeling and Genetic Analysis of the Wave of Differentiation**

Sato, Makoto
Kanazawa Univ.

Miura, Takashi
Kyushu Univ.

Nagayama, Masaharu
Graduate School of Medicine

Kanazawa Univ.

**Abstract:** Notch-mediated lateral inhibition is found in various developmental processes. However, how it behaves when combined with the other signaling systems is not understood in detail. By combining mathematical modeling and genetic analysis, we demonstrate that it plays an unexpected role in combination with EGFl signaling in the course of proneural wave progression during development of the Drosophila visual center.

**MS-Fr-E-09-4 17:30–18:00**

**Formation of Fractal Structure in Skull Suture**

Miura, Takashi
Kyushu Univ.

**Abstract:** Skull suture is also regarded as an example of fractal structure in biology. In the present study, we show the time course observation of human skull suture using 3DCT. Next we propose a new model that couples interface equation with nonlinear diffusion to reproduce fractal structures in numerical simulation. We also present scaling argument of this system to show the system can generate fractal structure.

**MS-Fr-E-10 16:00–18:00**

**Stochastic Dynamics with Applications - Part III of III**

**For Part 1, see MS-Th-E-10**

**For Part 2, see MS-Fr-D-10**

**Organizer:** Duang, Jingqiao
Illinois Inst. of Tech.

**Abstract:** Nonlinear systems are often under random influences. The uncertainties may be due to external fluctuations or unresolved scales. These random influences may affect system evolution at various spatial and temporal scales, subtly or profoundly. Taking uncertainty into account is essential in modeling various complex phenomena in biological, physical and chemical systems.

The objective of this special session is to bring together experts from multiple disciplines with complementary views and approaches to stochastic dynamics in the context of applications.

The topics to be discussed include: Overview of stochastic dynamics, stochastic approaches for multi-scale modeling, impact of noise, non-Gaussian dynamics, statistical physics near or out of equilibrium, adaptive dynamics, biological modeling, stochastic modeling in systems biology.
Zvyagin, Victor  
Veronezh State Univ.  

Abstract: In this report the theory of attractors is devoted to investigation of the asymptotic behavior as $\tau \to \infty$ of weak solutions of hydrodynamic equations describing the dynamics of incompressible fluids. Here we have used the concept of a trajectory attractor. It is effective tool for studying situations where there is no uniqueness of the corresponding boundary value problem solutions. In the report the new approach of the investigation of attractors for non-Newtonian fluids will be considered.

Some examples of a viscoelastic media hydrodynamics for which the existence of attractors is established on the basis of the developed theory are considered. We present the example on the existence theorem of attractors for Oldroyd models of viscoelastic media motion with memory, for low concentrated aqueous polymer solution motion model, for Bingam model.

In this report the theory of pullback-attractors of weak solutions for hydrodynamic equations is also considered.

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3D Hydrodynamic Mathematical Modeling and Simulations for Cell Morphology and Mitotic Dynamics
Zhao, Jia  
Univ. of South Carolina
Wang, Qi  
Univ. of South Carolina & Beijing Computational Sci. Research Center

Abstract: Cells are the fundamental unit in all living organisms since animals and plants are all made up of cells of different varieties. The study of cells is therefore an essential part of research in biological science and medicine. Recently, we have developed a framework of 3D hydrodynamic models studying the cell morphology and its mitotic dynamics by a multi-phase field approach. Quantitatively patterns of wrinkling cell morphology, mitotic cell rounding and cytokinesis have been observed. In this talk, our results on the mechanism and controlling factors guiding these interesting phenomenon would be addressed. 3D numerical simulations will be shown, as well.

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Modeling of driver’ s characteristics in a two-lane Lattice hydrodynamic traffic flow model
Sharma, Sapna  
DAV Univ. Jalandhar

Abstract: Due to modernization, the rapid increase of automobiles on roads leading to a serious problem of traffic congestion attracted much attention of drivers. Due to modernization, the rapid increase of automobiles on roads leading to a serious problem of traffic congestion attracted much attention of drivers. The effects of driver’s behavior on the stability of traffic flow is examined through linear stability analysis. To describe the propagation behavior of a density wave near the critical point, nonlinear dynamics is considered by introducing kink-antikink soliton is derived. The effect of anticipation parameter on traffic flow dynamics is investigated and found that it has a significant effect on the stability of two-lane traffic flow. Numerical simulation is performed and the results are found consistent with the theoretical findings.

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Melting Heat Transfer in MHD Non-Darcy Flow of A Nanofluid over A Shrinking Surface in the Presence of Thermal Radiation with Second Order Slip Flow Model
Ganesh, N. Vishnu  
Sri Ramakrishna Mission Vidyalaya CAS,Coimbatore - 20
A.K., Abdul Hakeem  
Sri Ramakrishna Mission Vidyalaya CAS

Abstract: The present paper is devoted to study the melting heat transfer and second order velocity slip effects on an incompressible magnetohydrodynamic non-Darcy boundary layer flow of a water based nanofluid over a shrinking surface embedded in a porous medium in the presence of thermal radiation and internal heat generation/absorption. Scaling group of transformations is used to convert the governing nonlinear PDEs to nonlinear ODEs. The analytical solutions are derived for both momentum and energy equations for a special case. The problem is solved numerically by the fourth-order Runge-Kutta method with shooting technique. Dual solutions are obtained for momentum equation which is classified as upper and lower branch solutions. The effects of various physical parameters on the velocity and temperature profiles, local skin friction coefficient and the reduced Nusselt number are discussed. Comparisons are found to be good with previously published results.

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Computer Extended Series Solution for Spherical Couette Flow
Tettamanti Bosnier, Florencia  
Imperial College London
Moore, Daniel  
Imperial College London
Mestel, Jonathan  
Imperial College London

Abstract: Incompressible, viscous flows in the spherical gap between differentially rotating concentric spheres arise naturally in several engineering, geophysical and astrophysical scenarios. Moreover, they exhibit properties of interest in hydrodynamic stability and bifurcation theory. Multiple steady flow patterns are known to exist at Reynolds numbers which depend on the gap geometry and velocity differential, in a manner similar to cylindrical Taylor vortices.

Typically, this bifurcation structure has been studied by numerical path continuation techniques. Instead, we use computer extended series as pioneered by Van Dyke. This approach represents the flow as a power series in the Reynolds number. The convergence of this series is limited by a complex singularity. We analytically continue the series by generalised Padé approximants as introduced by Oražin & Tourigny, which are able to detect multiple solution branches. The results are compared with direct numerical results.
first propose a series of SPRK with optimized coefficients which lead to minimized phase error, then we apply the new SPRK in NSPRK to obtain optimal NSPRK. The phase drift issue of conventional SPRK in long-time simulations, and further improve the phase accuracy of NSPRK. Theoretical analysis shows, that compared to NSPRK, the new optimal NSPRK is more loose on stability criteria and more accurate on numerical dispersion. Numerical experiments also verify that the new SPRK can much better conserve the phase information of Hamiltonian systems. On the other hand, for the effective use of NSPRK-type methods in wave simulation in unbounded media, we propose a new convolutionally perfectly matched layer (CPML) with improved absorption effect. In the new CPML, we introduce damping profile and phase transition functions formalized by high-degree polynomials. This technique can better reduce the numerical reflection at the boundary of computational and PML domains. Finally, several numerical simulations show that the combination of optimal NSPRK and the improved CPML is efficient.

**MS-Fr-E-13-2**
16:30–17:00
**Stiffness of Numerical Methods for Hyperbolic Problems and Orthogonal Polynomials**
Krivodonova, Lilia
Univ. of Waterloo

Abstract: High order methods for solution of hyperbolic equations have a CFL number that decreases with the order of approximation, e.g. quadratically with the discontinuous Galerkin methods. We show that there is an inherent trade-off between high-order approximation and a CFL restriction, thus less stiff methods are necessarily less accurate. We discuss how this trade-off can be exploited for the best balance of accuracy and computational efficiency.

**MS-Fr-E-13-3**
17:00–17:30
**Further Results on Irregular Weak Reflection**
Tesdall, Alain
City Univ. of New York, College of Staten Island

Abstract: Recent numerical solutions and physical experiments have shown the existence of a complex reflection pattern which provides a resolution of the triple point paradox. This pattern is characterized by a discontinuous transition from supersonic to subsonic flow at the rear of each patch in a sequence of tiny supersonic patches. We study numerically the possibility of an alternate structure in which the transition from supersonic to subsonic flow is smooth.

**MS-Fr-E-13-4**
17:30–18:00
**Shock Formation for Compressible Euler Equations**
Chen, Geng
Georgia Inst. of Tech.

Abstract: In this talk, we introduce the recent progress on the shock formation for compressible Euler equations. The talk includes several joint works with Ronghua Pan, Shengguo Zhu, Robin Young and Qingtian Zhang.

**MS-Fr-E-14**
16:00–18:00

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**Effective dynamics of stochastic partial differential equations - Part III of III**

For Part 1, see MS-Th-E-14
For Part 2, see MS-Fr-D-14

Organizer: Gao, Hongjun
Nanjing Normal Univ.

Organizer: Wang, Wei
Nanjing Univ.

Organizer: Huang, Jianghua
National Univ. of Defense Tech.

Abstract: In this talks, the well-posedness and dynamics of the Cauchy problem for the stochastic generalized Benjamin-Ono equation are presented, both Gaussian noise and fractional Brownian motion are considered respectively. By using the Bourgain spaces and Fourier restriction method and the assumption that \( \nu \in \mathcal{F}_r \)-measurable, the locally well-posedness of the Cauchy problem for the stochastic generalized Benjamin-Ono equation are obtained for the initial data \( u_0(x, \omega) \in L^2(\Omega; H^{s}(\mathbb{R})) \) with \( s \geq \frac{1}{4} \), where \( 0 < \alpha \leq 1 \).

**MS-Fr-E-14-2**
16:30–17:00
**A Linking Theory for Dynamical Systems with Applications to PDEs**
Li, Desheng
Tianjin Univ.

Abstract: We establish a linking theory for dynamical systems, thus providing an alternative approach for finding invariant sets without using Conley index. It can be also applied to variational problems of elliptic equations that may not satisfy the P.S. Condition. As applications, the existence of recurrent solutions of a nonautonomous resonant parabolic equation and that of positive solution of Shrodinger equation are investigated by using appropriate linking theorems and mountain pass lemmas of semiflows.

**CP-Fr-E-14-3**
17:00–17:20
**Mesoscopic Stochastic Modeling and Numerical Simulation of Transiently Networked Fluids**
Liu, Hailing
Iowa State Univ.

Abstract: We study long-time dynamics in a model of the Kompaneets equation. The Kompaneets equation describes evolution of photon energy spectrum due to Compton scattering of photons by electrons, an important energy transport mechanism in certain plasmas. For our model, we prove global existence for initial data with any finite moment, convergence to equilibrium in large time, and failure to conserve photon number for large solutions, due to formation of a shock at zero energy.
In this paper, we consider the existence of nodal solutions with two
Abstract:

and biology modeling involving nonlinear partial differential equations of elliptic
possibly including: (i) qualitative and quantitative properties enjoyed by solutions
world experts in the area of PDEs, both theory and computation, to report the
presented. The goal of this mini-symposium is to provide a platform for the
mixed type equations. Many problems of an applied nature reduce to finding
the mathematical modeling of physical and biological phenomena, including
Partial differential equations (PDEs) have been widely used in
Abstract:

Models.

analytical predictions is delicate and is carefully explored.

Viscoelastic fluids under varying conditions (temperature, salinity,
concentration) can exhibit exponential and/or power-law relaxations. We in-
Abstract:

tered out. All of numerical experiments support the new scheme.

analytical predictions, which appear in a theta-time discretization scheme for
forward-backward stochastic differential equations (FBSDEs), are studied and
analyzed. From these approximations, combining with Monte Carlo simula-
tion, a new numerical scheme based on least-squares regression for FBSDEs
is proposed. Numerical experiments for several examples are done to
test the availability and stability of the new scheme for Black-Scholes call and
calls combination. Moreover, an empirical expression about volatility is point-
ed out. All of numerical experiments support the new scheme.

A Regression-Based Numerical Method for Forward-Backward Stochastic D-
differential Equations

Yiqi, LIU
The Univ. of Macau
Abstract: Based on Fourier cosine expansion, the approximations for con-
ditional expectations, which appear in a theta-time discretization scheme for
forward-backward stochastic differential equations (FBSDEs), are studied and
analyzed. From these approximations, combining with Monte Carlo simula-
tion, a new numerical scheme based on least-squares regression for FBSDEs
is proposed. Numerical experiments for several examples are done to
test the availability and stability of the new scheme for Black-Scholes call and
calls combination. Moreover, an empirical expression about volatility is point-
ed out. All of numerical experiments support the new scheme.

MS-Fr-E-15-4 17:40–18:00

PDEs and applications: theory and computation - Part IV of IV
For Part 1, see MS-Th-D-16
For Part 2, see MS-Th-E-16
For Part 3, see MS-Fr-D-16
Organizer: Wang, Ying
Univ. of Oklahoma
Organizer: Nie, Hua
Shaanxi Normal Univ.
Abstract: Partial differential equations (PDEs) have been widely used in
the mathematical modeling of physical and biological phenomena, including
mixed type equations. Many problems of an applied nature reduce to finding
specific solutions and properties of PDEs of elliptic, parabolic, or of mixed
type, in particular, problems of plane transonic flow of a compressible medi-
un, and problems in the theory of envelopes. In this mini-symposium, recent
results in the theory and computation of PDEs and their applications will be
presented. The goal of this mini-symposium is to provide a platform for the
world experts in the area of PDEs, both theory and computation, to report the
recent progresses, exchange ideas and build up collaborative works. We an-
ticipate that our speakers will have expertise in a wide-ranging array of topics,
possibly including: (i) qualitative and quantitative properties enjoyed by solu-
tions, (ii) numerical partial differential equations of elliptic, parabolic, or of mixed
type, (ii) numerical schemes derived for various types of PDEs, (iii) physical
and biology modeling involving nonlinear partial differential equations of ellip-
tic, parabolic, or of mixed type.

MS-Fr-E-15-1 16:00–16:30

Two-bubble Nodal Solutions for Slightly Subcritical Fractional Laplacian
Guo, Qianqiao
Northwestern Polytechnical Univ.
Hu, Yunyun
Northwestern Polytechnical Univ.
Abstract: In this paper, we consider the existence of nodal solutions with two
bubbles to the slightly subcritical problem with the fractional Laplacian. This
work can be seen as a nonlocal analog of the results of Bartsch, Micheletti and

MS-Fr-E-15-2 16:30–17:00

Local and Global Dynamic Bifurcations of Nonlinear Evolution Equations
Li, Desheng
Tianjin Univ.
Abstract: We establish new dynamic bifurcation results for the nonlinear evo-
lution equation $u_t + Au = f(x, u)$ on a Banach space $X$, where $A$ is a
sectorial operator, and $x \in \mathbb{R}$ is the bifurcation parameter. Our main aim is
to give a global dynamic bifurcation theorem without assuming the "crossing
number" to be odd. Our method is mainly based on the Conley index theory.

MS-Fr-E-15-3 17:00–17:30

Regularity of Quasilinear Degenerate Subelliptic Equations with Carnot-
Caratheodory's Metric
Shenzhou, Zheng
Beijing Jiaotong Univ.
Abstract: In this talk, we establish a local comparison of its generalized
Green function with its fundamental solutions for a class of quasilinear de-
generate subelliptic operators with $\rho$-subharmonic as a prototype in Carnot-
Caratheodory's metric. As an application, we derive a local Hölder continuity
of quasilinear subelliptic equations by way of using a power of the Green func-
tion as the kernel function of some integral. On the other hand, for subelliptic
$\rho$-harmonic systems with the subcritical growth defined in Carnot group
we give that their weak solutions belong to $C_0^{1,\alpha}(\rho)$-regularity with respect to Carnot-
Caratheodory's distance provided that $\rho$ is close to 2. As a consequence, we
make it more clear that the critical growth of nonlinearity for $\rho$-harmonic type
systems in Carnot group is just a sharp borderline of partial regularity of the
small "excess" energy due to the counterexamples of $\rho$-harmonic maps with $\rho$
close to 2.

MS-Fr-E-15-4 17:30–18:00

Some Researches on Trivariate Lagrange Interpolation
LIHONG, CUI college of Mathematics, Liaoning Normal Univ.
Abstract: in this paper, we will lay emphasis on discussing trivariate Lagrange interpolation which is closely related to the interpolation along an algebraic surface and a space algebraic curve. In order to make the further research on the problem of trivariate Lagrange interpolation , we pose the concepts of sufficient intersection of algebraic surfaces and Lagrange interpolation along a space algebraic curve, and extend Cayley-Bacharach theorem in algebraic geometry from plane to space.

MS-Fr-E-16 16:00–18:00
205A
System of Conservation Laws and Related Models - Part IV of IV
For Part 1, see MS-Th-D-16
For Part 2, see MS-Th-E-16
For Part 3, see MS-Fr-D-16
Organizer: Li, Yachun
Shanghai Jiao Tong Univ.
Organizer: Wang, Weike
Shanghai Jiao Tong Univ.
Organizer: Wang, Yuguang
Shanghai Jiaotong Univ.
Organizer: Xie, Chunqing
Shanghai Jiao Tong Univ
Abstract: This minisymposium focuses on the analysis for system of conser-
vation laws and related models. It covers the following topics: 1. Multidimen-
sional conservation laws and transonic flows; 2. Compressible Navier-Stokes
system and singular limits for fluid dynamics; 3. Free boundary problems
arising in fluid mechanics and related models.

MS-Fr-E-16-1 16:00–16:30
Global Smooth Supersonic Flows in Infinite Expanding Nozzles
Wang, Chunjing
Jilin Univ.
Abstract: This talk concerns smooth supersonic potential flows with Lipschitz
continuous speed in two-dimensional infinite expanding nozzles. The condi-
tions for the global existence of smooth supersonic flows are shown. This is a
joint work with Professor Zhoupin Xin.

MS-Fr-E-16-2 16:30–17:00
On Linear Instability and Stability of Magnetic Rayleigh-Taylor Problems
Jiang, Song
Inst. of Applied Physics & Computational
Mathematics
Abstract: We investigate the stabilizing effects of magnetic fields in the lin-
earized magnetic Rayleigh - Taylor (RT) problem of the nonhomogeneous,
compressible and viscous magnetohydrodynamic fluids of zero resistivity in the
presence of a uniform gravitational field in a bounded domain, in which the
velocities of fluids are non-slip on the boundary. By a modified variation-
al method and careful energy estimates, we establish a criterion for instability
and stability of the linearized problem around a magnetic RT equilibrium state.
In the criterion, we find a novel conclusion that a sufficiently large horizontal
magnetic field has the same stabilizing effect as that of the vertical magnetic
field on growth of the magnetic RT instability. In addition, we further study the
converging compressible fluid case, i.e., the Parker (or magnetic buoyan-
ty) problem, in which the strength of the horizontal magnetic field decreases
with height, and also show the stabilizing effect of a sufficiently strong mag-
netic field. (joint work with Fei Jiang)

MS-Fr-E-16-3 17:00–17:30
Sonic-Subsonic Limit of Approximate Solutions to Multidimensional Steady Euler Equations  
Huang, Feimin  
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: A compactness framework is established for approximate solutions to sonic-subsonic flows governed by the steady full Euler equations for compressible fluids in arbitrary dimension. The new compactness framework applies for both non-isentropic and rotational flows. As direct applications, we establish two existence theorems for multidimensional sonic-subsonic full Euler flows through infinitely long nozzles.

MS-Fr-E-16-4 17:30–18:00  
Steady Subsonic Solutions for the Euler and Euler-Poisson System in Physical Domains  
Xie, Chunjing  
Shanghai Jiao Tong Universit

Abstract: We will discuss the recent progress on the steady subsonic solutions for the Euler equation in nozzles or past a bump. The subsonic solutions for the Euler-Poisson equations in a bounded nozzle will also be addressed.

MS-Fr-E-18 16:00–18:00  
Mathematics and Optics - Part IV of IV  
For Part 1, see MS-Th-D-18  
For Part 2, see MS-Th-E-18  
For Part 3, see MS-Fr-D-18  
Organizer: Santosa, Fadil  
Inst. for Mathematics & its Applications  
Organizer: Bao, Gang  
Zhejiang Univ.  
Organizer: Weinstein, Michael  
Columbia Univ.

Abstract: The importance of optics and is summarized in the 2013 US National Academy of Sciences report “Optics and Photonics: Essential Technology for Our Nation”. Envisioned technologies which rely on optics include computer and printing, imaging, sensing, and computing. What is clear from the report is that the Mathematical Sciences is poised to make significant contributions to the progress in technology. Indeed there is a growing research activity at the nexus of the Mathematical Sciences and the Optical Sciences. Together with advances in materials science and nano-structure fabrication, there is a growing role for mathematical tools, both computational and analytical.

Transformation Optics and Applications  
Ma, Yungui  
Zhejiang Univ.

Abstract: Transformation optics (TO) is a powerful mathematical tool that allows to control light propagation and shape light path almost in arbitrary ways. In the presentation, we will introduce our works to create interesting EM devices enabled by TO and metamaterials, including retroreflection lens, invincible cloaks and multiphysics functional devices.

Toward A Theory of Broadband Absorption Suppression in Magnetic-Dielectric Composites  
Welters, Aaron  
Florida Inst. of Tech.  
Fogtin, Alexander  
Univ. of California at Irvine

Abstract: A major problem with magnetic materials in application is they naturally have high losses in a wide frequency range of interest (e.g., Faraday rotation using ferromagnets in optical frequencies). Composites can inherit significantly altered properties from those of their components. Does this apply to losses and magnetic properties? How can broadband absorption suppression in magnetic-dielectric composites be achieved? We discuss new results towards answering these questions related to modal dichotomy and selective overdamping phenomena.

Asymptotic Characterization of Nanoparticle Plasmon Resonances  
Bonnetier, Eric  
Univ. of Grenoble-Alpes  
Triki, Faouzi  
Joseph Fourier Univ.

Abstract: In this talk, we study the asymptotic behavior of a 2D metallic nanoparticle. When the particle size is much smaller than the incident wavelength, the complex eigenvalues of the associated Helmholtz equation may get close to the real axis. We show that these eigenvalues can be derived from a nonlinear spectral problem associated to a boundary integral representation of the electric field and we derive their asymptotic expansion as the particle size tends to 0.

Stability and Pattern Formation in Nonlocal Interaction Models in Swarming  
Carrillo, Jose Antonio  
Imperial College London

Organizer: Jin, Bangti  
Univ. College London

Abstract: We present conditional existence results for the Landau equation with Coulomb potential. Their efficient and stable numerical solution is however very challenging. We will discuss the stability of these patterns for the continuum and discrete particle cases. These non-local models appear in collective behavior for animals, control engineering, and molecular structures among others.

Estimates for the Homogeneous Landau Equation with Coulomb Potential  
Gualdani, Maria  
George Washington Univ.

Abstract: We present conditional existence results for the Landau equation with Coulomb potential. Despite lack of a comparison principle for the equation, the proof of existence relies on barrier arguments and parabolic regularity theory. The Landau equation arises in kinetic theory of plasma physics. It was derived by Landau and serves as a formal approximation to the Boltzmann equation. In this talk, we present extensions to the inhomogeneous case where the opinion formation dynamics depend on an independent variable, e.g. an assertiveness or spatial variable.

Computational Inverse Problems - Part IV of IV  
For Part 1, see MS-Th-D-20  
For Part 2, see MS-Th-E-20  
For Part 3, see MS-Fr-D-20  
Organizer: Lu, Xiliang  
Wuhan Univ.

Abstract: Inverse problems arise in a wide variety of applications, e.g., medical imaging, tomography, anomalous diffusion and compressed sensing. Their efficient and stable numerical solution is however very challenging due to the ill-posed nature of inverse problems. There have been significant progress in recent years, in novel application, new mathematical techniques and efficient optimization algorithms. In this mini-symposium, we aim
Abstract: Topological and shape sensitivity are applied to electrical impedance, fluorescent diffusive optical or magnetic induction tomography. Here, topological sensitivity allows for initializations, which are free of user interaction, and shape sensitivity adjusts locally for achieving a better reconstruction of the geometry of hidden inclusions. Both sensitivities are incorporated into a level-set based descent algorithm for solving an output least squares formulation of the inverse problem. Analytical result and a report on numerical tests are given.

► MS-Fr-E-20-2 16:30–17:00 Forward–backward splitting method for quantitative photoacoustic tomography

Zhang, Xiaojun
Shanghai Jiao Tong Univ.

Abstract: Quantitative photoacoustic tomography (PAT) reconstructions optical maps using ultrasonic measurements, with improved resolution from conventional optical imaging due to significantly smaller acoustic scattering than optical scattering for detecting signals in depth. In this work, formulating quantitative PAT as a nonlinear least-squares problem with L1 norm sparsity regularization, we develop an efficient gradient-based reconstruction algorithm using a forward-backward splitting method, and prove its convergence for such a nonconvex problem.

► MS-Fr-E-20-3 17:00–17:30 An Undetermined Coefficient Problem for A Fractional Diffusion Equation

Zhang, Zhidong
Texas A&M Univ.
Zhou, Zhi
Texas A&M University

Abstract: We consider \(D_\alpha^\tau u(x, t) - u_{xx}(x, t) + q(x) u(x, t) = 0\) in \((0, 1) \times (0, T)\), where \(D_\alpha^\tau\) is the Caputo fractional derivative, \(0 < \alpha < 1\). An initial condition is given and Robin conditions are taken on the lateral boundary. The aim is to recover the unknown \(q(x)\) from additional final time data \(u(x, T) = g(x)\). We prove a uniqueness result and provide a constructive algorithm that produces a sequence \(\{q_n\}\) converging monotonically to \(q(x)\). We will also compare this fractional case with the corresponding problem for the classical case.

► MS-Fr-E-22 16:00–18:00 206A Recent development and applications of weighted essential non-oscillatory methods - Part V of V

For Part 1, see MS-Th-BC-22
For Part 2, see MS-Th-D-22
For Part 3, see MS-Th-E-22
For Part 4, see MS-Fr-D-22

Organizer: Qiu, Jianxian
Xiamen Univ.
Organizer: Shu, Chi-Wang
Simon Univ.

Abstract: The spectrum covered by the minisymposium ranges from recent development, analysis, implementation and applications, for the weighted essential non-oscillatory (WENO) methods. The WENO methods provide a practical effective framework to solve out many nonlinear wave-dominated problems with discontinuities or sharp gradient regions, which play an important role arising in many applications of computational fluid dynamics, computational astrophysics, computational plasma physics, semiconductor device simulations, among others. Devising robust, accurate and efficient WENO methods for solving these problems is of considerable importance and, as expected, has attracted the interest of many researchers and practitioners. This minisymposium serves as a good forum for researchers to exchange ideas and to promote this active and important research direction.

► MS-Fr-E-22-1 16:00–16:30 High Order Fixed-point WENO Sweeping Method for Steady State Problems

Zhang, Yong-Tao
Univ. of Notre Dame

Abstract: In this talk, I shall present our recent results on developing an efficient iterative fifth order WENO scheme for solving steady state hyperbolic conservation laws. The method is based on an explicit Gauss-Seidel sweeping framework combined with different new techniques. Numerical experiments will be presented to show the fast convergence of the iterations comparing with regular time marching method. This is a joint work with Liang Wu, Shuhai Zhang and Chi-Wang Shu.

► MS-Fr-E-22-2 16:30–16:50 LS-WENO: Weighted Least Squares Based Essentially Non-Oscillatory Schemes on Unstructured Meshes

Liu, Hongxu
Stony Brook Univ.

Jiao, Xiangmin
Stony Brook Univ.

Abstract: ENO and WENO schemes are widely used high-order schemes for solving hyperbolic conservation laws with structured meshes. For unstructured meshes, such schemes are less developed. We propose a new family of non-oscillatory schemes for unstructured meshes, called LS-WENO, based on local weighted least squares formulations. We show that LS-WENO can achieve better accuracy and stability than WENO for both structured and unstructured meshes, and verify the methodology using Burger’s equation and Euler equations.

► CP-Fr-E-22-3 15:45–17:10 A Hybrid Method for Convection Equations and Its Applications in Population Dynamics

Yang, Chang
Harbin Inst. of Tech.

Abstract: In this work, we present a new hybrid method for convection equations in order to study long term evolution dynamic of a group of cells. Indeed, lots of biological conjectures are based on the observation in long term. In modeling point of view this long term evolution dynamic is obtained by the analysis of the asymptotic behavior of the considered quantity. However, some numerical artifacts may lead to bad conjectures, caused by numerical diffusion of standard schemes in long term simulation. Thus, we develop the hybrid method, combining a high order method and an anti-diffusive method, can on the one hand achieve high accuracy for smooth solution; on the other hand avoid numerical dissipation for discontinuous one. The numerical simulations illustrate that the hybrid method can result a good agreement with the theoretical asymptotic analysis for the growth fragmentation type model.

► MS-Fr-E-23 16:00–18:00 208A Computational Methods of PDE-based Eigenvalue Problems and Applications in Nanostructure Simulations - Part IV of IV

For Part 1, see MS-Th-D-23
For Part 2, see MS-Th-E-23
For Part 3, see MS-Fr-D-23
For Part 4, see MS-Fr-E-23

Organizer: Bai, Zhaojun
Univ. of California, Davis
Organizer: Yang, Chao
Lawrence Berkeley National Lab.
Organizer: Zhou, Aihui
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.

Abstract: PDE-based eigenvalue problems arise from electronic structure calculations, band structure calculations in photonic crystals and dynamics of electromagnetic fields. This minisymposium brings together researcher’s working on PDE-based eigenvalue problems from areas of mathematical modeling and analysis, numerical analysis, high-performance computing and applications. This minisymposium features the latest progress on developing adaptive discretizations, stable nonlinear iterations and fast algebraic solvers, code designing and high performance computing on modern computer systems.

► MS-Fr-E-23-1 16:00–16:30 Why Higher-order Methods Are Preferred in PDE Eigenvalue Approximation in Some Cases?

Zhimin, Zhang
Beijing Computational Sci. Research Center, & Wayne State Univ.
Li, Huiyuan
Inst. of Software Chinese Acad. of Sci.

Abstract: We often find that in numerical approximation of PDE eigenvalues, higher-order methods, especially spectral methods, are superior to lower-order methods such as finite difference, finite element, and finite volume methods in many situations. In this talk, I shall discuss this phenomenon in some details. A general guide lie is that when regularity of the underlying eigenfunction is allowed, especially when it is analytic or piecewisely analytic, we should go with higher-order methods.

► MS-Fr-E-23-2 16:30–17:00 Adaptive Finite Element Approximations for Kohn-Sham Models

Xiaoying, Dai
Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.)

Abstract: The Kohn-Sham model is widely used approach for computation of ground state electronic energies. In this presentation, we will talk about our study for adaptive finite element approximations for the Kohn-Sham model. Based on the residual type a posteriori error estimators, we introduce an adaptive finite element algorithm, and obtain both the asymptotic contraction property and asymptotic quasi-optimal complexity of the adaptive finite element approximations. This is a joint work with H. Chen, L. He, and A. Zhou.

► MS-Fr-E-23-3 17:00–17:30 The Waveguide Eigenvalue Problem and the Tensor Infinite Arnoldi Method

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Abstract: We present a new iterative algorithm for nonlinear eigenvalue problems, the tensor infinite Arnoldi method, which is applicable to a general class of NEPs. We also show how to specialize the algorithm to the waveguide eigenvalue problem, which arises from a finite-element discretization of a partial-differential equation used in the study waves propagating in periodic medium. The algorithm is successfully applied to solve benchmark problems as well as complicated waveguides.

**A FINITE ELEMENT MULTIGRID SOLVER FOR P-NONCONFORMING MESHES USING ADDITIVE SCHWARZ SMOOTHING**

Jiang, Bongsoo, UNIST

Abstract: In this work, we propose a new semi-analytic method by using the generalized Taylor series for solving nonlinear fractional differential equations, which is called the generalized differential transform method (GDTM). In GDTM, it is a key to derive a recurrence relation of the coefficients of the generalized Taylor series associated with the solution. We provide the recurrence relations of complex nonlinear functions such as exponential, logarithmic and trigonometric functions. To enhance the computational accuracy, we apply the standard GDTM in each sub-domain, namely the multistage GDTM. From the global property of the fractional operator. A new recurrence relation with effect of memory is derived. Several illustrative examples are demonstrated to show the effectiveness of the proposed method.

**On Approximation Classes of Adaptive Finite Element Methods**

Tsogtgerel, Gantumur

McGill Univ.

Abstract: Recent studies on convergence of adaptive methods have shown that generally these methods converge at class-optimal rates with respect to approximation classes that are defined using a modified notion of error, the so-called total error, which is the energy error plus an oscillation term. In this talk, we present characterizations of those approximation classes in terms of memberships of the solution and data in Besov spaces. We will also discuss some modest improvements over the existing characterization results for the standard adaptive approximation classes (that are defined using the energy error).

**Explicit Finite Element Approximation and Invariant Domain Properties of Hyperbolic Systems**

Yang, Yong

Texas A&M Univ.

Abstract: An explicit continuous finite element approximation of hyperbolic systems will be presented. This technique is first-order in space but preserves all the invariant domain properties up to a standard CFL condition and works in any space dimension on nonuniform grids. The invariant domain property implies positivity of the density and internal energy and a minimum principle on the specific entropy for the Euler equations. A second-order extension to scalar conservation equations will also be presented.

**Numerical Methods for Compositional Models in Reservoir Simulation**

Zhang, Chensong

Acad. of mathematics & Sys. Sci.

Abstract: Compositional models are widely used by petroleum engineers to understand oil recovery mechanisms. We focus on a general compositional model and develop a fully-implicit method as well as an efficient linear solver. We will also discuss parallel implementation of the proposed preconditioner
to solve the Jacobian system arising from the fully implicit discretization. The accuracy, robustness, and parallel scalability of the parallel simulator are then validated using large-scale black oil benchmark problems.

**MS-Fr-E-25-3** 17:00–17:30

**Finite Element Approximation of Beltrami Fields in Multiply Connected Domains**

Rodriguez, Rodolfo

Universidad de Concepcion

Abstract: A couple of finite element methods to solve the eigenvalue problem for the curl operator in simply connected domains have been recently introduced and analyzed. This topological assumption is not just a technicality, since the eigenvalue problem is ill-posed on multiply connected domains, in the sense that its spectrum is the whole complex plane. However, additional constraints can be added in order to recover a well posed problem with a discrete spectrum. We consider as additional constraint a zero-flux condition of the curl on all the cutting surfaces. We introduce two weak formulations of the corresponding problem, one of them mixed and the other a Maxwell-like formulation. We prove that both are well posed and show how to take care of these additional constraints. We prove spectral convergence of both discretizations and establish a priori error estimates. We also report numerical tests which allow assessing the performance of the proposed methods.

**MS-Fr-E-25-4** 17:30–18:00

**Solitary Waves and Time-reversible Solutions to Nonlinear Hyperbolic Problems in Layered Media**

LeVeque, Randall

Univ. of Washington

Abstract: Solutions to nonlinear hyperbolic equations in homogeneous media generally develop shocks. However, if the medium varies periodically or randomly, then an effective dispersion arises that can inhibit shock formation and instead lead to the appearance of solitary waves and time-reversible solution structure. Numerical simulations in one and two space dimensions will be presented, along with some theoretical results and open questions. This is joint work with David Ketcheson and several other collaborators.

**MS-Fr-E-27** 16:00–18:00

Decoupling methods for multi-physics and multi-scale problems - Part VIII of VIII

For Part 1, see MS-Tu-E-27

For Part 2, see MS-We-D-27

For Part 3, see MS-We-E-27

For Part 4, see MS-Th-BC-27

For Part 5, see MS-Th-D-27

For Part 6, see MS-Th-E-27

For Part 7, see MS-Fr-D-27

Organizer: He, Xiaoming

Missouri Univ. of Sci. & Tech.

Organizer: Xu, Xuejun

Inst. of Computational Mathematics, AMSS, CAS

Abstract: The inherent multi-physics and multi-scale features of many real world problems accentuate the importance to develop efficient and stable numerical methods for the relevant PDEs, especially the decoupling methods. Although great efforts have been made for solving these problems, many practical and analytical challenges remain to be solved. This mini-symposium intends to create a forum for junior and senior researchers from different fields to discuss recent advances on the decoupling methods for multi-physics and multi-scale problems with their applications.

**MS-Fr-E-27-1** 16:00–16:30

**Domain Decomposition Proper Orthogonal Decomposition Method**

Wang, Zhu

Univ. of South Carolina

Abstract: We put forth a new framework for the applications of the proper orthogonal decomposition (POD) method in a domain decomposition (DD) setting. It includes a new partitioned method of snapshots for efficiently generating the POD basis; adaption of the POD to inhomogeneous boundary value problems; and development of a heterogeneous DD methodology that will accommodate different PDEs and ROMs in different domains. A thermal flow problem is utilized to verify the proposed method.

**MS-Fr-E-27-2** 16:30–17:00

**A parallel Robin - Robin domain decomposition method with optimal convergence rate**

Wang, Feng

Nanjing Normal Univ.

Abstract: In this talk, we propose a parallel Robin – Robin domain decomposition method for the second order elliptic problems. After choosing suitable parameters, we get a convergence rate which is independent of the mesh size. We also show that the idea can be generalized to other problems.

**MS-Fr-E-27-3** 17:00–17:30

**Decoupling the Navier-Stokes-Darcy Model**

He, Xiaoming

Missouri Univ. of Sci. & Tech.

Abstract: The Navier-Stokes-Darcy model arises in many real world applications. This model describes the free flow of a liquid by the Navier-Stokes equation and the confined flow in a porous media by the Darcy equation; the two flows are coupled through interface conditions. This presentation shows the wellposedness of the model and discusses the multiphysics domain decomposition method for decoupling this system.

**MS-Fr-E-28** 16:00–18:00

Network biology and medicine

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**Detecting Critical Transitions of Dynamical Systems by Big Data**

Chen, Luohan

Shanghai Inst.of Biological Sci.

Abstract: We develop a model-free method to detect early-warning signals of such critical transitions, even with only a small number of samples. We derive an index based on a dynamical network biomarker (DNB) that serves as a general early-warning signal indicating an imminent bifurcation or sudden deterioration before the critical transition occurs. We show that predicting a sudden transition from small samples is achievable provided that there are a large number of measurements for each sample.

**MS-Fr-E-28-2** 16:30–17:00

**Profiling Cell/Tissue Specific Gene Regulatory Networks**

Zhang, Louxin

National Univ. of Singapore

Abstract: In network biology, a cell is commonly described as a gene regulatory network and as such a cell-type is modelled by a state-dependent system over the network. Hence, understanding the topological structures of gene regulatory network plays a crucial role in uncover the biology of cell types. The talk will cover our recent work on the structures and dynamics of cell-specific regulatory networks.

**MS-Fr-E-28-3** 17:00–17:30

**HTSS Marine Natural Products for Potential Anti-Infective Drugs**

Zhang, Lixin

Chinese Acad. of Sci.

Abstract: Many drugs could be more effective at a reduced dosage if low dosages of other synergistic compounds are introduced simultaneously, especially from our microbial natural product library. To rapidly discover new antifungal agents for drug-resistant pathogens, we developed a high-throughput synergy screening (HTSS) strategy for novel microbial natural products. Here we report the production of drugable secondary metabolites from microbial producers could be further increased by synthetic biology approaches.

**MS-Fr-E-28-4** 17:30–18:00

**Human Microbes-disease Network**

Cui, Qinghua

Peking Univ. Health Sci. Center

Abstract: We use a large-scale manually-curated microbes-disease association dataset to construct a microbe-based human disease network and investigate the relationships among them. We reveal that the microbe-based disease loops are significantly coherent. Microbe-based disease connections have strong cross talks with those constructed by disease genes, symptoms, chemical fragments, and drugs. We confirm that the microbes-based disease analysis is powerful to predict novel connections and mechanisms for disease, microbes, genes, and drugs.
length scales are ubiquitous in modern science and engineering such as physics, biology, and materials. Those multiscale problems pose major mathematical challenges in terms of analysis, modeling and simulation. At the same time, advances in the development of multiscale mathematical methods coupled with continually increasing computing power have provided scientists with the unprecedented opportunity to study complex behavior and model systems over a wide range of scales. This minisymposium is aimed at presenting the state-of-the-art in multiscale modeling, simulation and analysis for the applications in science and engineering. It will focus on the developments and challenges in numerical multiscale methods and multiscale model reduction methods. The lectures will cover the following subjects: - Numerical homogenization methods, e.g. Generalized FEM, MsFEM, FEM-HMM, DG methods, Partition of Unity methods, multiscale domain decomposition etc. - Multiscale model reduction methods for stochastic systems, such as stochastic PDEs and random materials. - Multiscale methods for problems arising in composite materials and heterogeneous porous media. - Multiscale methods for eigenvalue problems, high frequency waves, and multiscale hyperbolic PDEs. - Multiscale modeling in various applications such as reservoir performance prediction, bio-motility, chemical vapor infiltration, etc.

**MS-Fr-E-29-1** 16:00–16:30
Stochastic Uncertainty Analysis for Unconfined Flow in Randomly Heterogeneous Media Using A High-dimensional Model Representation Method
He, Xinguang
Hunan Normal Univ.
Jiang, Lijian
Hunan Univ.

Abstract: In this study, we present a stochastic dimension reduction method for solving unconfined flow problems in randomly porous media. A high-dimensional model representation technique is applied to decompose the high-dimensional stochastic problem into a moderate-dimensional stochastic problem and a few one-dimensional stochastic problems. Then, the derived low-dimensional stochastic problems are solved separately by the sparse grid stochastic collocation method. We examine the accuracy of the approach for the unconfined flow with multiple random inputs.

**MS-Fr-E-29-3** 17:00–17:30
An Efficient Numerical Method for Elliptic Problems with Oscillatory Boundary Data
Ming, Pingbing
Chinese Acad. of Sci. AMSS

Abstract: We shall propose a new numerical method for elliptic problems with oscillatory boundary data. Both Dirichlet and Neumann boundary data will be discussed. Our method is based on a suitable coupling of multiscale basis functions. Theoretical results and numerical results are presented to show the efficiency of the method.

This minisymposium covers mathematical research in PDE constrained optimization ranging from numerical analysis and adaptive concepts over algorithm design to the tailored treatment of optimization applications with PDE constraints. It thereby forms a platform and fair for the exchange of ideas among young researchers and leading experts in the field, and for fostering and extending international collaborations between research groups in the field.

**MS-Fr-E-30-1** 16:00–16:30
Modeling and Computation of Transboundary Industrial Pollution with EmissionPermits Trading by Stochastic Differential Game
Zhang, Shuhua
Tianjin Univ. of Finance & Economics

Abstract: In this talk, a differential game model of transboundary pollution with emission permits trading is presented. We make use of stochastic optimal control theory to derive the value function for the noncooperative and cooperative games and propose a fitted finite volume method to solve it. The optimal emission paths, which maximize the region’s discounted stream of net revenue, are obtained. Several examples are presented to illustrate the results and the efficiency of the method.

**MS-Fr-E-30-2** 16:30–17:00
Parallel Domain Decomposition Procedures for Optimal Control Problems Governed by Parabolic Equations
Chen, Jixin
East China Normal Univ.
Yang, Danping
East China Normal Univ.

Abstract: Several parallel domain decomposition algorithms for solving optimal control problems governed by parabolic partial differential equations are proposed. These procedures are based on non-overlapping domain decomposition. The global problem is reduced to solving some implicit sub-problems defined on sub-domains at each time step. Optimal rates of a priori error bounds and convergence for approximation solution are derived and proved. Numerical examples are also performed to verify the theoretical analysis.

**MS-Fr-E-30-3** 17:00–17:30
Convergent Adaptive Finite Element Method for Optimal Control Governed by Elliptic Partial Differential Equations
Li, Zheng
East China Normal Univ.
Yang, Danping
East China Normal Univ.

Abstract: Convergent adaptive finite element method is proposed to solve distributed optimal control problems governed by elliptic partial differential equations. Based on posteriori error estimators for standard finite element approximation in L2-norm and H1-norm, an error reduction rates of is derived. Together with a reduction rate of data oscillations, we construct a convergent adaptive FEM algorithm. Some numerical experiments are performed to verify theoretical results.

**MS-Fr-E-30-4** 17:30–18:00
Model-free Implied Volatility, Quadratic Variation and Risk-neutral Density
Yang, Hongtao
Univ. of Nevada Las Vegas

Abstract: We shall present our recent work on the relationship among three important measures used in financial derivative field: the expectation of integrated return variance, the model-free implied volatility (MFIV), and the expectation of the quadratic variation of return. In particular, we have shown that these three quantities are significantly different when asset prices contains jumps. It suggests that the CBOE volatility index should be reconsidered by incorporating with the possible jumps. We also propose a new model for risk-neutral density in order to test the consistency of information contained in the option premiums, which are used to calculate the MFIV.

This minisymposium will gather about 16 world experts and young researchers to discuss the most recent advances in this challenging field as well as future directions for research.

**Schedules: Friday Sessions**

**MS-Fr-E-31-1**

16:00–16:30

**Structure Preservation and Some Discretisation Schemes in Linear Elasticity**

Zhang, Shuo

Inst. of Computational Mathematics, Chinese Acad. of Sci.

Abstract: In this talk, I will report some recent works on the discretization of linear elasticity and related problems. Judging from theoretical and/or numerical analysis, I will talk about the construction and application of structure-preserving relation in designing and analysing discretization schemes, especially the contrast and interaction between the primal and mixed forms.

**MS-Fr-E-31-2**

16:30–17:00

**Lower Order Symmetric Finite Elements for Linear Elasticity on Simplicial Grids**

Zhang, Shangyou

Univ. of Delaware

Abstract: We construct, in a unified fashion, lower order, conforming, symmetric finite elements on triangular and tetrahedral grids. These spaces are Pk polynomials (k is no less than 2 but not greater than than the space dimension n), enriched, by minimum local bubbles of polynomials of degree n+1.

**MS-Fr-E-31-3**

17:00–17:30

**The Elasticity Complex, Its Discretization, and Applications**

Arnold, Douglas

Univ. of Minnesota

Abstract: Much progress in mixed finite elements for the Laplacian and electromagnetics came from their relationship with the de Rham complex within the framework of Hilbert complexes. The elasticity complex plays a similar role for the equations of elasticity, and also for the Einstein equations. The BGG construction constructs the elasticity complex from the de Rham complex and discretization leads to new stable elements for elasticity. We present this systematically and discuss applications and recent advances.

**MS-Fr-E-31-4**

17:30–18:00

**Adaptive Mixed FEM in Elasticity**

Carstensen, Carsten

Humboldt-Universitaet zu Berlin

Abstract: The PEERS and Arnold-Winther FEM are discussed for the computer simulation of elastic solids with Neumann and Dirichlet boundary conditions. The presentation discusses a few a priori comparisons and a refined L2 error control of the stress variables. Some remarks on open questions towards adaptive mesh-refining concludes the presentation.

References:


**MS-Fr-E-32**

16:00–18:00

307A

Structured-mesh methods for interface problems. - Part VIII of VIII

For Part 1, see MS-Tu-E-32
For Part 2, see MS-We-D-32
For Part 3, see MS-We-E-32
For Part 4, see MS-Th-BC-32
For Part 5, see MS-Th-D-32
For Part 6, see MS-Th-E-32
For Part 7, see MS-Fr-D-32

**Organizer:** Chen, Huanzhen

College of Mathematical Sci. Shandong Normal Univ.

Organizer: Lin, Tao

Purdue University

Abstract: We discuss new immersed finite element (IFE) methods for an elliptic interface problem. The proposed methods can be used on Cartesian meshes regardless of the interface geometry. Compared to classical IFE methods using Galerkin formulation, these new IFE methods contain additional stabilization terms on interface edges. A priori error estimation shows the optimal convergence in a mesh-dependent energy norm. Numerical results demonstrate that our new methods can significantly improve the accuracy around the interface.

**MS-Fr-E-33**

16:00–18:00

406

Mathematical and computational methods for coupling local and nonlocal models - Part IV of IV

For Part 1, see MS-Th-D-33
For Part 2, see MS-Th-E-33
For Part 3, see MS-Fr-D-33

**Organizer:** O’Elia, Marta

Sanda Labs

Organizer: Seleson, Pablo

Oak Ridge National Laboratory

Organizer: Bochev, Pavel

Sandia National Laboratories

Abstract: Nonlocal continuum and atomistic models are used in many scientific and engineering applications, where material dynamics depends on microscopic structure. The numerical solution of nonlocal models might be prohibitively expensive; therefore, concurrent multiscale methods have been proposed for efficient and accurate solutions of such systems. These methods employ nonlocal models in parts of the domain and use local, macroscopic, models elsewhere. A major challenge is to couple these models at interfaces or in overlapping regions. This minisymposium invites contributions on coupling local and nonlocal continuum models and concurrent multiscale methods for atomistic-to-continuum coupling. Related domain decomposition methods are also considered.

**MS-Fr-E-33-1**

16:00–16:30

**A Stochastic Multiscale Method for Coupling of Peridynamics and Continuum Model**

Lin, Guang

Purdue University

Abstract: We present a stochastic multiscale method coupling peridynamics, and continuum model. The method is able to cover a wide range of spatio-temporal scales, in particular mesoscopic with peridynamics and continuum through the elastic constitutive model (ECM), peridynamics and ECM are for-
mulated in separate domains and are coupled via the deformation communi-
cations at the domain boundaries. There are many uncertain sources in the
multiscale model. The proposed method is able to quantify the uncertainty
across scales.

A meshless method based on radial basis function collocation tech-
iques is applied for the solution of elliptic partial differential equation with mul-
tipoint nonlocal boundary condition. Such nonclassical boundary conditions
appear in mathematical models describing various real-world processes. Be-
tipoint nonlocal boundary condition. Such nonclassical boundary conditions
are decoupled. Proper penalty terms are applied to control the variations at
the interface. Using energy stability analysis, we show that the scheme is sta-
table independent of the fluid-structure density ratio. Numerical examples are
provided to show that although the penalty terms degrade the time accuracy,
optimal accuracy is recovered by performing defect-correction subiterations.

Abstract: The analysis of atomist-to-continuum coupling methods at zero
temperature has recently seen rapid development, but the rigorous analysis of
the finite temperature case has seen little development. In my talk I will
present some recent results on the accuracy of finite-temperature defect cal-
culation. In particular, I will propose a theory allowing to compare accuracy of
various methods and make predictions about their performance.

A Stabilized Explicit Scheme for Coupling Fluid-structure Interactions

Controlled Heavy Metals and Cohesive Sedimentation in Canals

A Study of Radial Basis Function Method for Elliptic PDE with Multipoint Non-
local Boundary Condition

Abstract: A meshless method based on radial basis function collocation techni-
que is applied for the solution of elliptic partial differential equation with mul-
tipoint nonlocal boundary condition. Such nonclassical boundary conditions
appear in mathematical models describing various real-world processes. Be-
sides other advantages, the examined method allows to impose multipoint
nonlocal boundary condition very easily. The influence of nonlocal condition to
the properties of the method (for example, accuracy and conditioning) is
investigated by analysing some test examples.

MS-Gr-E-33-2 16:00–17:00
Analysis of Finite-temperature Coupling of Atomistic and Continuum Mechani-
ics
Shapeev, Alexander Skolkovo Inst. of Sci. & Tech.

Abstract: The analysis of atomistic-to-continuum coupling methods at zero
temperature has recently seen rapid development, but the rigorous analysis of
the finite temperature case has seen little development. In my talk I will
present some recent results on the accuracy of finite-temperature defect cal-
culation. In particular, I will propose a theory allowing to compare accuracy of
various methods and make predictions about their performance.

Organizer: Zhang, Hui Bejing Normal University
Organizer: Forest, M. Gregory Univ. of North Carolina at Chapel Hill
Organizer: Wang, Qi Univ. of South Carolina & Beijing Computational Sci.
Research Center

Abstract: This mini symposium will bring together researchers in complex flu-
id and biological systems to exchange ideas and perspectives as well as to
share their most recent findings. The goal is to integrate advances in math-
ematics (theory, modeling, data analytics, algorithms, simulations, high per-
formance computing techniques) with new experimental data from complex
fluids and biological systems, and targeted applications. The specific system-
s represented include single living cells, biofilms, active molecular fluids, and
transport properties of biological fluids such as lung mucus.

We would like to invite you to give a talk on your current research at the pro-
posed mini-symposium. The talks are scheduled to be 25 minutes each + 5
minutes for discussion.

MS-Gr-E-34-1 16:00–16:30
Single-Chain Mean-field Theory of Wormlike Chain System
Zhang, Xinghua Beijing Jiaotong Univ.

Abstract: Wormlike chain is the best model for liquid crystal and bio-
macromolecules. Its behaviors involve the diffusion in a five dimensional s-
pace which is hard to solve. This hindered the application of the mean-field
theory in these systems. Here, the ensemble average of the density operator
by directly sampling the conformations of wormlike chain in auxiliary field, and
then find solution by iterating the mean-field equations. These procedures can
be accelerated by parallel computation.

MS-Gr-E-34-2 16:30–17:00
Deformation of Spherical Polymer Micelle Confined in A Channel
Zhang, Hui Beijing Normal University

Abstract: When the spherical polymer micelles are confined in a channel, the
shape of the micelles may differ from that of the bulk micelles. We study the
shape variation of a spherical micelle under confinement with different A-homopolymer length. The results reveal depletion effect and capillary con-
densation. This numerical result can be used to understand the ADP transport
in blood.

CP-Gr-E-34-3 17:00–17:20
Moving Least Squares Interpolation Applied to Octree-based Methods for Flu-
id Flow Simulations
Sousa, Fabricio Univ. of Sao Paulo
Simao, Adenilso Univ. of Sao Paulo
Castelo, Antonio Univ. of Sao Paulo
Souza, Leandro Univ. of Sao Paulo

Abstract: Octree-based methods bring the advantage of using fast cartesian
grid discretizations, such as finite differences, and the flexibility and accuracy
of local mesh refinement. The problem however is how to adapt the discretiza-
tion stencil near the transition between grid elements of different sizes, which
is usually solved by local high-order interpolations. These interpolations de-
pend on the distribution of cells in the vicinity of the point of interest, which can
become quite complex in 3D simulations, especially in staggered grids. Most
methods usually avoid this by limiting the mesh configuration, reducing the
number of cases to be treated locally. In this work, we employ a moving least
squares meshless interpolation technique in order to allow for more complex
mesh configurations, still keeping the overall order of accuracy. Numerical
tests and application to fluid flow simulations are performed to illustrate the
flexibility and robustness of this new approach.

MS-Gr-E-34-4 17:20–17:40
Model and Algorithm for Analysis of Fluid Dynamics During Hemodialysis
Zhu, Fanzan Renal Research Inst.
Kotanko, Iko Renal Research Inst.
Levin, Nathan W. Renal Research Inst.

Abstract: Intradialytic hypotension (IDH) is a major problem largely due to
an imbalance between ultrafiltration rate and vascular refilling rate (VRR) dur-
ing hemodialysis (HD). The aim of this study was to develop a mathematical
model and an algorithm to predict IDH during HD. A model is based on rel-
ate blood volume (RBV), blood pressure (BP) and heart rate (HR) since
alterations in the VRR can be indicated by change in the second derivative of
RBV and the ratio of BP to HR. Forty five HD patients with 245 measurements
were monitored during HD. Occurrence of IDH can be predicted with 72.5%
sensitivity and 65% specificity about 30 minutes before IDH using the model
and algorithm. The model provides information to understand fluid dynamics
occurring in fluid compartments during removal of excess fluid by ultrafiltration
so that the optimal parameters for individual HD treatments might be estab-
lished and evaluated in future studies.

CP-Gr-E-34-5 17:40–18:00
Comparison of the Minimum Gap in A Thrust Bearing for Compressible and Incompressible Flow
Bailey, Nicola Univ. of Nottingham

Abstract: Thrust bearing technology comprises a rotor and stator separated by
a thin air film used to maintain a face clearance when subjected to exter-
nal axial forces. The coupled processes of the pressurised flow through the
bearing and axial motion of the rotor and stator is examined for rotor under-
going prescribed periodic oscillations and stator modelled as a spring-mass-damping system. Compressible and incompressible flow models for a thin film bearing are derived in the form of modified Reynolds equations, incorporating high speed effects and a Navier slip boundary condition. For incompressible flow, the modified Reynolds equation leads to analytical expressions for the pressure and force, with the stator equation reduced to a nonlinear second order differential equation solved for the minimum gap. The compressible Reynolds equation is solved numerically simultaneously with the stator equation, due to extra pressure derivatives. Results are compared for compressible and incompressible flow.

Abstract: It is not surprising that algorithms can be devised by different means and understanding for the surface hopping algorithms. (joint work with Zennan Zhou)

Towards A Mathematical Understanding of Surface Hopping

Lu, Jianfeng Duke Univ.

Abstract: Surface hopping algorithm is widely used in chemistry for mixed quantum-classical dynamics, while it is yet clear whether it can be derived asymptotically. We will discuss some recent progress in semiclassical asymptotics and understanding for the surface hopping algorithms. (joint work with Zennan Zhou)

Factorizations, Sweeping, Source Transfer, Potentials and Schwarz: Why Are These Algorithms Equivalent?

Gander, Martin Universite de Geneve
Zhang, Hui Universite de Geneve

Abstract: It is not surprising that algorithms can be devised by different means and be stated in apparently different formulations but actually do the same thing. This is especially interesting for the recent emerging algorithms for the iterative solution of the Helmholtz equation such as the sweeping preconditioners, the source transfer and the single and/or double layer potential based methods. We will see how these algorithms resemble and differ in terms of optimized Schwarz methods.

A Fast Treecode Algorithm for Stokes Flow in 3D

Wang, Lei Univ. of Wisconsin, Milwaukee
Tlupova, Svetlana Epic Sys. Corporation
Krasny, Robert Univ. of Michigan

Abstract: A large number of problems in fluid dynamics are modeled as many-particle interactions in Stokes flows, for example, simulations of falling jets of particles in viscous fluids, microfluidic crystals, and vesicle flows. The formulation is often based on fundamental solutions. The Stokeslet and the Stresslet are the kernels in the single and double layer potentials, respectively. Many situations (e.g., through superposition or discretization of boundary integrals) involve sums of Stokeslets and Stresslets, which is an example of an $N$-body problem and the direct sum requires $O(N^2)$ operations. This can make the numerical calculation prohibitively expensive. A Barnes-Hut tree code algorithm is developed for speeding up the computation. The particles are restructured recursively into a tree, and the particle-particle interactions are replaced with particle-cluster interactions computed by either a far-field expansion or a direct summation. Numerical results exhibit the promising performance of the algorithm.

CP-Fr-E-35-4
17:20–17:40
Asymptotic Issues
Chipot, Michel
Univ. of Zurich

Abstract: We would like to present some results on the asymptotic behaviour of different problems set in cylindrical domains of the type $\ell \omega \times \omega$ when $\ell \to \infty$. For $i=1,2 \omega$, we have two bounded open subsets in $\mathbb{R}^k$. To fix the ideas on a simple example consider for instance $\omega_1 = \omega_2 = (-1,1)$ and $v_i$ the solution to

$$-\Delta u_i = f \text{ in } \Omega = (-\ell, \ell) \times (-1,1), \quad u_i = 0 \text{ on } \partial \Omega.$$ 

It is more or less clear that, when $\ell \to \infty$, $u_i$ will converge towards $u_{\infty}$ solution to

$$-\Delta u_{\infty} = f \text{ in } \Omega_{\infty} = (-\infty, \infty) \times (-1,1), \quad u_{\infty} = 0 \text{ on } \partial \Omega_{\infty}.$$ 

However this problem has infinitely many solutions since for every integer $k$

$$\exp(k \pi x) \sin(k \pi y)$$

is solution of the corresponding homogeneous problem. Our goal is to explain the selection process of the solution for different problems of this type when $\ell \to \infty$.

CP-Fr-E-35-5
17:40–18:00
Blow-up of Finite Difference Solutions to Nonlinear Schrodinger Equations
Sasaki, Takiko Univ. of Tokyo
Saito, Norikazu The Univ. of Tokyo

Abstract: Finite difference schemes for computing blow-up solutions of one dimensional nonlinear Schrodinger equations are presented. By applying time increments control technique, we can introduce a numerical blow-up time which is an approximation of the exact blow-up time of nonlinear Schrodinger equation. After having verified the convergence of our proposed schemes, we proved that the solution of a finite-difference scheme actually blows up in the numerical blow-up time. Then, we proved that the numerical blow-up time converges to the exact blow-up time as the discretization parameters tend to zero. Several numerical examples that confirm the validity of our theoretical results are also offered.

MS-Fr-E-36
16:00–18:00
Advances in MCMC and related sampling methods for large-scale inverse problems - Part IV of IV

For Part 1, see MS-Th-D-36
For Part 2, see MS-Th-E-36
For Part 3, see MS-Fr-D-36
For Part 4, see MS-Fr-E-36

Organizer: Marzouk, Youssef Massachusetts Inst. of Tech.
Organizer: Bui-Thanh, Tan The Univ. of Texas at Austin
Organizer: Ying, Lexing Stanford Univ.
Organizer: Yang, Xu Univ. of California, Santa Barbara

CP-Fr-E-36-1
16:00–18:00
Quasi-Monte Carlo and Multilevel Monte Carlo Methods for Computing Posterior Expectations in Elliptic Inverse Problems

Scheichl, Robert
University of Bath
Stuart, Andrew
University of Warwick
Teckentrup, Aretha
University of Warwick

Abstract: We present an approach (based on Bayes’ formula and ratio estimates) to apply QMC and multilevel MC methods for the computation of posterior expectations of functional of the solution of an elliptic PDE, typically used as a model for uncertainty quantification in subsurface flow. We give a rigorous analysis of the cost to achieve a total mean square error bounded by a given tolerance and numerical results that confirm their superiority over standard approaches.
Abstract: Ensemble Prediction Systems (EPS) are used to quantify the uncertainty of weather predictions, by leading predictions with perturbed initial values. Here we extend EPS, with essentially no additional CPU costs, to online estimation by perturbing the model parameters as well. The estimation can be performed both by a covariance update process using importance weights, or by employing evolutionary optimisation. Both single and multiple cost function criteria cases are discussed.

Adaptive Randomize-then-Optimize: A Sampling Algorithm for Bayesian Inference

Wang, Zheng  
Massachusetts Inst. of Tech.

Marzouk, Youssef  
Massachusetts Inst. of Tech.

Abstract: In Bayesian inference, the uncertainty of parameters of a physical system is characterized by a probability distribution. Numerical algorithms are typically used to draw samples from this distribution. (Bardsley et al., 2014) introduced one such sampling algorithm, titled Randomize-then-Optimize (R-TO). We present a new geometric interpretation of RTO that builds intuition on the algorithm’s strengths and weaknesses, and from this interpretation, we propose an adaptive version of RTO that is more robust and efficient.

Numerical Solution of the Kupershmidt Equation by Chebyshev-Legendre Pseudo-Spectral method

Abstract: A Chebyshev-Legendre Pseudo-Spectral method is applied for solving Kupershmidt equation. In time direction we used a leapfrog scheme, while Chebyshev-Legendre Pseudo-Spectral method is used for space direction. For practical computation Chebyshev-Gauss-Lobatto (CGL) nodes are used. The error estimates of semi-discrete and fully-discrete of Chebyshev-Legendre Pseudo-Spectral method for Kupershmidt equation are obtained by energy estimation method. The numerical results of the present method are compared with the exact solution for two test problems.


Sultana, Talat  
Janki Devi Memorial College, Univ. of Delhi, New Delhi, India

Khan, Arshad  
Jama Millia Islamia, New Delhi, India

Abstract: In this paper, we report three level implicit method of high accuracy schemes of \( O(k^4 + h^8) \), \( O(k^6 + h^8) \) and \( O(k^8 + h^{10}) \) for the numerical solution of fourth order non-homogeneous parabolic partial differential equation, that governs the behavior of a vibrating beam. Parametric septic spline is used in space and finite difference discretization in time. The linear stability of the presented method is investigated. The presented method is tested on three examples. The computed results are compared wherever possible with those already available in literature. This shows the superiority of the presented method.

Numerical Solutions of Moisture and Thermal Transfer in A Bulk of Stored Corn

Abstract: A mathematical modeling for stored corn proposed by Lopes et al. (Lopes D. de C. et al. 2006. Aeration simulation of stored grain under variable mass transfer in a silo of stored corn. The numerical solutions are compared with those already available in literature. This shows the superiority of the presented method.) is studied. The finite difference method, forward time backward space, is applied for discretization of the differential equations that described the heat and mass transfer in a silo of stored corn. The numerical solutions are compared with the collected data during October and November 2013. Numerical results show that the quality of the results obtained by forward time backward space verifies the efficiency and applicability for the simulation.

Computing Highly Elastic Flows of Viscoelastic Fluids

Oishi, Cassio  
UNESP - Sao Paulo State Univ.

Lopes Palhares Junior, Irineu  
FCT-UNESP

Alonso, Alexandre  
FEUP

Abstract: We present in this work a numerical study of the square-root formulation which is a stabilization method for computing highly elastic flows of viscoelastic fluids. The underlying mathematics of this factorization is rooted on an important property of the conformation tensor which is symmetric and positive definite. Different of the famous Log-conformation transformation, that is widely used to treat the High Weissenberg Number Problem, the symmetric factorization of the conformation tensor does not require the numerical computation of the eigenvectors and eigenvalues of the conformation tensor reducing the CPU times of the simulation. In this work, in the context of the Marker-And-Cell method, we describe the application of the square-root formulation for finite difference scheme including free surface boundary conditions. According to the numerical results, the square-root formulation is able to address important problems at high-Weissenberg number flows, for instance, the lid-driven cavity flow and the die-swell free surface problem.
s and applied control problems. The second session will present different mathematical methods to solve control issues for degenerate parabolic or hypoelliptic PDE’s, bang-bang control of parabolic questions, under-observed coupled hyperbolic systems and hierarchical control for coupled parabolic systems.

**Control of Certain Classes of Hypoelliptic Diffusions**

Cannarsa, Piermarco
Univ. of Rome “Tor Vergata”

**Abstract:** The control of diffusion models is very well developed for uniformly parabolic operators, much less so for degenerate problems. In the latter case, a general model which covers controllability/observability issues is still missing. However, we can give a fairly complete analysis of such properties for certain classes of degenerate parabolic equations. This talk will focus on controllability, observability, and Lipschitz stability for distributions associated with hypo-elliptic operators such as the Grushin and Heisenberg Laplacian.

**TIME OPTIMAL CONTROL OF HEAT EQUATIONS**

WANG, GENGSHENG
Wuhan Univ.

**Abstract:** This talk presents some progress and comments on time optimal control problems of heat equations. It focuses on the bang-bang property. We will present a new way to derive the bang-bang property for time invariant heat equations. This method might be applied to time varying systems. We will show that some conditions can ensure the bang-bang property for time varying heat equations. One of them is connected with the completion of the space of all solutions for the time varying heat equations with initial data in $L^2(\cdot)$, under a suitable norm.

**Criteria of Kalman’s Type for the Approximate Controllability and the Approximate Synchronization of A Coupled System of Wave Equations**

Rao, Bongep
Univ. of Strasbourg

**Abstract:** In this talk, we give some necessary conditions, presented as criteria of Kalman’s type, for the approximate null controllability, the approximate synchronization and the approximate synchronization by groups respectively, for a coupled system of wave equations with Dirichlet boundary controls. The sufficiency of these conditions is proved for 2x2 symmetric system, cascade system and one-dimensional systems.

**NEW METHODS AND TRENDS IN THE FIELD OF NONLINEAR FILTERING - PART II**

Organizer: Guo, Wei Hong
Case Western Reserve Univ.
Organizer: Qin, Jing
Univ. of California, Los Angeles

**Abstract:** Variational/PDE is a powerful tool in image processing and analysis. After decades of intensive research, it is still a challenge to recover high quality images from their noisy, blured, low-resolution counterparts and/or incomplete measurements. It is especially difficult for images containing important details of various scales. Effective regularity schemes and efficient algorithms play important roles in these problems. This mini-symposium brings together leading researchers to discuss the state-of-the-art theoretical developments in variational image reconstruction, image segmentation, image super-resolution and their applications in medicine, biology, etc.

**Fuzzy Image Segmentation Based on TV Regularization and L1-norm Fidelity**

Li, Fang
East China Normal Univ.

**Abstract:** We propose a variational multi-phase image segmentation model based on Total Variation (TV) regularization and L1-norm fidelity. To deal with the non-smooth regularization term, we apply the Alternating Direction Method of Multipliers by splitting variables. In particular, we reorder the memberships functions and intensities to obtain fuzzy median. Experimental results and comparisons show that the L1-norm based method is more robust to outliers such as impulse noise and preserves contrast better than its L2-norm counterpart.

**Convex Variational Model for Restoring Blurred Images with Rician Noise**

Zeng, Tielong
Hong Kong Baptist Univ.

**Abstract:** In this talk, a new convex variational model for restoring images degraded by blur and Rician noise is proposed. Due to the convexity, the solution of our model is unique and independent of the initialization of the algorithm. We utilize a primal-dual algorithm to handle the minimization. Numerically, our model outperforms some of the state-of-the-art models in both medical and natural images. Our non-Gaussian noise will be addressed if time permitted.
We designed a new model evaluation paradigm that simulates the online user practice. A substantial discrepancy between the offline and online performance exists in Offline evaluation metrics, such as AUC (the Area Under the Receiver Operating Characteristic Curve) and RIG (Relative Information Gain) are indicators of the expected model performance on real data. However, a substantial discrepancy between the offline and online performance exists in practice. We designed a new model evaluation paradigm that simulates the online user behavior from the historic user behaviors. The experimental results on click prediction models for search advertising are highly promising.
Reduced Order Models for Seismic Full Waveform Inversion.

Mammon, Alexander Schlumberger
Drukin, Vladimir Schlumberger-Doll Research
Zaslavsky, Mikhail Schlumberger-Doll Research

Abstract: We present a framework for the seismic full waveform inversion (FWI) using the reduced order models (ROMs). The ROM is a projection of the PDE operator on the subspace spanned by the snapshots of the solutions of the forward problem. The ROM can be found directly from the measured time domain seismic data. The use of the ROM in FWI improves the convergence and completely removes the multiple reflections.

MS-Fr-E-48 16:00–18:00 212B
Image restoration: new algorithms and new applications - Part III of III
For Part 1, see MS-Th-E-48
For Part 2, see MS-Fr-D-48
Organizer: Sgallari, Fiorella Univ. of Bologna
Organizer: Chan, Raymond The Chinese Univ. of Hong Kong

Abstract: The field of digital image restoration is concerned with the reconstruction or estimation of uncorrupted images from noisy, blurred ones. This blurring may be caused by optical distortions, object motion during imaging, or atmospheric turbulence. There are existing or potential applications of image restoration in many scientific and engineering fields, e.g., aerial imaging, remote sensing electron microscopy, and medical imaging. From these arise some real challenging problems related to image reconstruction/restoration that open the way to some new fundamental scientific questions closely related with the world we interact with and Mathematics has become one of the main driving forces of the modern development of image restoration. The purpose of this mini-symposium is to gather the leading researchers in the areas of image restoration/reconstruction to present a series of talks that will expose the current state of knowledge in the algorithmic and application field. Our goal is also to establish connections between different techniques, talk about important issues in the emerging application fields and generate novel ideas for future development.

MS-Fr-E-48-1 16:00–16:30
Total-variation-based-denoising of Gravitational Wave Signals
Marquina, Antonio Univ. of Valencia

Abstract: In this talk we formulate total variation based denoising algorithms to recover numerically-simulated gravitational wave signals. We shall give a brief introduction to the variational denoising and compressing models to better understand the purpose of this research work. We also introduce the fundamentals of the theory of gravitational wave signals generated by high energy astrophysical events and the interest to detect these signals. We present some numerical results for two types of waveforms, namely, “bursts” and “chirps” for which catalogs are available.

MS-Fr-E-48-2 16:30–17:00
An Adaptive Inner-outer Iterative Regularization Method for Image Edge Recovery
Klimer, Misha Tufts Univ.

Abstract: We consider a new inner-outer iterative algorithm for edge recovery in image restoration and reconstruction problems. We propose a sequence of dynamically updated regularized least squares problems where the value of the regularization parameter for each problem is determined on-the-fly for each through a hybrid regularization approach. We present results on applications in X-ray CT and image deblurring that show that our algorithm has the potential to produce high-quality images in a computationally efficient manner.

MS-Fr-E-48-3 17:00–17:30
Distributed Regularization Parameter Choice Based on Bilevel Optimization
Hintermueller, Michael Humboldt-Univ. of Berlin

Abstract: Based on the pre-dual formulation of the total variation regularization (TV) model in image restoration, a bilevel optimization approach to the choice of a spatially distributed regularization parameter is introduced. The upper level problem contains the TV-model as a constraint and has an objective which depends on a variance corridor for a locally averaged residual. Stationarity conditions for the bilevel problem are derived, a solution algorithm is devised, and numerical results are discussed.

MS-Fr-E-49 16:00–18:00 107
Mathematical Models of Retinal Degeneration and Treatments
Organizer: Wirkus, Stephen Arizona State Univ.

Abstract: While mathematical physiology has given numerous insights into biological systems, only recently have mathematical models been proposed to study retinal degeneration. Many conditions that lead to blindness have cures but the degenerative conditions Retinitis Pigmentosa (genetic) and retinal detachment (usually caused by physical trauma) do not have cures. This session focuses on recent work involving mechanistic mathematical models of photoreceptor degeneration and potential therapies some of which have been physiologically proposed. Dynamical systems and control theory are used to investigate the various mathematical models presented here and interpret their results.

MS-Fr-E-49-1 16:00–16:30
Optimal Control of MANF to Prevent Apoptosis in Retinitis Pigmentosa
Melara, Luis Shippensburg Univ.
Villalobos, Cristina Univ. of Texas-Pan American
Wirkus, Stephen Arizona State Univ.
Camacho, Erika Arizona State Univ.

Abstract: Protein misfolding is one of the major causes of apoptosis in Retinitis Pigmentosa, where apoptosis is programmed cell death. Mesencephalic-Astrocyte-derived-Neurotrophic Factor (MANF) is a protein that has been shown to correct protein misfolding, thus reducing the death of cells due to “cell suicide.” In this talk, we formulate an optimal control problem that incorporates MANF treatment to rescue photoreceptors in the eye. Numerical results are shown and discussed.

MS-Fr-E-49-2 16:30–17:00
Optimal Control in the Treatment of Retinitis Pigmentosa
Villalobos, Cristina Univ. of Texas-Pan American
Melara, Luis Shippensburg Univ.
Wirkus, Stephen Arizona State Univ.
Camacho, Erika Arizona State Univ.

Abstarct: Given the recent discovery of the RdCVF protein, we study its potential therapy in the treatment of the degenerative eye disease, Retinitis Pigmentosa (RP). We build on an existing mathematical model of photoreceptor interactions in the presence of RP and incorporate various treatment regimens via RdCVF. In addition, we present numerical results for various cases of degeneration.

MS-Fr-E-49-3 17:00–17:30
The Role of RdCVF in Photoreceptor Degeneration
Camacho, Erika Arizona State Univ.
Wirkus, Stephen Arizona State Univ.

Abstract: Retinitis pigmentosa is an inherited disease characterized by death of the rod photoreceptors due to mutation(s) within the rod. Death of cones is also inevitable even though they do not carry any mutation. Experimentists have developed numerous hypotheses including the observed production of a rod-derived cone viability factor (RdCVF) that is necessary for cone survival. This talk examines a mathematical model of RdCVF and investigates its effect on the stability of solutions.

MS-Fr-E-49-4 17:30–18:00
A Mathematical Model of Photoreceptor Death: Retinitis Pigmentosa and Retinal Detachment
Wirkus, Stephen Arizona State Univ.
Camacho, Erika Arizona State Univ.

Abstract: This talk will provide a brief overview of the recent physiology of the eye as it pertains to photoreceptor degeneration. With mathematical models, we will explore the experimentally observed photoreceptor death and rescue in retinitis pigmentosa and retinal detachment, comparing known datasets with our model. Our work highlights the delicate balance between the availability of nutrients, and photoreceptors’ energy uptake and consumption needed for a normal functioning retina.

MS-Fr-E-50 16:00–18:00 207
Mathematical and Numerical Aspects of Electronic Structure Theory - Part V of V
For Part 1, see MS-Th-E-50
For Part 2, see MS-Th-D-50
For Part 3, see MS-Th-D-50
For Part 4, see MS-Fr-D-50
Organizer: Lin, Lin Univ. of California at Berkeley
Organizer: Lu, Jianfeng Duke Univ.

Abstract: Electronic structure theory and first principle calculations are among the most challenging and computationally demanding science and engineering problems. This minisymposium aims at presenting and discussing new developments of mathematical analysis, and numerical methods for achieving a higher level of accuracy and efficiency in electronic structure theory. This includes ground state and excited state density functional theory calculations, wavefunction methods, together with some of their applications.
in computational materials science and quantum chemistry. We propose to bring together experts on electronic structure theory, which include not only mathematicians, but also physicists working actively in the field.

**MS-Fr-E-50-1** 16:00–16:30  
**Parallel Scalability of Hartree-Fock Calculations**  
Chow, Edmond  
Georgia Inst. of Tech.  

**Abstract:** Quantum chemistry is increasingly performed using large cluster computers consisting of multiple interconnected nodes. For a fixed molecular problem, calculation efficiency usually decreases as more nodes are used. We empirically investigate the parallel scalability of Hartree-Fock calculations. We use density matrix purification from the linear scaling methods literature, but without using sparsity. When using large numbers of nodes for moderately-sized problems, density matrix computations are network-bandwidth bound, making purification methods potentially faster than eigen-decomposition methods.

**MS-Fr-E-50-2** 16:30–17:00  
**H-P Finite Element Method for Electronic Structure Calculations**  
Marcato, Carlo  
Laboratoire J.-L. Lions, Univ. Pierre et Marie Curie  
Madjay, Yvon  
Laboratoire J.-L. Lions, Univ. Pierre et Marie Curie  

**Abstract:** The (continuous) finite element approximations of different orders for electronic structures approximation has recently been proposed and the performance of these approaches is becoming appreciable and is now well understood. In this presentation we propose to extend this discretization by combining the refinement of the finite element mesh where the solution is most singular with the increase of the degree of the polynomial approximations in the regions where the solution is mostly regular.

**MS-Fr-E-50-3** 17:00–17:30  
**Localized Resolution-of-identity Approach to Correlated Methods under Peri-odic Boundary Condition**  
Ren, Xinguo  
Univ. of Sci. & Tech. of China  

**Abstract:** The implementation of correlated methods with numerical atomic orbitals (NAO) for infinite periodic systems is challenging. With a recently developed resolution-of-identity technique, we implemented the random-phase approximation and the GW method in the NAO-based FHI-aims code. In this talk, we will present the basic algorithm behind our implementation as well as benchmark results to demonstrate the accuracy and efficiency of the algorithm. The promise and the remaining challenges will be highlighted.

**MS-Fr-E-50-4** 17:30–18:00  
**Large-scale Ab Initio Simulations Based on Systematically Improvable Atomic Basis**  
He, Lixin  
Univ. of Sci. & Tech. of China  

**Abstract:** Atomic orbitals have many advantages as basis sets for ab initio electronic structure calculations. However, the atomic basis sets must be constructed very carefully to ensure both good accuracy and transferability. We have proposed a unique scheme to construct systematically improvable optimized atomic basis sets. This scheme has been implemented in our home-made first-principles packages ABACUS. Our benchmark tests show that our atomic bases work very well for wide range of physical systems, including bulks, molecules, surfaces, defects, etc.

**MS-Fr-E-51** 16:00–18:00  209A  
Recent Developments in the Modeling, Simulation and Analysis of Mathematical Models Arising from Biology - Part III of III  
For Part 1, see MS-Th-E-51  
For Part 2, see MS-Fr-D-51  

**Organizer:** Jain, Harsh  
Florida State Univ.  
Organizer: Zhao, Kun  
Tulane Univ.  

**Abstract:** Mathematical modeling is an effective and powerful tool in understanding complex biological phenomena. These models, using tools from diverse areas of mathematics ranging from partial and ordinary differential equations to group theory and topology, provide deep insights into the complex nature of biology that would otherwise be difficult to capture experimentally or in a clinical setting. Active research areas in mathematical biology include modeling of human vascular system, chemotaxis, wound healing, population dynamics, angiogenesis, cancer, morphogenesis and epidemiology. Speakers in this mini-symposium will discuss current research progress on the modeling, analysis and numerical simulation of models in these areas.

**MS-Fr-E-51-1** 16:00–16:30  
**Identifiability and Interacting Scales in Modeling Disease Dynamics**  
Eisenberg, Marisa  
Univ. of Michigan, Ann Arbor  

**Abstract:** Disease dynamics involve interacting factors at multiple scales, and modeling these processes can involve working with a wide range of (sometimes incomplete) data sets. I will discuss identifiability and parameter estimation of disease transmission models, and examine how these issues are affected when incorporating processes and data from a range of scales (from cellular to environmental). I will highlight examples from some of our recent work, including applications to cholera, ebola, and human papillomavirus (HPV).

**MS-Fr-E-51-2** 16:30–17:00  
**Identifiability and Nature of Solutions in Models of Tumor Growth and Treatment**  
Jain, Harsh  
Florida State Univ.  
Eisenberg, Marisa  
Univ. of Michigan, Ann Arbor  

**Abstract:** Delay differential equation models of solid tumor treatment with taxanes (anti-mitic drugs) and platinum-based compounds will be presented. Necessary and sufficient conditions for stability of the cancer free equilibrium are derived, and in the cases where chemotherapy is administered periodically, the existence of periodic solutions is investigated analytically. Issues of model identifiability will be discussed, together with several numerical examples.

**MS-Fr-E-51-3** 17:00–17:30  
**Gierer-Meinhardt System with Activator Production Saturation and Gene Expression Time Delays**  
Shi, Junping  
College of William & Mary  

**Abstract:** Gierer-Meinhardt reaction-diffusion system is one of prototypical models for spatial-temporal pattern formation. The dynamics of Gierer-Meinhardt system with activator production saturation and gene expression time delays is considered here. We analyze (i) bifurcation and pattern formation of non-delay model; (ii) global asymptotic stability for large saturation coefficient; (iii) delay-induced oscillations.

**MS-Fr-E-52** 16:00–18:00  212A  
Recent Development of Mathematical Models in Computational Biology - Part V of V  
For Part 1, see MS-Th-BC-52  
For Part 2, see MS-Th-D-52  
For Part 3, see MS-Th-E-52  
For Part 4, see MS-Fr-D-52  

**Organizer:** Zhang, Lei  
Peking Univ.  
Organizer: Ge, Hao  
Peking Univ.  
Organizer: Lei, Jinzhi  
Tsinghua Univ.  

**Abstract:** One of the central problems in biology is to understand the design principles of complex biological systems. Mathematical and computational models of biological processes can be characterized both by their level of biological detail and by their mathematical complexity. In this minisymposium, we focus on recent findings of computational models and methods to gain insights of the complexity of cellular life and efficiently analyze the experimental observations. Topics of interests include stem cells, developmental patterning, gene regulatory networks, neuron networks, uncertainty quantification of biological data, etc.

**MS-Fr-E-52-1** 16:00–16:30  
**Injury-initiated Clot Formation under Flow: A Mathematical Model with Warfarin Treatment**  
Ma, Yanping  
Loyola Marymount Univ.  

**Abstract:** When an individual at risk for forming a thrombus is treated with anticoagulant medication, the International Normalized Ratio (INR) must be measured regularly. We explore the conditions under which an injury-induced thrombus may form in vivo but not in vitro. We extend previous models and present numerical simulations that compare scenarios in which drug doses and flow rates are modified. Our results indicate that traditional INR measurements may not accurately reflect in vivo clotting times.

**CP-Fr-E-52-2** 16:30–16:50  
**Red Queen Dynamics in Specific Predator-prey Systems**  
Harris, Terence  
Univ. of New South Wales  
Cai, Anna  
Univ. of New South Wales  

**Abstract:** The dynamics of a predator-prey system are studied, with a comparison of discrete and continuous strategy spaces. For a 2X2 system, the average strategies used in the discrete and continuous case are shown to be the same. It is further shown that the inclusion of constant prey switching in the discrete case can have a stabilising effect and reduce the number of available predator types through extinction.

**CP-Fr-E-52-3** 16:50–17:10  
**A New Mathematical Model of Tumor Growth, Treatment and Regression**  

**Abstract:**
Saltzman, Jeffrey AstraZeneca

Abstract: Pharmacometricians are often constrained in what types of mathematical constructs they may apply to modeling drug efficacy and safety. Current scientific frameworks limit models to sets of algebraic and/or differential equations yet many questions arise in tumor modeling that simply cannot be answered by the current paradigm. We have developed a set of age-structured partial differential equations describing tumor evolution that are both efficiently approximated numerically and provide modellers with a higher fidelity modeling platform.

MS-Fr-E-53 16:00–18:00 3115
Risk Management and Financial Regulation
Organizer: Łukowski, Mike-UC Santa Barbara
Organizer: Leung, Tim-Columbia Univ.
Organizer: Peng, Xianhua-Hong Kong Univ. of Sci. & Tech.
Abstract: There has been a growing interest in the study of issues related to risk management and financial regulation in the financial mathematics community. This minisymposium will cover issues related to how to design risk weights and how to measure risk for setting capital requirements in financial regulations and the risk analysis and hedging of financial derivatives.

► MS-Fr-E-53-1 16:00–16:30
On the Measurement of Economic Tail Risk
Peng, Xianhua-Hong Kong Univ. of Sci. & Tech.
Abstract: This paper attempts to provide a decision-theoretic foundation for the measurement of economic tail risk, which is related to utility theory and statistical model uncertainty. The main result is that the only tail risk measure that satisfies a set of economic axioms for Choquet expected utility and the statistical property of elicibility (there exists an objective function such that minimizing the expected objective function yields the risk measure) is median shortfall.

► MS-Fr-E-53-2 16:30–17:00
Unbiased Estimators of the Greeks for General Diffusion Processes
Kang, Wannoo-KAIST
Abstract: Computing derivative price sensitivities is widely applicable in financial engineering. Discretization schemes are conventionally used for the simulation of general diffusion models because of unknowingness of distributions associated with general diffusions. Taking advantage of Roberts-Beskos method which is an exact simulation algorithm of one dimensional SDE, we propose estimators of Delta and Gamma without discretization bias. We detail the algorithms and give numerical results. This is a joint work with Jongmyn Lee.

► MS-Fr-E-53-3 17:00–17:30
Multiname Default Intensity Models under Stochastic Time-change
Gordy, Michael-Federal Reserve Board
Abstract: We develop a reduced-form multiname model of credit risk that incorporates stochastic volatility in default intensity via stochastic time-change. The model is estimated by particle Markov chain Monte Carlo on panel data of credit default swap spreads on five major banks. We find strong evidence of dependence on a common volatility factor, as well as a common factor in intensities. Implications for forecasting the probability of systemic events in the finance sector are illustrated.

MS-Fr-E-54 16:00–18:00 VIP1-2
Modeling and Simulations of Complex Biological Systems - Part IV of IV
For Part 1, see MS-Th-D-54
For Part 2, see MS-Th-E-54
For Part 3, see MS-Fr-D-55
Organizer: Liu, Xinfeng-Univ. of South Carolina
Organizer: Ju, Lili-Univ. of South Carolina
Abstract: This mini-symposium aims to bring together researchers focusing on using modeling and numerical approach to study complex biological systems including (but not limited to) cell signaling pathways, complex bio-fluids, biofilms, cell polarization, developmental and cell biology, and stem cells, and etc. Such complex biological systems in general consist of multiple interacting components that exhibit complicated temporal and spatial dynamics. Furthermore, feedback, nonlinearities and multiple time and length scales often make such systems extremely difficult to describe, model or predict. The invited speakers will discuss the challenges of modeling such complex systems, introduce new computational techniques to simulate them and, where possible, present novel analytical techniques to extract meaningful information.

► MS-Fr-E-54-1 16:00–16:30
PDCCDS Interacts with P53 and Functions as A Regulator of P53 Dynamics in the DNA Damage Response
Lei, Jinzhi-Tsinghua Univ.
Abstract: In this talk we introduce a computational model that includes PDCCDS interactions into the p53 signaling network and study the effect of PDCCDS to the p53-mediated cell fate decision in DNA damage response.

► MS-Fr-E-54-2 16:30–17:00
Modeling Active Liquid Crystal Flows with Applications to Complex Biological Systems
Wang, Qi-Univ. of South Carolina & Beijing Computational Sci. Research Center
Zhao, Jia-Univ. of South Carolina
Abstract: In this talk, we will present a continuum model for active polar liquid crystals and discuss how to use it to model complex biological systems in a multiphase complex fluid model formulation for cells and drops of active particles. Numerical examples will be given for cytokinesis of eukaryotes and active liquid crystal drops.

► MS-Fr-E-54-3 17:00–17:30
Phase Field Modeling of Inter-Vesicle and Vesicle-Substrate Interactions
Wang, Xiaojing-Florida State Univ.
Abstract: The study for cell membranes has been a hot topic for many years due to its widespread application in bio-medical science. Here we introduce a phase field method for tracking vesicle deformation and movement, focusing on the modeling of the vesicle-vesicle and vesicle-substrate interactions. Several phase field functions are integrated into the phase field model to derive a uniform phase field model. We will show the numerical experiments and compare them with biological experiments.

► MS-Fr-E-54-4 17:30–18:00
Morphological Stability of A Tumor Using A Two-phase Flow Model
Li, Shuowang-Illinois Inst. of Tech.
Abstract: We consider the morphological stability of a tumor spheroid in Stokes flow, where the viscosity of the tumor and host microenvironment is different. We demonstrate that tumor evolution is regulated by a reduced set of nondimensional parameters that characterize apoptosis, cell-cell/cell-extracellular matrix adhesion, vascularization and viscosity ratio. When the tumor is more viscous than its environment, it tends to develop invasive fingers. This is a joint work with Kara Pham, Emma Turian and John Lowengrub.

MS-Fr-E-55 16:00–18:00 106
Wavelet Methods for Inverse Problems Modelling Real World Systems - Part IV of IV
For Part 1, see MS-Th-D-55
For Part 2, see MS-Th-E-55
For Part 3, see MS-Fr-D-55
Organizer: Siddiqi, Prof., Abul-Sharda Univ.,NCR
Organizer: Al-Lawati, M.A.-Sultan Qaboos Univ.
Abstract: In a direct problem an effect is determined by a cause while in an inverse problem cause is determined from an effect. In an image processing inverse problem cause is determined from an effect. In an image processing algorithm the direct problem is to find out how a given sharp photograph would look like while camera is incorrectly focused.A related inverse problem is to find sharp photograph from a given blurry image.Inventors of CAT and MRI were awarded Nobel Prize of Medicine and Physiology respectively in 1979 and 2003.Inverse problems typically involve certain quantities based on indirect measurements of these quantities,Seismic exploration,CAT,MR,l-ray are examples of inverse problems. Bio metric identifiers are measurements from human body;examples are ear,facial thermogram,hand thermogram,hand vein,hand geometry,finger print,iris,retina,signature and voice..The direct and indirect problems of biometrics correspond to the analysis and synthesis of biometric information,respectively.Recognition of face is a direct problem while face reconstruction is an an inverse problem.Refinement of Fourier methods,called wavelet methods including curve lets,shear lets play important role for study of inverse problems occurring in above themes. The symposium is devoted to updated research on applications of wavelets to the above problems.

► MS-Fr-E-55-1 16:00–16:30
Statistical and Synthetic Methods Used in Flood Calculation and Estimation
Odabaği, Didem-Istanbul Gelisim Univ.
Abstract: This paper aims to examine statistical methods used in flood calculation and also it indicates that hydrologic series are related to notions of probability theory and statistical methods. Too many reliable mathematical methods to estimation of flood exist. These methods are related to formulas, statistical methods, observations and hydrographs obtained by synthetic way. An evaluation of hydrological synthetic techniques which are Snyder, Kirpich,
Mockus and S.C.S. for making flood estimations have been explained with
details.

**MS-Fr-E-55-2**

16:30–17:00

*A Class of Wavelets for Inverse Problem*

Irfan, Nagma  
Sharda Univ.

Al Lawati, Mohamed  
Sultan Qaboos Univ.

Siddiqi, Prof., Abul  
Sharda Univ., NCR

*Abstract:* In the recent years a series of papers are devoted to study of inverse
problems representing phenomenon of different disciplines using wavelet
methods. Special focus is given on themes like wavelet methods in tomog-
raphy, atmospheric tomography. Well known wavelets like Haar, Daubechies
have been used but the application of Sine-cosine wavelets have escaped
attention in these areas. The talk is mainly focused on application of Sine-
cosine wavelets to Radon Transform and atmospheric tomography.

**CP-Fr-E-55-3**

17:00–17:20

*Overcoming Element-Quality Dependency with Adaptive Extended-Stencil Fi-
nite Element Method*

Delaney, Tristan  
Stony Brook Univ.

Jiao, Xiangmin  
Stony Brook Univ.

Conley, Rebecca  
Stony Brook Univ.

*Abstract:* FEMs are widely used, but one of their major limitations is the se-
vere dependency on element quality. We propose a generalization of FEM,
called AES-FEM, which overcomes this dependency by adaptively replacing
the basis functions and test functions around poor-quality elements. The new
basis functions are Lagrange least squares basis, allowing easy enforcement
of boundary conditions. We demonstrate that AES-FEM significantly improves
the accuracy and stability of standard FEM for 2-D and 3-D elliptic PDEs.

**CP-Fr-E-55-4**

17:20–17:40

*Discrete Maximal Regularity for Abstract Cauchy Problems and Its Application
to the Finite Element Method*

Kemmochi, Tomoya  
The Univ. of Tokyo

Saito, Norikazu  
The Univ. of Tokyo

*Abstract:* Maximal regularity is one of significant concepts for parabolic partial
differential equations. It is widely applied to analysis of quasilinear parabolic
equations and the Navier-Stokes equation. On the other hand, we are inter-
ested in numerical analysis of nonlinear partial differential equations. It is thus
natural to ask whether the discrete analogue of maximal regularity is avail-
able. If this is the case, it is expected that discrete maximal regularity can be
applied to the numerical analysis of nonlinear equations. From the above per-
spective, we are studying the discrete maximal regularity for abstract Cauchy
problems. In this paper, we first prove discrete maximal regularity for time-
discrete Cauchy problems in a UMD space. We also report an application of
this result to the finite element method and obtain a priori estimate. Further-
more, we apply the estimate to linear or semilinear heat equation and derive
the optimal error estimates for finite element approximation.

**MS-Fr-E-55-5**

17:40–18:00

*Finite Element Approximation for the Stokes Equations under A Unilateral
Boundary Condition*

Sugitani, Yoshiki  
Graduate School of Mathematical Sci., the Univ. of Tokyo

Zhou, Guanyu  
University of Tokyo

Saito, Norikazu  
The Univ. of Tokyo

*Abstract:* One of the main issues in simulations of blood flow in arteries is a
proper setting of the outflow boundary condition at artificial boundaries. The
common outflow boundary conditions are a prescribed constant pressure,
traction, and velocity profiles. However, the flow distribution and pressure
field are unknown and cannot be prescribed at the outflow boundary in many
simulations. In order to tackle this problem, we recently proposed an unilater-
al outflow condition, which needs no profiles of velocity and traction but only
restricts their directions. With this condition, we obtain an energy inequality
so that numerical solutions are expected to be stable. In this talk, we consid-
er a model Stokes problem and report some results on the well-posedness,
penalty formulation, and finite element approximation. We derive the error
estimates of order 1/2 with respect to the discretizing parameter h, and verify
the results by numerical experiments.
long-range time memory and long-range spatial interactions. They offer a new way of accessing the mesoscale using the continuum formulation and hence extending the continuum description for multiscale modeling of viscoelastic materials, control of autonomous vehicles, transitional and turbulent flows, wave propagation in porous media, electric transmission lines, and speech signals. PDEs raise modeling, computational, mathematical, and numerical difficulties that have not been encountered in the context of integer-order partial differential equations. The aim of this minisymposium is to cover the recent development in mathematical and numerical analysis, computational algorithms, and applications in the context of PDEs and related nonlocal problems.

**MS-Fr-E-57-1 16:00–16:30**

**Fractional Diffusion: from Discrete Time Random Walks to Continuous Time Random Walks and Back**

A. Angstmann, S. Hargreaves, J. Lai, A. Oswald, UNSW Australia

**Abstract:** Starting with the continuous time random walk (CTRW) we derive the generalized master equation for an ensemble of particles with reactions and forcing. We show reductions, in the diffusion limit, to nonlinear fractional PDEs where numerical solutions are sought. Rather than discretising the PDEs we start with a discrete time random walk (DTRW). The master equations for the DTRW share the CTRW diffusion limit thus providing a novel numerical method that is explicit and stable.

**MS-Fr-E-57-2 16:30–17:00**

**On Two Fully Discrete Schemes for the Subdiffusion Equation**

Jin Bangtang, East China Normal Univ. & University College London

**Abstract:** In this talk we discuss two fully discrete schemes based on the Galerkin finite element method and L1 scheme/convolution quadrature. We shall establish error estimates optimal with respect to the regularity of the initial data. Both schemes are first order accurate in time for smooth and nonsmooth initial data. Extensive numerical experiments confirm the convergence analysis. The numerical results indicate that they are accurate and robust for nonsmooth data.

**MS-Fr-E-57-3 17:00–17:30**

**Wellposedness of Variable-coefficient Conservative Fractional Elliptic Differential Equations**

Yang Danping, East China Normal Univ.

**Abstract:** The previous theoretical results for constant-coefficient fractional differential equations (FDEs) cannot be extended to variable-coefficient FDEs. We derive a Petrov-Galerkin weak formulation to variable-coefficient FDES and prove that the bilinear form of the Petrov-Galerkin weak formulation is weakly coercive and so the weak formulation has a unique solution and is well posed. Finally, we outline potential application of these results in the development of numerical methods for variable-coefficient conservative FDEs.

**MS-Fr-E-57-4 17:30–18:00**

**Time-splitting Schemes for Fractional Differential Equations**

Cao Wanrong, Southeast Univ.

Zhang Zhongqiang, Worcester Polytechnic Inst.

Karniadakis George, Brown Univ.

**Abstract:** We propose time-splitting schemes for nonlinear time-fractional differential equations with both smooth solutions and nonsmooth solutions, and prove the convergence and stability of proposed schemes. Numerical examples illustrate the flexibility and the efficiency of these time-splitting schemes and show that they work for multi-rate and stiff time fractional differential systems successfully.

**MS-Fr-E-58 16:00–16:30**

**Numerical Simulation of Endocytosis: Diffuse Interface Models for Membranes with Curvature-inducing Molecules**

Lowengrub, John, UC Irvine

**Abstract:** We develop new diffuse interface models for the dynamics of inextensible vesicles in a viscous fluid with stiff, curvature-inducing molecules. A local Lagrange multiplier harmonically extended off the interface enforces inextensibility. A local relaxation scheme dynamically corrects local stretching/compression errors thereby preventing their accumulation. Hydrodynamic effects are thus accurately captured during endocytosis. By varying the membrane coverage of curvature-inducing molecules, we find that there is a critical neck radius and a critical budding time.

**MS-Fr-E-59 16:00–18:00**

**A Fast Explicit Operator Splitting Method for the Molecular Beam Epitaxy Model**

Zhang Hui, Beijing Normal University & Li Xiao, Beijing Normal University

**Abstract:** We present a fast explicit operator splitting method to solve numerically the molecular beam epitaxy model in the 1-D case. The equation is split into nonlinear and linear parts which are approximated by the finite difference method and pseudo-spectral method, respectively. The algorithm is second-order convergent in time and fourth-order in space. Both the stability and the discrete $L_2$-error estimate are proved rigorously and verified numerically. Extensive numerical experiments show the robustness of the algorithm.

**ISIAM 2015 Schedules**

**MS-Fr-D-58-1 16:00–16:30**

**Island Formation in Epitaxially Strained Crystalline Films**

Zwicknagl, Barbara, Universitat Bonn

**Abstract:** I will discuss analytical results on variational models that have been...
introduced in the physical literature to describe the shape of an epitaxially s-
trained crystalline film deposited on a rigid substrate when there is a mismatch
between the lattice parameters of the two crystals. The resulting energy func-
tional is a nonlocal isoperimetric functional. This talk is based on joint works
with P. Bella and M. Goldman, and with I. Fonseca and A. Pratelli.

**Defects in Landau-de Gennes Theory**

Robbins, Jonathan  
Univ. of Bristol

**Abstract:** We present some recent results concerning point defects in li-
quid crystals in two dimensions within the Landau-de Gennes model. In the
deenematic regime, we establish the existence of global minimizers of the
Landau-de Gennes energy for defects of arbitrary degree, and obtain explic-
tit profiles in the limit of vanishing elastic constant. The stability of index-1/2
defects under relaxed assumptions and the case of unequal elastic constants
will be briefly discussed.

**Nucleation of Austenite and Martensite**

Ball, John  
Univ. of Oxford

**Abstract:** When a new phase is nucleated in a martensitic phase transfor-
mation, we add an interfacial energy for twin boundaries. We identify the
We are interested in alloys that undergo a martensitic phase trans-
formation of complex biological phenomena and to find practical ways of action. On
the other hand, new branches of applied mathematics have emerged, e.g., math-
ematical biology, theoretical biology, and computational neuroscience. But
information flow and causality as rigorous notions in biology and medicine. Their theoretical backgrounds cover mainly nonlinear
dynamics, computational neuroscience, time series analysis, network theory,
and partial differential equations, thus a representative blend of current re-
search. Specially important are the actual and potential applications to the
biomedical industry of topics such as complex fluids, drug discovery, compu-
tational methods and information analysis, all of them included in the minisym-
posium. For instance, the parametric study of the flow in ventricular cavities
for the treatment of hydrocephalus presented in one of the communications,
has led new designs which are patent pending. If approved, this minisymposium will be certainly a great place to create syn-
nergies in an area of mathematics which has scientific interest, applications to
the biomedical industry, and social impact.

**Rithmimotic Drug Delivery**

Calderer, Maria-Carme  
Univ. of Minnesota

**Abstract:** We study a prototype model of drug delivery based on a polyelec-
trolyte gel membrane driven by glucose. We formulate and analyze related
system of partial and ordinary differential equations modeling the device and
characterize the associated limit cycles, in several dimensions. This is joint
works with Lingxun Yao, Yoichiro Mori and Ronald Siegel.

**Optimal Martensitic Inclusions**

Otto, Felix  
Max Planck Inst. for Mathematics in the Sci.

Kneuper, Hans  
Univ. of Heidelberg

Kohn, Robert  
New York Univ.

**Abstract:** We are interested in alloys that undergo a martensitic phase transfor-
mation of cubic to tetragonal symmetry breaking, which we study variation-
ally based on geometrically linearized elasticity. In order to unfold the energy
landscape, we add an interfacial energy for twinning. We identify the
scaling of the minimal energy of a martensitic inclusion of prescribed vol-
ume in the austenitic surrounding. The construction features a hierarchical
microstructure. This is joint work with H. Kneuper and R. Kohn.
in response to the global trend in STEM education. Award presentation to local teams will be held during the minisymposium. A team of students and their teacher advisor who won the Outstanding Prize in the first Annual IM2C 2015 will make presentation. Review in depth of the contest problem Movie Scheduling and commentary on solution papers by awarded teams will be lectured. Hands-on workshop on mathematical modeling teaching and learning will be offered in the minisymposium.

▶ MS-Fr-E-67-1 16:00–16:30
Mathematical Modeling Education in High School
Wang, Yaoyang
Affiliated High School of Peking Univ.
Abstract: Mathematical Modeling Education in High School

▶ MS-Fr-E-67-2 16:30–17:00
Mathematical Modeling Education in High School
Wang, Yaoyang
Affiliated High School of Peking Univ.
Abstract: Mathematical Modeling Education in High School

▶ MS-Fr-E-67-3 17:00–17:30
Hands-on Workshop in Mathematical Modeling for High School Students
Xie, Jinxing
Tsinghua Univ
Abstract: Hands-on Workshop in Mathematical Modeling for High School Students
Abstract: We have firstly defined a new error formulation and presented a method to solve an over determined linear system of equations with multiple right-hand side vectors, where the unknown matrix is to be symmetric and positive definite A more complicated problem is encountered when the unknown matrix is to be positive semi-definite. We defined an efficient error formulation for the semi-definite case and test both algorithms in MATLAB to show their efficiency.

The Proof of the Twin Primes Conjecture
Ye, Zhiju Shaanxi technical college of finance & economics

Abstract: This report proves that a class of congruence equations has no solutions using mathematical induction. If so, then Twin Primes Conjecture is true, i.e. there are infinite numbers of twin primes within the domain of natural numbers. Thus Twin Primes Conjecture is true.

Cycles of Linear and Semilinear Mappings
Klymchuk, Tetiana Taras Shevchenko National Univ. of Kyiv

Abstract: We give a canonical form of matrices of a cycle of linear or semilinear mappings \( V_1 \rightarrow V_2 \rightarrow \cdots \rightarrow V_n \). In which all \( V_i \) are complex vector spaces, each line is an arrow \( \rightarrow \) or \( \leftarrow \), and each arrow denotes a linear or semilinear mapping. Its special cases are the canonical forms of matrix pencils, contragredient matrix pencils, and pairs consisting of a linear and semilinear mappings.

On Condition Number of Weighted Least Squares Problem and Its Statistical Estimation
Wang, Shaoxin Chongqing Univ. Yang, Hu Chongqing Univ.

Abstract: we mainly focus on the derivation of a flexible condition number for weighted least squares problem. With the Fréchet derivative and kroenecker product, the explicit expression of condition number is taken into consideration. When the coefficient matrix is large and dense, considering the difficulties of explicitly forming the expression of condition number in computer, we also present its simplified form. The probabilistic condition estimation method is also introduced, and the numerical experiments are also performed.

LINEAR 2-NORMED SPACES
Krishna Reddy, Basireddy Osmania Univ.

Abstract: The defining properties of normed linear spaces are well-known and many important and useful results have been derived for these spaces. However, in certain application involving vector spaces these properties are not, appropriate, and another type of norm referred to as 2- norm, in general \( n \)-norm is more useful. Some necessary and sufficient conditions for \( n \)-norms to be equivalent on a linear normed space are given and some properties of linear \( n \)-normed spaces are explored.

Novel Krylov-subspace Solver of Generalized Shifted Linear Equations for Massively Parallel Quantum Material Simulations
Hoshi, Takeo Tottori Univ. Imachi, Hiroto Tottori Univ.

Abstract: Novel Krylov-subspace algorithms were developed for massively parallel quantum material simulations or electronic structure calculations. The method solves the generalized shifted linear equations (i\( S^{-1} \)H + \( \alpha \)) instead of conventional generalized eigen-value equation. The paper presents the algorithms and the results of 100-nm-scale or one-hundred-million-atom materials on the K supercomputer with a high parallel efficiency. The paper also presents recent linear-algebraic algorithms based on time-dependent Schrödinger-type equations and its application to organic electronics materials.

Subordination Results for A New Class of Analytic Functions Defined by Fractional Q-Calculus Operators
Selvakumaran, K A Dept. of Mathematics, R.M.K College of Engg. & Tech., Puduvoyal – 601206, Tamil Nadu Purohit, Sunil Dutt Rajasthan Technical Univ., Kota

Abstract: The subject of fractional calculus has gained noticeable importance and popularity due to its applications in various fields of science and engineering during the past three decades or so. In this article, we introduce and investigate a new class of Bazilevic functions with respect to k-symmetric points defined by fractional q-calculus operators. Several interesting subordination results are also derived for the functions belonging to this class in the open unit disc.

ON APPLICATIONS OF Q-LAPLACE TRANSFORMS TO THE BASIC ANALOGUE OF THE GENERALISED HYPERGEOMETRIC FUNCTIONS
Vyas, Vijay Kumar The ICFAI Univ., Jaipur Patel, Saurabh Rai Univ. ahmedabad

Abstract: The q-Laplace transforms of the basic analogue of H-function of \( \omega \) variables have been evaluated in the present paper. Special cases of the main results are also discussed.

Certain Geometric Properties of the Mittag-Leffler Function

INTEGRALS OF GENERALIZED BESSEL FUNCTIONS OF THE FIRST KIND
Jain Agarwal, SHILPI Poornima College of Engineering AGARWAL, PRAVEEN Anand International College of Engineering

Abstract: In this poster our aim is to derive two generalized integral formulas involving generalized Bessel functions of the first kind, which are expressed in terms of the generalized Wright hypergeometric function. Some interesting special cases of our main results are also considered.

Transformation Formulas of Incomplete Hypergeometric Functions Via Fractional Calculus Operators
Purohit, Sunil Dutt Rajasthan Technical Univ., Kota Raina, R.K. M.P . University of Agriculture & Tech., Udaipur

Abstract: The main object of this paper is to derive certain transformation formulas expressing potentially useful incomplete hypergeometric functions in terms of a finite sum of lower order functions by making use of the fractional calculus operators. We further consider certain new forms of extensions of the main results. Some consequences and special cases of the various results are also pointed out.

Unified Fractional Integral Formulas for the Incomplete Hypergeometric Functions
Bohra, Mahesh Government Women Engineering College, Ajmer Purohit, Sunil Dutt Rajasthan Technical Univ., Kota

Abstract: The aim of this paper is to study some properties of the generalized incomplete hypergeometric functions. Here we establish two theorems which provides the images of this function under the generalized fractional integral operators involving Fox’s H-function as kernel. Corresponding assertions in terms of Saigo, Erdélyi-Kober, Riemann-Liouville and Weyl type of fractional integrals are also presented. Further, we also point out their relevance with other related known results.

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Certain Geometric Properties of the Mittag-Leffler Function
PP-A02-8

The Algebraic Equalities and Their Topological Consequences in Weighted Spaces

Tien, Pham
Hanoi Univ. of Sci.

Abstract: We study algebraic equalities and their topological consequences in weighted Banach, Fréchet, or (LB)-spaces of holomorphic-like functions on a locally compact and ω-compact Hausdorff space X. One of our main results is the following: The algebraic equality \( V(A(X)) = \mathcal{V}(A(X)) \) for (LB)-spaces with \( \omega \)- and \( \omega \) growth conditions given by a weight sequence \( \mathcal{V} = (\mathcal{V}_n) \) always implies that these spaces are (DFS).

PP-A02-9

Nonuniform Multiresolution Analyses with Multiplicity \( D \)

Mittal, Shiva
SMP Govt. Degree College, Phaphamau, Allahabad (A constituent college of Univ. of Allahabad)

Abstract: A notion of nonuniform multiresolution analysis (NUMRA) with multiplicity \( D \) (a positive integer) based on the theory of one-dimensional spectral pairs is studied which is a generalization of MRA as well as NUMRA. The concept of NUMRA was introduced by Gabardo and Nashed in which the translation set is a spectrum that is no longer a group. In this nonstandard setting, we obtain a characterization of multiscaled functions associated to the NUMRA with multiplicity \( D \) (NUMRA-\( D \)). Further, we obtain a characterization of nonuniform multiwavelets associated with NUMRA- \( D \) in terms of their dimension function that generalizes a result obtained by Gabardo and Yu for NUMRA as well as Calogero and Garrigós for MRA.

PP-A02-10

A Note on Dynamics in \( C(0) \)-semigroups

Yang, Chong
Beijing Univ. of Tech.

Abstract: We prove that a \( C(0) \)-semigroup is hereditarily hypercyclic with respect to a syndetic sequence, then it is mixing. Then we get characterizations of Li-Yorke chaos in \( C(0) \)-semigroups. Firstly, we characterize Li-Yorke chaos in terms of the existence of irregular vectors. Then we present necessary and sufficient criteria for Li-Yorke chaos. Finally, we give the interplay between the continuous and the discrete cases.

PP-A02-11

On Compact-continuous Mappings

Guo, Zhi-Fang
Beijing Univ. of Tech.

Abstract: We study some properties of compact-continuous mappings, which are related to function space theory. We prove that if \( X \rightarrow Y \) is a compact-continuous surjection and \( X \) is a Lindelof \( \Sigma \)-space (sequentially compact space), then \( Y \) is a Lindelof \( \Sigma \)-space (sequentially compact space). We introduce a notion of a weak Tychonoff space. Some properties of weak Tychonoff spaces are discussed in this note.

PP-A02-12

Refinable Function-based Construction of Affine Dual Frames for Reducing Subspaces

Zhang, Jianping
Beijing Univ. of Tech.

Abstract: In this work we provide three new characterizations of affine dual wavelet frames constructed from a pair of refinable functions in the setting of reducing subspaces. We show that these characterizations are valid without any decay assumptions on the generators of the affine system. As an application, we also obtain a Fourier domain characterization of affine Parseval frames.

PP-A02-13

Some Characterizations of Function-valued Frames on Half Space

Zhang, Wei
Beijing Univ. of Tech.

Abstract: Affine frames have been extensively studied. In recent years, function-valued frames were studied by some mathematicians. Interestingly, the literature shows that function-valued frames can be used for construction of frames on half spaces which are generated by dilated and modulated versions of a function. In this paper, we give some characterizations of such frames. These characterizations are easily realized, and many examples are also provided.

Abstract: Error Analysis of Analytic Solution for High-order Boundary Value Problems and Applications

Zhang, Xiaolong
Dalian Univ. of Tech.

Abstract: The homotopy analysis method is a powerful analytic method for seeking approximate series solutions to differential equations with initial/boundary conditions. However, error analysis for the homotopy analysis method has not been given so far. For general \( 2n \)-order linear boundary value problems, significant estimates for the absolute errors of the approximations, along with sufficient conditions for the existence and uniqueness of solutions will be given in this talk.

PP-A03-2

Existence, Uniqueness and Stability of Periodic Solutions for a Hematopoiesis Model

Balderrama, Balderrama
Univ. of Buenos Aires

Amster, Pablo
Universidad de Buenos Aires

Abstract: To explain the regulation of hematopoiesis Mackey and Glass introduced a nonlinear autonomous delay differential equation. Various aspects of the environment that turn out influential were analyzed and incorporated to the model. Existence of positive \( T \)-periodic solutions of the model and its generalizations has been studied. However, almost periodic effects are even more frequent in the real world. We prove the existence, uniqueness and stability of positive almost periodic solutions for a more general model.

PP-A04-1

Entropy and Renormalized Solutions for Nonlinear Elliptic Problem Involving Variable Exponent and Measure Data

Benboubker, Mohamed Badr
National School of Applied Sci. (ENSA) of Tetouan

Abstract: We give an existence result of entropy and renormalized solutions for strongly nonlinear elliptic equations in the framework of Sobolev spaces with variable exponents of the type:

\[
-\text{div} (a(x, u, \nabla u)) + \phi(u) + g(x, u, \nabla u) = \mu,
\]

where the right hand side belongs to \( L^1(\Omega) + W^{-1, p'(\cdot)}(\Omega) \). The function \( g(x, u, \nabla u) \) is a Leray-Lions operator defined from \( W^{-1, p'(\cdot)}(\Omega) \) into its dual and \( \phi \in C^0(\mathbb{R}, \mathbb{R}^+) \). The function \( g(x, u, \nabla u) \) is a non linear lower order term.

PP-A04-2

Existence Results for Strongly Nonlinear Elliptic Equations of Infinite Order

CHRIF, MOUSSA
faculty of Sci. Fes

Abstract: In this work, generalized Sobolev spaces and Sobolev spaces of infinite order are considered. Existence of solutions for strongly nonlinear equations of infinite order of the form \( Au + g(x, u) = f \) is established. Here \( A \) is an elliptic operator from a functional space of Sobolev type to its dual and \( g(x, \cdot) \) is a lower order term satisfying a sign condition on \( \cdot \).

PP-A04-3

Traveling Waves for a Diffusive SIS Model

Fu, Sheng-Chen
Chengchi Univ.

Abstract: We study a diffusive SIS model for a disease that the infectives recover without immunity. We analytically show that there exists a family of traveling waves with the minimum speed; and investigate the dynamical behavior of the solution with the initial distribution that the susceptible species is infinitely small tails near infinity, which will lead to the formation of a pair of diverging waves.

PP-A04-4

A Triangular Spectral Element Method for Stokes Eigenvalues

Shan, WeiKun
Inst. of Software, Chinese Acad. of Sci.

Li, Huiyuan
Inst. of Software Chinese Acad. of Sci.

Abstract: A triangular spectral element method is proposed for Stokes eigenvalues utilizing generalized Koornwinder polynomials. Based on natural local-to-global mapping, Fortin interpolation is established, and then its stability is analysed such that an optimal estimate on discrete inf-sup constant of divergence can be derived theoretically. Next, we obtain the error estimate for \( H^1 \)-orthogonal projection and Stokes eigenvalues. Finally, numerical experiments are presented to illustrate our theories on discrete inf-sup constant and the accuracy of computational eigenvalues.
Abstract: In recent decades, permeable floating flexible structures are in great demand in coastal engineering practices for creating a tranquility zone. The present study deals with the scattering of obliquely incident waves by a two-dimensional floating flexible porous plate in water of finite and infinite depths. The associated boundary value problem is converted into an integro-differential equation in terms of the plate deflection. The effectiveness of the floating flexible porous plate as wave barrier is analyzed.

PP-A04-6
Simultaneous Identification of Convection Parameters in the Reaction Diffusion Convection System
Gnanavel, Soundararajan
Central Univ. of Kerala

Abstract: Inverse problems associated with the convection-diffusion equation are of much scientific importance, as they appear in the modelling of many practical problems. In this paper, we study an inverse problem of reconstructing two space and time dependent convection parameters via the optimal control framework and the stability estimate has been established with the upper bound given by some Sobolev norms of the over specified data.

PP-A04-7
Inverse Coefficient Problems for the Coupled Kuramoto-Sivashinsky Equation with Heat Equation
Natesan, Barani Balan
Central Univ. of Tamil Nadu

Abstract: In this work, we present an inverse coefficient problems for the Kuramoto-Sivashinsky equation coupled to a heat equation. More precisely, we study the simultaneous reconstruction of two smooth coefficients from the measurement of the solution on a part of the domain/boundary and also at some particular time. The proof of these results relies on an appropriate Carleman estimate and certain energy estimates for the given system.

PP-A04-8
The P-Laplacian and Geometric Structure of Riemannian Manifolds
Dung, Nguyen Thac
Hanoi Univ. of Sci.

Abstract: It is well-known that there are beautiful relationships between the theory of p-harmonic function, topology and geometric structure of Riemannian manifolds. In this paper, I will recall some results on this topic. Moreover, I show that if the first eigenvalue for the p-Laplacian achieves its maximal value on a Kahler manifold or a quaternionic Kahler manifold then such a manifold must be connected at infinity unless it is a topological cylinder.

PP-A04-9
Bifurcation and Stability Analysis of a Diffusive Predator-prey Model with Ratio-dependent Type III Functional Response
Muthusamy, Sivakumar
Bharathirai Univ., Coimbatore

Abstract: This poster concerns the diffusive Leslie-Gower predator-prey system with ratio dependent Holling type III functional response subject to Neumann boundary conditions. By linearizing the system the local stability, existence of Hopf bifurcation at the coexistence of the equilibrium and stability of bifurcating periodic solutions in the absence of diffusion are studied. Furthermore, Turing instability and Hopf bifurcation analysis with diffusion are studied. Finally, numerical simulations are provided in order to verify our theoretical results.

PP-A04-10
On A Nonlinear Renewal Equation with Diffusion
Bhargav Kumar, Kakumani
Univ. of Hyderabad

Abstract: In this article we consider a nonlinear age structured McKendrick-Von Foerster population model with diffusion term. Here we prove existence and uniqueness of the solution of the equation. We consider a particular type of nonlinearity in the renewal term and prove Generalized Relative Entropy type inequality. Longtime behavior of the solution has been addressed for both linear and nonlinear versions of the equation.

PP-A04-11
Dolfin-adjoint: Automatic Adjoint Models for FEniCS
Funke, Simon
Simula Research Laboratory
Farrell, Patrick
Univ. of Oxford
Ham, David
Imperial College London
Rognes, Marie
Simula Research Laboratory

Abstract: The implementation of adjoint models for nonlinear, time-dependent models is notoriously challenging. dolfin-adjoint solves this problem by au- tomatically analyzing the high-level mathematical structure inherent in finite element methods. It raises the traditional abstraction of algorithmic differentiation from the level of individual floating point operations to that of whole systems of differential equations. This approach delivers a number of advantages: hands-off automation of adjoint model derivation, efficiency native parallel support. We demonstrate this by numerical examples.

PP-A04-12
Global Spatial Regularity Results for Elasticity Models with Nonsmooth Constraints
Knees, Dorothee
Univ. of Kassel

Abstract: For the analysis of strongly coupled material models it is useful to have deeper insight into the spatial regularity properties of the involved quantities like displacement fields or internal variables. In this poster we will present some recent results for non-smooth situations with a special focus on certain rate-independent damage models in the small strain regime and Tresca friction models along cracks.

PP-A04-13
Numerical Study of A Renewal Equation with Diffusion
Tumuluri, Suman Kumar
Univ. of Hyderabad

Abstract: We present a numerical scheme for McKendric von Foerster equation with diffusion which arises naturally in population dynamics. In our scheme we first discretize the time variable to get a system of elliptic equations. Later we use a standard discretization for age variable to solve the elliptic equation numerically. We perform stability analysis for our scheme. Numerical results are presented in some cases and compared with the corresponding analytic solutions where the latter is known explicitly.

PP-A04-14
Existence of Solutions for A Fourth Order Eigenvalue Problem with Variable Exponent under Neumann Boundary Conditions
El Allali, Zakaria
Poldisciplinary Faculty of Nadir

Abstract: In this work we will study the eigenvalues for a fourth order elliptic equation with p(x)-growth conditions which is known explicitly. Under Neumann boundary conditions, where p(x) is a continuous function defined on the bounded domain with p(x) > 1. Through the Ljusternik-Schnirelman theory on C1-manifold, we prove the existence of infinitely many eigenvalue sequences and sup λ = +∞, where λ is the set of all eigenvalues.

PP-A04-15
Exact Solution of Navier-Stokes’s Equation
HungKuk, Oh
Ajou Univ.

Abstract: The equation for quantum state particles are derived for non-steady state and steady state. General relativity is completed by deriving the equations of quantum state particles. The two dimensional stress tensors in the partial differential equilibrium equations can be converted to one dimensional tensors per unit volume, which generate Laplacian.

The Laplacian has exact analytical solution and needs boundary conditions. It gives us exact solution of Navier – Stokes’s equation.

PP-A04-16
Numerical Treatment of Diffusion Equation of Fractional Order with Reflecting and Absorbing Boundary Conditions
Ali, Itikkar
King Fahd Univ. of Petroleum & Minerals

Abstract: Fractional order differential equations arise naturally in the modeling of many complex physical processes in various engineering and science disciplines. In this work, we find numerical solutions of time fractional diffusion equation in Caputo’s form by using an explicit and an implicit finite difference numerical schemes. Reflecting and Absorbing boundary conditions are considered both on finite and infinite domains together with delta initial conditions. We also provide Matlab code to help the readers.

PP-A04-17
Overcoming Element-Quality Dependency with Adaptive Extended-Stencil Finite Element Method
Conley, Rebecca
Stony Brook Univ.
Delaney, Tristan
Stony Brook Univ.
Jiao, Xiangmin
Stony Brook Univ.

Abstract: FEMs are widely used, but one of their major limitations is the severe dependency on element quality. We propose a generalization of FEM, called AES-FEM, which overcomes this dependency by adaptively replacing the basis functions with Lagrange least squares basis functions around poor quality elements. We explore a parallel algorithm for improved efficiency. We demonstrate that AES-FEM significantly improves the accuracy and stability.
of standard FEM for 2-D and 3-D elliptic PDEs.

PP-A04-18
A Discontinuous Galerkin Method for Neutron Transport Equations on 3-D Unstructured Grids
Wei, Junxia
Inst. of Applied Physics & Computational Mathematics

Abstract: Time-dependent neutron transport equation is a kind of important hyperbolic partial differential equation in nuclear science and engineering applications. High dimension neutron transport calculation include computing of space grid, angle direction, energy group and time step, is very complex and huge scale scientific calculation problem. Discontinuous finite element discrete ordinates (DFE-Sn) method is very efficient for solution of such equations especially while concerned with complicated physics including multimedia, larger grid distortion, complex initial and boundary conditions. In this paper, the discrete scheme of Sn discrete ordinate and discontinuous finite method 3-D unstructured tetrahedral meshes are presented. we developed a serial solver with DFE-Sn method to solve time-dependent neutron transport equations on unstructured tetrahedral grids. Domain decomposition scheme and parallel Sn sweep algorithm on unstructured grids are adopted to improve the efficiency, the parallel computation for the scheme is realized on MPI systems. Numerical experiments demonstrate the accuracy and efficiency of these methods.

PP-A04-19
Coupled Thermo-mechanical Simulations on Distributed Devices Due to Electromagnetic Loss
Liu, Qingzhe
Department of Mathematics & Computer Sci., Univ. of Greifswald
Pulch, Roland
Univ. of Greifswald

Abstract: In the apparatus such as transformers and rotating machines the main source of heat consists of winding losses generated by resistances and power loss in the core due to eddy currents and hysteresis effect. The total losses are then dissipated to all parts of the machine and make the machine hotter. We present a finite element simulation of thermo-mechanical behaviours to capture deformation and stresses based on the electromagnetic loss.

PP-A04-20
Electrical Impedance Spectroscopy-based Defect Sensing Technique in Estimating Cracks
Zhang, Tingting
Yonsei Univ.

Abstract: A defect sensing method based on electrical impedance spectroscopy is proposed to image cracks and reinforcing bars in concrete structures. The method utilizes the frequency-dependent behavior of thin insulating cracks: low-frequency electrical currents are blocked by insulating cracks, whereas high-frequency currents can pass through thin cracks to probe the conducting bars. From various frequency-dependent EIT images, we can show its advantage in terms of detecting both thin cracks with their thickness and bars.

PP-A04-21
On the Variations of the Vortex Number in A Periodic Ginzburg-Landau Model
ZHANG, Peng
Shanghai Jiao Tong Univ.

Abstract: In this paper, we study the variations of the number of vortices contained in the minimizer of a two-dimensional Ginzburg-Landau functional describing a Type-II superconductor in the London limit, with periodic conditions on the boundary of the sample. We prove that if the sample is rectangular with height small enough, the number of vortices contained in the minimizer of the periodic Ginzburg-Landau functional jumps by unit step as the applied magnetic field increases.

PP-A04-22
Firedrake: Automating Finite Element by Composing Abstractions
Ham, David
Imperial College London

Abstract: Firedrake automates the portable solution of partial differential equations using the finite element method. Firedrake takes separation of concerns in automated FEM to a new level. In addition to the Unified Form Language from the FEniCS project, and PETSc’s linear algebra abstraction, Firedrake introduces the PyOP2 abstraction for mesh iteration and the COFFEE abstraction for kernel vectorisation and optimisation. The result is faster, more flexible and more capable automated simulation.

PP-A04-23
Constitutive Framework of Maxwell Nanofluid with Cattaneo-Christov Upper-convected Derivative
Sui, Jize
Univ. of Sci. & Tech. Beijing

Zheng, Liancun
Univ. of Sci. & Tech. Beijing
Zhao, Jinhu
Univ. of Sci. & Tech. Beijing

Abstract: The Cattaneo-Christov upper-convected material derivative is introduced in characterizing the constitutive relationship of Maxwell nanofluid shear flow, thermal and nanoparticles concentration diffusion over a stretching slipping sheet. The effects of Brownian motion and thermophoretic force are also taken into account. Results show that the internal elastic stress aggregates initially and then release along with the growth of the boundary layer. Moreover, the effects of velocity slip on three boundary layer are also discussed.

PP-A04-24
A New Eulerian Approach to Crystal Plasticity
Minakowski, Piotr
Univ. of Warsaw

Abstract: Looking at severe plastic deformation experiments, it seems that crystalline materials at yield behave as a special kind of anisotropic, highly viscous fluids flowing through an adjustable crystal lattice space. Using the energy estimates we prove global in time existence of a weak solution to the proposed model. As a test example we analyze a micropillar compression. We propose finite element scheme for a numerical solution in the Arbitrary Lagrangian Eulerian (ALE) configuration.

PP-A05-1
On Hamiltonian Colorings of Block Graphs
BANTVA, DEVSI
Lukhdhirji Engineering College, Morbi

Abstract: A hamiltonian coloring c of a graph G with order p is an assignment of colors to the vertices of G such that d(u,v)+cd(u)-c(v)≥p-1, where d(u,v) denotes the distance between u and v. In this paper, we discuss for minimum span of hamiltonian colorings of block graphs and as an example we present symmetric block graphs and its hamiltonian coloring with minimum span.

PP-A05-2
Radio Number for Cacti of Wheels
BANTVA, DEVSI
Lukhdhirji Engineering College, Morbi

Abstract: A radio labeling of a graph G is a function f from the vertex set V(G) to the set of non-negative integers such that d(u,v)+f(u)-f(v)≤diam(G)+1, for every pair of distinct vertices u, v of V(G). The radio number of G is the smallest integer k such that G has a radio labeling f with maxf(v) : v ∈ V(G) = k. In this article, we determine the exact radio number for some cacti of wheels.

PP-A05-3
On the Metric Dimension of Join of A Graph with Op
ACHUTHODIKA, SHAHIDA
National Inst. of Tech. Calicut, Kerala
Sunitha, M S
National Inst. of Tech. Calicut, Kerala

Abstract: Given a graph G = (VE), a subset W of V is a resolving set if for every pair of distinct vertices u,v in V there is a vertex w in W such that d(wv,W) = w + ≤ daim(G)+1-d(u,v), for every pair of distinct vertices u, v of V(G). The number of G is the smallest integer k such that G has a radio labeling f with maxf(v) : v ∈ V(G) = k. In this paper, we determine the exact radio number for some cacti of wheels.

PP-A05-4
Weakly Connected Closed Geodetic Numbers of Graphs
Patangan, Rachel
MSU-Iligan Inst. of Tech.

Abstract: A subset S of V(G) is called a weakly connected closed geodetic set if I(G)[S] = V(G) and (S) is connected, where (S) = (N(S), E(S)) with E(S) consists of edges uv ∈ E(G) such that u ∈ S or v ∈ S. In this paper, we characterize the weakly connected closed geodetic sets of some common graphs and graphs under binary operations. Also, we determine the weakly connected closed geodetic numbers of these graphs.

PP-A06-1
Mixed Finite Element Methods for Time Fractional Parabolic Optimal Control Problems - A Priori Error Estimates
Kandasamy, Manickam
Periyar Univ., Salem 636011, Tamil Nadu, INDIA

Abstract: In this paper, a numerical theory based on mixed finite element methods for time fractional parabolic optimal control problems is presented and analyzed. The space discretization of the state variable is done using usual mixed finite elements, whereas the time discretization is based on difference methods. We derive, a priori error estimates for both the control variable and the state variables. We illustrate with a numerical example to confirm our theoretical results.

PP-A06-2
Strong Stability Preserving Multi-Derivative Runge-Kutta Time Discretization
Abstract: We develop a posteriori error estimates for elliptic problems with point sources in two- and three-dimensional domains. We prove a global upper bound and a local lower bound for the error measured in a weighted Sobolev space. The weight is a power of the distance to the support of the Dirac delta source term, and belongs to the Muckenhoupt’s class \( A_2 \). Numerical experiments with an adaptive algorithm yield optimal meshes and very good effectiveness indices.

- PP-A06-9
  Multi-level Decoupling of Free Flow Coupled with Porous Media Flow
  Chidyagwai, Prince
  Loyola Univ. Maryland
  Abstract: We present a multi-level decoupling technique for solving the coupled Stokes-Darcy model. The model describes the interaction between free flow and porous media flow. We present a multi-numerics scheme based on continuous finite elements for the flow in the free flow region and the Discontinuous Galerkin method to approximate the flow in the porous medium. Multi-level methods offer computational efficiency by solving the fully coupled problem on a coarse mesh (thus computationally less expensive) and using the solution from the coarse mesh to decouple the model on successively finer meshes for a desired accuracy. This method naturally decouples the problem into two systems: one for the free flow region and the other for the porous medium region. We present numerical results to verify the theoretical convergence rate of the numerical solution from the decoupled scheme. Further, we compare the accuracy of the decoupled numerical scheme to the fully coupled scheme.

- PP-A06-10
  Exponential Quartic Spline Solution of Fifth Order Singularly Perturbed Boundary Value Problems
  Khanddelwal, Pooja
  Jamia Millia Islamia, New Delhi
  Abstract: In this paper, we develop a numerical technique for the solution of fifth order singularly perturbed boundary value problems using exponential quartic spline. End conditions of the spline are derived. Convergence analysis of the method is briefly discussed and the method is proved to be second order convergent. Numerical examples are provided to show the efficiency and accuracy of the technique.

- PP-A06-11
  Research on the Extension of Cubic Spline Function
  Li, Ning
  Chongqing Univ.
  Abstract: Based on the analysis of basic cubic spline function, we promote the boundary conditions of the traditional cubic spline interpolation, and search how to solve cubic spline interpolation on the condition that the first derivative and second derivative of arbitrary node are given, at the same time, we give out the corresponding solving methods, then we use these some examples to illustrates the effectiveness of the solving methods.

- PP-A06-12
  Numerical Methods for One-Dimensional Stefan Problems
  CALDWELL, James
  OPEN Univ. OF HONG KONG
  NG, Kei Shing Douglas
  OPEN Univ. OF HONG KONG
  CHU, Chun Fai Carlin
  OPEN Univ. OF HONG KONG
  Abstract: This paper describes and compares several effective methods for the numerical solution of one-dimensional Stefan problems. We restrict our attention to problems and geometries which include melting in the half-plane, outward cylindrical solidification and outward spherical solidification. Effectively, a range of methods is introduced including (1) enthalpy method, (2) boundary immobilization method, (3) perturbation method, (4) nodal integral method, and (5) heat balance integral method. These methods are then applied to test problems.

- PP-A06-13
  Numerical Solution of Stefan Problems by Variable Space Grid Method
  CALDWELL, James
  OPEN Univ. OF HONG KONG
  CHU, Chun Fai Carlin
  OPEN Univ. OF HONG KONG
  NG, Kei Shing Douglas
  OPEN Univ. OF HONG KONG
  Abstract: The variable space grid method based on finite-differences is applied to the one-dimensional Stefan problem with time-dependent boundary conditions describing the solidification/melting process. The temperature distribution, position of the moving boundary and its velocity are evaluated in terms of finite differences. The computational results by the variable space grid method exhibit good agreement with the exact solution. Also, the present results are superior to those from the variable time step method.

- PP-A06-14
  A Mortar Finite Element Method Using Non-conforming Crouzeix-Raviart Space
  Agnellii, Juan Pablo
  Univ. of Cordoba
  Abstract: We develop a posteriori error estimates for elliptic problems with
Numerical Techniques for Variable Order Fractional Semilinear Diffusion Problems

Birajdar, Gunvant
Tata Inst. of Social Sci.

Abstract: The aim of our study is to obtain the numerical solution of first initial boundary value problem (IBVP) for semilinear variable order fractional diffusion equation. We develop the three numerical techniques namely explicit difference scheme, implicit difference scheme and Crank-Nicholson difference scheme respectively. The stability as well as convergence of schemes are studied via Fourier method. As an application test problems are also solved using MATLAB.

Numerical Homogenization of Harmonic Maxwell’s Equation with A Heterogeneous Multiscale Method

Stohrer, Christian
POEMS team, ENSTA ParisTech

Abstract: The approximation of an electromagnetic wave propagating through a highly oscillatory medium is challenging. Using standard edge finite elements a very fine mesh is needed to obtain reliable numerical solutions. Hence, this approach may lead easily to infeasible computational costs. We propose a finite element heterogeneous multiscale method for the Maxwell’s equations in frequency domain, which overcomes this issue. The method relies on estimating effective parameters solving small cell problems on the fly.

Approximation of Semilinear Stochastic Evolution Equations Driven by Colored Noise

Kamrani, Minoo
Razi Univ.

Abstract: We investigate the approximation by space and time discretization of semi linear stochastic evolution equations driven by colored noise. A numerical method will be introduced and an error bound for the method is given. Convergence rate of the scheme will be obtained. Numerical examples are also presented to examine the theoretical results.

Convergence Proof and Error Analysis of the Homotopy Analysis Method

Ma, Junchi
Dalian Univ. of Tech.

Abstract: The homotopy analysis method has been applied to solve many problems. However, proof of convergence for the method has not been given. For second-order linear differential equations, a proof of convergence for the series solutions is presented. An approach for seeking convergent series solutions is proposed, which includes the determination of a valid region of the convergence-control parameter for ensuring convergence, and an upper bound for the absolute error of a series approximation.

Numerical Applications of Tikhonov Regularization for the Fourier Multiplier Operators

Almarashi, Adel
Thamar Univ.

Abstract: In this manuscript we present a simple and efficient approximation for some class of Fourier multiplier operators \( T \) on the Paley-Wiener spaces \( H \), using the theory of reproducing kernels to the Tikhonov regularization. Furthermore, we give several numerical computational examples to test and validate the theory.


Sandilya, Ruchi
Indian Inst. of Space Sci. & Tech.

Kumar, Sarvesh
Indian Inst. of Space Sci. & Tech.

Abstract: This paper deals with discontinuous finite volume approximations of the distributed optimal control problems governed by a class of semilinear parabolic partial differential equations and subject to inequality control constraints. For discretizing the control parameter, the variational discretization technique is employed. A priori error estimates are derived in different norms for the semi-discrete and fully-discrete piecewise linear discontinuous finite volume methods. Several numerical experiments are presented to test the theoretical findings.
Numerical Dispersion Analysis of the Convected Helmholtz Equation
Kwon, Ohsung
Sim, Imbo
National Inst. for Mathematical Sci.
National Inst. for Mathematical Sci.

Abstract: We present the numerical dispersion effects in solving the convected Helmholtz equation by the conforming and nonconforming quadrilateral finite elements. Particularly, we evaluate the dispersion relations for the numerical schemes and analyze the dispersive behaviors focusing on Mach number and the angular frequency. Moreover, numerical experiments are conducted to verify that the numerical dispersion represents the relation between the numerical error and the parameters.

Structure-preserving Numerical Schemes for the One-phase Interior/Exterior Hele-Shaw Problem by the Charge Simulation Method
Sakabara, Koya
Yazaki, Shigetoshi
The Univ. of Tokyo
Meiji Univ.

Abstract: The solutions to the classical Hele-Shaw problem are discretized in space by means of a modified charge simulation method combined with the discrete asymptotic uniform distribution method, and then a system of ordinary differential equations is obtained, which is solved by the usual fourth order Runge-Kutta method. The Hele-Shaw problem has curve-shortening and area-preserving properties. Our scheme realizes these properties asymptotically in a discrete sense.

Control of Parasitism in G-symplectic Methods via Projection
Habib, Yousaf
National Univ. of Sci. & Tech.

Abstract: G-symplectic general linear methods approximately preserve symplectic invariants for Hamiltonian systems over long times. However, being multivalue in nature, these methods are prone to parasitic corruption of the numerical solution. As a remedy and in order to control parasitism, standard projection as well as symmetric projection is employed to project the numerical solution on the invariant manifold.

Numerical Homogenization Method with Partition of Unity Property
Chen, Hongfei
Zhang, Lei
Shanghai Jiatong Univ.
Shanghai Jiao Tong Univ.

Abstract: Numerical homogenization is a typical and widely applied multiscale method. It is believed that a multiscale method with partition of unity property has better stability and convergence. We aim to seek the general method in constructing a specific numerical homogenization method with partition of unity property and analyze its stability, convergence and computational complexity. Moreover, we wish to generalize it to high-dimensional and nonlinear problems. This is a joint work with Professor Lei Zhang.

A Moving Grid Method via A Hodograph Transformation for the Short-pulse Equation under the Periodic Condition
Sato, Kun
The Univ. of Tokyo

Abstract: When the pair of PDEs are associated with each other via hodograph transformation, a numerical integrator of one PDE can be obtained from that of the other, which gives rise to moving grid effect. Oguma–Matsuo–Feng showed that this can be in fact realized for the short-pulse and sine-Gordon equations. However, they only considered it on whole real line. We show that their result can be generalized to the periodic case.

The Construction of the Basis of the Multi-scale Finite Element Method and Its Parallel Realization
Chi, Hai
Zhang, Lei
Shanghai Jiao Tong Univ.
Shanghai Jiao Tong Univ.

Abstract: With the development of subjects like material science, biological medical engineering and so on, the problem of how to deal with the interaction between different scales feasibility and efficiently becomes more important. Our research designs an efficient parallel package to realize different multi-scale algorithms. Based on the package, we try to design a Multi-scale algorithm with the property of the partition of unity. Furthermore, we will try to generalize it to the non-linear function.

IB-BGMRES-DR: An Augmented Block Krylov Method with Inexact Breakdowns
Jing, Yanfei
Univ. of Electronic Sci. & Tech. of China

Abstract: A block GMRES method for solution of large linear systems with multiple right-hand sides given simultaneously is presented. This new algorithm addresses the problems related to spectral augmentation at restart and the partial convergence of some linear combinations of the right-hand sides. Through numerical experiments, we show that the new algorithm combines efficiently the attractive numerical features of its two parents that it outperforms.

Mixed Discontinuous Galerkin Discretizations for Photonic Crystals
Lu, Zhongjie
Univ. of Sci. & Tech. of China

Abstract: Photonic crystals are nanostructures that contain periodic variations in dielectric materials on length scales comparable to the wavelength of light. Light with frequencies inside the photonic band gap cannot exist in these materials. To find those gaps, we need to solve the Maxwell eigenproblem. Here, we use mixed discontinuous Galerkin finite element discretization with basis functions modified according to the Bloch-Floquet theory. And we prove the correctness of the spectrum of the corresponding numerical operator.
Their Performance on Modern HPC Architectures
High-resolution Numerical Schemes for Hyperbolic Conservation Laws, and varying flow features for gaining the expected accuracy.
a priori error estimate and presented numerical results to support the estima-
tive mesh redistribution approach based on the mesh redistribution functions
spread property of reservoirs as it is caused by thin-layering or systems of
Analyzing Standing Waves on Periodic Waveguides by Pseudospectral Modal
Sourcewise Represented Sets
A Generalized Extending Compacts Method for Inverse Source Problems on
practical/temporal complexity of both methods. The analysis shows that BASFMM
Abstract: In this work, we consider an inverse source problem for elliptic par-
tional differential equations with both Dirichlet and Neumann boundary condi-
finite element methods (MFEMs) for solving second-order elliptic boundary
problems. The differences, similarities, and connection among these
suitable parameters in the hyperbolic contour are selected based on these
regions to solve the fractional diffusion equations. Numerical experiments are
properties, the regions that the spectra of resulting matrices lie in are derived.
graphs.
coming to fluid field, we define the mass and energy (such as density, velocity,...) in time to the corresponding change in space. Math-
ematically the proper discretization of conservation laws is of importance to
Abstract: The modeling of fluids usually results in a number of partial differen-
tial equations that relate the change of local properties (such as density, velocity, temperature,...) in time to the corresponding change in space. Math-
ematically the proper discretization of conservation laws is of importance to
obtain physically relevant result. The problems are challenging from a numeri-
cal point of view, since care has to be taken to propagate shock waves without
diminish the performance of the scheme.
Abstract: A new closed-form formula is developed for the image of a genera-
general multipole source with arbitrary degree (order) outside a dielectric sphere. A method of images based on this formula is developed, then coupled with the method of moments and the fast multiple method to solve boundary val-
ue problems for systems consists of multiply closely compacted charged di-
electric spheres. The accuracy and efficiency for this new hybrid method is
demonstrated through several numerical experiments.
Abstract: Computer aided detection is one of the most promising methods for
timely diagnosis and treatment of Cerebrovascular Disease. The initial signs of
cerebrovascular disease are often too subtle for the patients to notice. Open
multivariate clustering is carried out to identify different groups of the data.
A univariate clustering is carried out to identify the centroids of the clusters. It has been examined for white-noise process and spectral densities have been computed. Finally, detrended fluctuation
analysis has been carried out. Long-range power-law correlation has been
observed and performance of AR-NN(3) is identified as better than AR(3) and
ARMA(3,1).

Abstract: To control the rapid increasing memory of Fast Multipole Method
(FMM) in highly accurate numerical simulations, we propose a new Big Step
Acceleration Fast Multipole Method (BSAFMM). The new method is recon-
structed based on FMM by restricting the number of grid levels. We analyze
both qualitatively and quantitatively the number of grid levels and the spe-
cial/temporal complexity of both methods. The analysis shows that BASFMM
remarkably save memory compared with FMM.

Analyzing Standing Waves on Periodic Waveguides by Pseudospectral Mod
Algorithms for Anisotropic Viscoelastic Media: Parallel Implementation
Hsueh-Chen

Abstract: For some periodic waveguides, there are standing waves, which are
special guided modes, non-propagating and localized around the waveguide
core, and they are related to transmission anomalies and other resonant
phenomena. A recently developed pseudospectral modal method (PSMM), for
diffraction gratings is reformulated to analyze standing waves on periodic
waveguides.

PP-A07-4

Galina Reshetova, Egor Lys, Vladimir Tcheverda
Numerical Simulation of Sonic Log in Anisotropic Viscoelastic Media: Parallel Implementation
Reshetova, Galina
Inst. of Computational Math. & Math. Geoph

Abstract: Modern high performance computers allow to study complete wave
fields which of acoustic logging for 3D heterogeneous media with realistic
properties such as anisotropy and attenuation. Anisotropy is rather wide-
spread property of reservoirs as it is caused by thin-layering or systems of
oriented fractures, while attenuation may indicate fluid saturation. We present
a new approach for seismic simulation of sonic log for anisotropic vis-
coelastic media on the base of Lebedev scheme in cylindrical coordinates.

PP-A07-5

An Adaptive Approach Based on Least-squares Finite Element Approxima-
tions to Viscoelastic Fluid Flows
Lee, Hsueh-Chen
Wenzao Ursuline Univ. of Languages

Abstract: We implemented an adaptive least-squares finite element method
for viscoelastic fluid flows. To capture the flow region, we developed an adap-
tive mesh redistribution approach based on the mesh redistribution functions
varied with grading functions of the least-squares solutions. We provided an
a priori error estimate and presented numerical results to support the estima-
tion. Numerical results showed that adaptive grids were required in areas with
varying flow features for gaining the expected accuracy.

PP-A07-6

High-resolution Numerical Schemes for Hyperbolic Conservation Laws, and
Their Performance on Modern HPC Architectures

Prugger, Martina
Univ. of Innsbruck

Abstract: The modeling of fluids usually results in a number of partial differen-
tial equations that relate the change of local properties (such as density, velocity, temperature,...) in time to the corresponding change in space. Math-
ematically the proper discretization of conservation laws is of importance to
obtain physically relevant result. The problems are challenging from a numeri-
cal point of view, since care has to be taken to propagate shock waves without
diminish the performance of the scheme.

PP-A07-7

A Hybrid Method for Solving the Poisson’s Equation in the Presence of Multi-
ple Closely Compacted Dielectric Spheres
Gan, Zecheng
Inst. of Natural Sci., Shanghai Jiao Tong University
Jiang, Shidong
New Jersey Inst. of Tech.
Xu, Zhenli
Shanghai Jiao Tong Univ.

Abstract: A new closed-form formula is developed for the image of a genera-
general multipole source with arbitrary degree (order) outside a dielectric sphere. A method of images based on this formula is developed, then coupled with the method of moments and the fast multiple method to solve boundary val-
ue problems for systems consists of multiply closely compacted charged di-
electric spheres. The accuracy and efficiency for this new hybrid method is
demonstrated through several numerical experiments.

PP-A07-8

A Single-sweep Algorithm for Computing the Asymptotic Spectrum for Net-
works with Pairwise Rates of the Form $K_{ij} \exp(-U_{ij}/T)$
Gan, Tingyue
Univ. of Maryland at College Park
Cameron, Maria
Univ. of Maryland

Abstract: We propose a single-sweep algorithm to compute the asympot-
ic eigenvalues and eigenvectors of a matrix with entries of the form $L_{ij} = k_{ij} \exp(-U_{ij}/T)$ for $i = j$, and $L_{ij} = -\sum_{k=1}^{n} L_{jk}$. Parameter $T > 0$
tends to zero. This problem is essentially reduced to the computation of the
family of so called optimal $W$-graphs(Wentzell) of a weighted directed
diagram.

PP-A07-9

The Entropy Dissipation Scheme for Two-Dimensional Hyperbolic Equations
Li, Hongxia
Zhejiang Univ. of Finance & Economics

Abstract: We design the entropy dissipation scheme for the two-dimensional
hyperbolic equations. The scheme computes both the numerical solution and
the numerical entropy. We use the entropy dissipation term that simulates
the variation of the entropy to stabilize the calculation. Finally, numerical
experiments for scalar case are presented.

PP-A07-10

Fast Numerical Contour Integral Method for Fractional Diffusion Equations
Pang, Hong-Kui
Jiangsu Normal Univ.
Song, Hsi-wei
Univ. of Macau

Abstract: The numerical contour integral method with hyperbolic contour is
exploited to solve space-fractional diffusion equations. By making use of the
Toeplitz-like structure of spatial discretized matrices and the relevant prop-
erties, the regions that the spectra of resulting matrices lie in are derived.
Suitable parameters in the hyperbolic contour are selected based on these
regions to solve the fractional diffusion equations. Numerical experiments are
provided to demonstrate the efficiency of our contour integral methods.

PP-A07-11

Comparison of Weak Galerkin Finite Element Method with Dgfbem and Mfbem,
Sadre-Marandi, Farrah
Colorado State Univ.

Abstract: We present a comparative study on the newly introduced weak
Galerkin finite element methods (WGFEMs) with the widely accepted discon-
tinuous Galerkin finite element methods (DGFEs) and the classical mixed
finite element methods (MFEs) for solving second-order elliptic boundary
value problems. The differences, similarities, and connection among these
methods in scheme formulations, implementation strategies, accuracy, and
computational cost are compared. We demonstrate that WGFEMs are viable
alternatives to MFEs and hold some advantages over DGFEs.

PP-A07-12

A Generalized Extending Compacts Method for Inverse Source Problems on
Sourcewise Represented Sets
Ye, Zhang

Abstract: In this work, we consider an inverse source problem for elliptic par-

differential equations with both Dirichlet and Neumann boundary condi-
tions. The unknown source term is to be determined by additional boundary
data. This problem is ill-posed since the boundary is one dimension lower

PP-A07-13

Present paper analyzes long-range autocorrelation in total ozone
time series and subsequently develops autoregressive neural network (AR-
NN) as a predictive model . A univariate clustering is carried out to identify the
centroids of the clusters. It has been examined for white-noise process and spectral densities have been computed. Finally, detrended fluctuation
analysis has been carried out. Long-range power-law correlation has been
observed and performance of AR-NN(3) is identified as better than AR(3) and
ARMA(3,1).
than the inner domain. To overcome the ill-posed nature, using the a priori information (sourcewise representation) based on the coupled complex boundary method we will propose a generalized extending compacts method.

PP-A07-13
A New Globally Hyperbolic Moment System by Generalized Hermite Expansion
Fan, Yuwei
School of Mathematical Sci., Peking Univ.
Ruo, Li
Peking Univ.

Abstract: In gaskinetic theory, Grad’s expansion actually is using a polynomial to approach the distribution divided by local Maxwellian. However, distribution function is usually anisotropic while Maxwellian is isotropic. In the sense of distribution, Grad’s expansion can be treated as a linear approximation of Levermore’s maximum entropy around Maxwellian. Why Maxwellian? Here we expand the distribution around a Gaussian, which is anisotropic and closer to maximum entropy, and the resulting moment system is better Grad’s.

PP-A07-14
AN ADAPTIVE INDEPENDENCE SAMPLER MCMC ALGORITHM FOR INFINITE-DIMENSIONAL BAYESIAN INFERENCE
Feng, Zhe
Shanghai Jiao Tong Univ.
Li, Jinglai
shanghai jiaotong university

Abstract: In this work we develop an independence sampler based MCMC method for the Bayesian inferences in function spaces. We represent the proposal distribution as a mixture of a finite number of specially parametrized Gaussian measures. We show that the resulting MCMC algorithm is dimension independent. We also design an efficient adaptive algorithm to adjust the mixture parameters from the sample history. Examples are provided to demonstrate the efficiency and robustness of the proposed method.

PP-A07-15
A Fast Computational Method for Optimizing Hyper-parameters in Bayesian Linear Inverse Problems
Liu, WenQing
Shanghai Jiao Tong Univ.
Li, Jinglai
shanghai jiaotong university

Abstract: In Bayesian inferences the hyper-parameters are often determined to suit time-mesh of arbitrary size. In this project, a numerical algorithm is proposed to approach the distribution divided by local Maxwellian. However, distribution function is usually anisotropic while Maxwellian is isotropic. In the sense of distribution, Grad’s expansion can be treated as a linear approximation of Levermore’s maximum entropy around Maxwellian. Why Maxwellian? Here we expand the distribution around a Gaussian, which is anisotropic and closer to maximum entropy, and the resulting moment system is better Grad’s.

PP-A07-16
A Fast Computational Method for Optimizing Hyper-parameters in Bayesian Linear Inverse Problems
Liu, WenQing
Shanghai Jiao Tong Univ.
Li, Jinglai
shanghai jiaotong university

Abstract: In Bayesian inferences the hyper-parameters are often determined to suit time-mesh of arbitrary size. In this project, a numerical algorithm is proposed to approach the distribution divided by local Maxwellian. However, distribution function is usually anisotropic while Maxwellian is isotropic. In the sense of distribution, Grad’s expansion can be treated as a linear approximation of Levermore’s maximum entropy around Maxwellian. Why Maxwellian? Here we expand the distribution around a Gaussian, which is anisotropic and closer to maximum entropy, and the resulting moment system is better Grad’s.

PP-A07-17
A Non-Gaussian Prior for Infinite Dimensional Bayesian Inverse Problems.
Hu, Zixi
Shanghai Jiao Tong Univ.
Yao, Zhewei
Shanghai Jiao Tong Univ.
Li, Jinglai
shanghai jiaotong university

Abstract: We consider the Bayesian methods for solving inverse problems in function space. The often used Gaussian processes prior has difficulty in dealing with functions with discontinuities. In this work we present a non-Gaussian prior for such problems and we develop an efficient MCMC algorithm to sample the posteriors resulting from this non-Gaussian prior. Numerical examples are provided to demonstrate the effectiveness of the method.

PP-A07-18
Joint MAP Estimation for Fractional Diffusion Inverse Problems
Yao, Zhewei
Shanghai Jiao Tong Univ.
Hu, Zixi
Shanghai Jiao Tong Univ.
Li, Jinglai
shanghai jiaotong university

Abstract: We consider an inverse problem where the model is a time-fractional diffusion. In particular we consider the problem where the Caputo fractional derivative order $\alpha$ is not known. We present a joint MAP approach to estimate the unknown and $\alpha$ simultaneously. Numerical examples are provided to demonstrate the effectiveness of the proposed method.

PP-A07-19
Cloud Computing Technology for Education and Research in Mathematics
Liu, Xuelong
Niigata Univ., Japan
Tanaka, Tamaki
Niigata Univ.

Abstract: A system based on cloud computing technology is developed for the purpose of education and research in mathematics. The system can provide dynamic service (computing servers) corresponding to the needs of users. It is now very easy for one to set up an online demonstration site to reveal mathematics including various resource-consuming computing algorithms.

PP-A07-20
Bounds on the Size of An Inclusion Using the Translation Method for Two-dimensional Complex Conductivity
Li, Xiaofei
Inha Univ.

Abstract: The size estimation problem in electrical impedance tomography is considered when the conductivity is a complex number and the body is two-dimensional. Upper and lower bounds on the volume fraction of the unknown inclusion embedded in the body are derived in terms of two pairs of voltage and current data measured on the boundary of the body. We also provide numerical examples to show that these bounds are quite tight and stable under measurement noise.

PP-A08-1
Methods and Tools of Functional Programming for Supporting of Cloud Supercomputing
Kasyanov, Victor
Inst. of Informatics Sys.

Abstract: In the paper, the CSS project being under development at the Institute of Informatics Systems in Novosibirsk with support of the Russian Foundation for Basic Research (15-07-02029) is considered. The CSS system uses the Cloud Sisal language, is available on web via browser and includes interface, interpreter, graphic visualization/debugging subsystem, optimizing cross compiler, cluster runtime. It provides means to write and debug Cloud-Sisal-programs on low cost devices and to translate and execute Cloud-Sisal-programs in clouds.

PP-A09-1
Detecting the Source of Failure in Distributed Data
Szajowski, Krzysztof
Wroclaw Univ. of Tech.

Abstract: The system generate events in random moments and with random effects. Any deviation from the regularity of events or results significantly different from the expected should be treated as a malfunction of the system. The mathematical model of such system is proposed. The change points could be in events appearance and the size. The detection of disorder moments is investigated in general case: known or unknown order.

PP-A09-2
Eigenvalue Condition and Model Selection Consistency of Lasso
Yang, Yuehan
Central Univ. of Finance & Economics

Abstract: In this paper, we investigate a new train of thought to lead the model selection consistency of lasso. One important but more standard and much weaker condition, Eigenvalue Condition, is proposed. We can prove that the probability of lasso selecting wrong variables can decay at an exponential rate in ultra-high dimensional settings without other restraints except Eigenvalue Condition.

PP-A09-3
An Efficient and Robust Variable Selection Method for Longitudinal Generalized Linear Models
Liu, Jie
Chongqing Univ.
Yang, Hu
Chongqing Univ.
Guo, Chaohui
Chongqing Univ.

Abstract: This paper presents a new efficient and robust smooth-threshold generalized estimating equations for generalized linear models (GLMs) with longitudinal data. The proposed method is based on a bounded exponen- tial score function and leverage-based weights to achieve robustness against outliers both in the response and the covariate domain. Our motivation for the new variable selection procedure is that it enables us to achieve better robustness and efficiency by introducing an additional tuning parameter $\gamma$.

PP-A09-4
Penalized Weighted Composite Quantile Estimators with Missing Covariates
Yang, Hu
Chongqing Univ.
Liu, Huilan
Chongqing Univ.

Abstract: In this paper, we propose the penalized weighted composite quantile regression estimation for linear model when the covariates are missing at
random. Under some mild conditions, the asymptotic normality, oracle prop-
erty and Horvitz-Thompson property of the proposed estimators are estab-
lished. Simulation results and a real data analysis are provided to examine the performance of our methods.

- PP-A09-5
  The Adaptive L1-penalized LAD Regression for Partially Linear Single-index
  Models
  Yang, Jing Chongqing Univ.
  Yang, Hu Chongqing Univ.

Abstract: We propose a stepwise penalized LAD regression to generate ro-
bust estimators based on PLSIM. An iterative procedure is firstly presented to
estimate the index parameters with the univariate link function is approx-
imated by local linear LAD regression, then adaptive L1-penalized LAD pro-
cedure is introduced to do estimation and variable selection for the linear part
parameters based on the index estimator. Compared with the penalized LS
estimator, our proposed estimator is shown to be robust.

- PP-A09-6
  A Robust and Efficient Estimation Method for Single-index Varying-coefficient
  Models
  Yang, Hu Chongqing Univ.
  Guo, Chaohui Chongqing Univ.
  Lv, Jing Chongqing Univ.

Abstract: A new estimation procedure based on modal regression is proposed for
single-index varying-coefficient models. The proposed method achieves better robustness and efficiency than that of Xue and Pang (2013). We es-

tablish the asymptotic normality of proposed estimators and evaluate the
performance of the proposed method by a numerical simulation.

- PP-A09-7
  The Pth Moment Asymptotic Stability and Exponential Stability of Stochastic
  Functional Differential Equations with Polynomial Growth Condition
  Feng, Lichao Beijing Univ. Of Tech.
  Li, Shoumei Beijing Univ. Of Tech.

Abstract: This paper mainly discusses the pth moment asymptotic stabili-
y and the exponential stability of nonlinear stochastic functional differential
equations (SFDEs) satisfying the local Lipschitz condition but not the lin-
ear growth condition. These new conditions assume that the coefficients of
SFDEs are polynomials or dominated by polynomials. We establish some suf-
cient conditions for the pth moment asymptotic stability and the exponential
stability of nonlinear SFDEs by applying some novel techniques.

- PP-A09-8
  Generalized Empirical Likelihood Inference for Longitudinal Data with Missing
  Response Variables and Error-Prone Covariates
  Liu, Juanfang Beijing Univ. of Tech.
  Xue, Liugen Beijing Univ. of Tech.

Abstract: Incomplete longitudinal data often arise in many areas. In this ar-
ticle, we consider longitudinal partial linear models when the response vari-
able is missing probability depending on the covariate that is measured with
error. A generalized empirical likelihood method is proposed by combining
inverse probability-weighted generalized estimating equations and quadratic
inference functions based on the working correlation matrix. Empirical studies
demonstrate that the proposed method performs better than normal approxi-
mate method.

- PP-A09-9
  Weak Approximation for Non-smooth Functionals of Stochastic Differential
  Equations with Irregular Diffusion and Application in Mathematical Finance
  Ngo, Hoang Long Department of Mathematics & Informatics

Abstract: We study the weak approximation for non-smooth functionals of (reflected) stochastic differential equations with irregular drift and constant-
t diffusion coefficient, when their solution is approximated by a continuous
Euler-Maruyama scheme. We also discuss some applications of your study
to study the numerical pricing problem in mathematical finance.

- PP-A09-10
  Semiparametric Estimation of the Single-index Varying-coefficient Model
  Zhao, Yang Beijing Univ. of Tech.
  Xue, Liugen Beijing Univ. of Tech.

Abstract: In this paper, we consider the choice of pilot estimators for the
single-index varying-coefficient model, which may result in radically different
estimators, and develop the method for estimating the unknown parameter
in this model. Asymptotic properties for the proposed estimation procedure
have been established. Simulation studies are carried out to assess the finite
sample performance of the proposed estimators, and efficiency comparisons
between the estimation methods

- PP-A09-11
  Martingale Optimal Transport Dualities in Skorokhod Space
  Gaoyue, GUO CMAP, Ecole Polytechnique

Abstract: The problem consists in maximizing the expectation of some reward
function among all martingale measures under some marginal constraints.
We establish the dualities and give a geometric characterization of its opti-
mizers.

- PP-A09-12
  A Semiparametric Empirical Likelihood on the Linear Models with Covariates
  Parametrically Transformed
  Zhang, Jinghua Beijing Univ. of Tech.
  Xue, Liugen Beijing Univ. of Tech.

Abstract: The linear assumption between the non-parametrically transformed
response and the covariates in the traditional linear transformed models may
not be satisfied in practice. With the covariates been parametrically trans-
formed, the linearity may be recovered. Here we apply the empirical likelihood
method to such a linear transformed model. We obtain the confidence region
for the regression parameters via an U-statistics. Simulations and a real data
analysis demonstrate that the proposed method substantially outperforms the
normal approximation based method.

- PP-A09-13
  Tests for High-dimensional Regression Coefficients in Linear Panel Models
  Jing, Zhao Beijing Univ. of Technology

Abstract: To test regression coefficients of linear panel models, the FW-test
based on within estimation of regression coefficients often is suggested. This
paper investigates the performance of the FW-test for testing part of high di-

menional regression coefficients in a panel data model under the case of p/N → p (0 < p < 1). The asymptotic normality of the FW-statistic is ob-
tained, and then two asymptotic tests (UA-test, UB-test) are presented. The inference
approach does not require any specification of the error distribu-
tion. Some simulation results are presented which show that the UA-test and UB-test
are more powerful than FW-test for moderate large dimension and sample
sizes. A pharmacokinetics study on renal cancer data is illustrated using the
proposed method.

- PP-A09-14
  Gaussian Processes Accelerated Multi-canonical Monte Carlo for Rare Prob-
  ability Estimation
  Wu, Keyi Shanghai Jiao Tong Univ.
  Li, Jinglai shanghai jiaotong university

Abstract: Multi-canonical Monte Carlo (MMC) has been used to estimate s-
mall failure probabilities in various engineering problems. MMC often requires
a rather large number (e.g. 1E5) of simulations to obtain a reliable estimate,
which can be prohibitively expensive for computationally demanding models.
We present a method to accelerate MMC with Gaussian processes, which can
significantly reduce the computational cost of the standard MMC. Numerical
examples are provided to demonstrate the efficiency of the proposed method.

- PP-A09-15
  Analysis of High-Frequency Stock Data Based on Realized Power Variation
  Shi, Xin Peking Univ.

Abstract: Firstly I fitted a group of five-minute stock data with ARIMA+GARCH
model as tool, after that I acquired daily volatility based on realized power vari-
ation theory and proved that there was a lot of jump behavior in stock data,
and then I introduced an improved jump test statistic which can solve the prob-
lem caused by many zeros in return ratios in one day. This is also the main
innovation and finding of this work.

- PP-A09-16
  Formulas for Sizes of Markov Equivalence Classes
  HE, Yangbo School of Mathematecal Sci. , Peking Univ.

Abstract: The size of a Markov equivalence class is an important concept in
graphical models and causal learning. In this paper, we introduce a concept of
"core graph". Then, we show that the size is a polynomial of the number
of dominating vertices given the core graph, and deduce the polynomial vi-
sualization. The proposed methods can improve dramatically the
estimation methods in the existing counting method for the Markov equivalence class represented by
dense undirected graph.

- PP-A09-17
  Empirical Likelihood in Generalized Linear Models for Longitudinal Data with
  Dropout
  Zhang, Jinghua Beijing Univ. of Tech.
  Xue, Liugen Beijing Univ. of Tech.

Abstract: The linear assumption between the non-parametrically transformed
response and the covariates in the traditional linear transformed models may
not be satisfied in practice. With the covariates been parametrically trans-
formed, the linearity may be recovered. Here we apply the empirical likelihood
method to such a linear transformed model. We obtain the confidence region
for the regression parameters via an U-statistics. Simulations and a real data
analysis demonstrate that the proposed method substantially outperforms the
normal approximation based method.
Abstract: In this paper, the generalized linear model for longitudinal data with dropout is studied. An empirical likelihood method is proposed by combining generalized estimating equations and quadratic inference functions based on the working correlation matrix. It is proved that the proposed generalized empirical likelihood ratios are asymptotically chi-squared. This can construct the confidence regions of the parameters. An example of a real data is used for illustrating our methods.

A Test of Linearity in Partial Functional Linear Regression

Yu, Ping
Beijing Univ. of Tech.
Zhang, Zhongzhan
Beijing Univ. of Tech.
Du, Jiang
Beijing Univ. of Tech.

Abstract: This paper investigates the hypothesis test of the parametric component in partial functional linear regression. We propose a test procedure based on the residual sums of squares under the null and alternative hypotheses. This is to establish the asymptotic properties of the resulting test. A simulation study shows that the proposed test procedure has good size and power with finite sample. Finally, we present an illustration through fitting the Berkeley growth data with a partial

Stability Analysis and Reduction of A Class of Large-scale Supply Chain System by Co-semigroup Theory

Wang, Yuan
Northeastern Univ.
Tang, Lixin
Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Abstract: From the actual production in iron and steel industry, we considered the inventory problem of the stability in the supply chain. In this paper, the complex dynamic behaviors which are produced by supply chain system under the uncertain conditions were studied, including stability, bifurcation and chaos. The distributed supply chain system model is constructed and qualitative analysis will be analyzed by using group theory and convex optimization.

Controllability of Nonlinear Fractional Delay Integrodifferential Systems

Joice Nirmala, Rajagopal
Bharathiar Univ., Coimbatore

Abstract: Controllability is a qualitative property of control system. Controllability generally means, that it is possible to steer dynamical system from an arbitrary initial state to final state using the control. In this paper controllability conditions for nonlinear fractional delay integrodifferential systems have been presented with suitable fractional order. The solution representation is obtained by Laplace transform technique and further the Schauder fixed point theorem is used to obtain the controllability result.

Optimal Control Problem of Some Parabolic Hemivariational Inclusion - Galerkin Approximation

Just, Andrzej
Lodz Univ. of Tech. Centre of Mathematics & Physics

Abstract: In this paper we shall consider nonlinear and nonmonotone optimal control problem governed by parabolic hemivariational inclusion in $W$, $T = \{ y \in L^2(0, T; V); y' \in L(0, T; V) \}$ where $V$ is a real reflexive Banach space,

\[
\begin{align*}
  y'(t) + A(t)y(t) + \chi(t) &= (Bu)(t) \text{a.e. } t \in (0,T) \\
  y(0) &= y_0 \\
  \chi(x, t) &\in \partial \beta(x, t, y(x, t)) \text{a.e. } (x, t) \in Q
\end{align*}
\]

We derive some results on the existence of optimal solutions. Then we introduced Galerkin approximation. These problems arise in many important real-life models of control. Finally, we give simple example.

Non-fragile Adaptive Synchronization for Time-varying Complex Delayed Dynamical Networks

Li, Junmin
Xidian Univ.

Abstract: In this paper, a non-fragile adaptive control scheme is proposed for a complex dynamical network with time-varying delay. Under the weakened assumptions that the weight matrix of the complex network is bounded and the norm of the perturbation of internal coupled matrix is bounded and the topological structure of the network is unknown, an adaptive feedback control is designed and the robustness is analyzed. Non-fragile adaptive control schemes are constructed with unknown gain perturbations.
Optimal Inventory Problem in Steel Slab Yard of Iron and Steel Enterprises

Jia, Yanhe  
Northeastern Univ. of China, The Inst. of Industrial Engineering & Logistics Optimization

Tang, Lixin  
Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Abstract: In most of the production enterprises, commodity inventory plays a certain buffer role. Excessive inventory will make the inventory cost increase; if the inventory is too small, this will cause supply shortage. Therefore, determining the reasonable inventory is very important for enterprises. This paper uses the S curve analysis and combines with the actual historical data to determine the reasonable inventory level.

The Analysis of Inventory with Submodularity

Wu, Jing  
Northeast Univ.

Tang, Lixin  
Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Jia, Yanhe  
Northeast Univ. of China, The Inst. of Industrial Engineering & Logistics Optimization

Abstract: This paper builds model about product-inventory which includes continuous or discrete variables. There are many factors affecting the quantity of inventory, such as the demand, the price, types of productions, the continuous or discrete variables. There are many factors affecting the quantity of inventory, such as the demand, the price, types of productions. The objective function which has the submodularity is to minimize the inventory costs. Through the analysis of submodularity, it can obtain the optimal quantity.

Global Optimization for Multiperiod Blend Scheduling with Environmental Consideration

Su, Lijie  
Northeast Univ., China

Tang, Lixin  
Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Abstract: The multiperiod blend scheduling problem for refinery operations is addressed, in which environmental protection and product profit are simultaneously considered. A Mixed Integer Nonlinear Programming (MINLP) model based on continuous-time representation is formulated to describe the optimization problem. One efficient global optimization algorithm based on Outer Approximation is designed to solve the nonconvex MINLP problem. Through numerical experiments, advantages of the model are illustrated and performances of the proposed methods are compared with others.

Optimal Control of the Hot Metal Ladle in Steel Production

Cao, Xueyun  
The Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Tang, Lixin  
Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Lang, Jin  
Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Abstract: In this paper, the problem of determining the optimal policy for hot metal ladle the blast furnace(BF) – basic oxygen furnace(BOF) region in iron and steel factory is considered. The problem is formulated as a batch arrival, parallel servers closed queueing system. In addition, a dynamic programming is established, and the objective function is submodular with respect to the set of the number hot metal ladle and time.

Batching Model and Solution for Stochastic Unit Commitment with Wind Power Generation

Lang, Jin  
The Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Tang, Lixin  
Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Cao, Xueyun  
The Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.

Abstract: This paper presents a stochastic unit commitment with volatility of wind power generation. By introducing scenario trees, the problem is formulated as MINLP model. As a large-scale wind power penetration into power grid systems, we group wind turbines based on their physics locations to formulate the problem. Because the batching model is hard to solve with commercial optimizers, a Lagrangian relaxation algorithm is developed. Computational results demonstrate the validity of the batching model and algorithm.
Abstract: In this article a recurrent neural network model proposed for solving nonsmooth optimization problems. The model is designed by a differential inclusion. Under some assumptions, solution trajectory of designed differential inclusion converges to optimal set of the optimization problem. For differentiable problems, the model is implemented by circuit form. Some numerical example are solved by this model to confirm effectiveness of the new neural network.

Identification of Scene Structures Using Affine Vector Fields
Shen, Ruobing
Heidelberg Univ.

Abstract: We consider an optimization problem arising in Image Segmentation, where a finite grid of points (i,j) and a function f(i,j) are given, and the problem consists of finding a piecewise linear function f'(i,j) that approximates f, while minimizing at the same time the square error sum of \( \sum_{i,j} (f - f')^2 \) and the number of different affine functions. We investigate different variants of this problem, propose and compare alternative Mixed Integer Programming (MIP) formulations, and report computational results.

Symmetries and Curvature Structure in Riemannian Geometry
Motions and collineations of a tensor are the vectors along which the tensor remains invariant under the Lie transport relative to that vector. Symmetries of tensors used in Riemannian geometry, and their applications.

Optimization, Bernstein Basis
Better Certificate of Positivity in Bernstein Basis
Mamouni, My Ismail
CRMERF Rabat, Morocco

Abstract: The topological study of Robots motion planning algorithms emerged in the 2003-2004 with the works of M. Farber. His main tool was the concept of Topological Complexity denoted \( TC \). Our aim in this talk is to introduce a similar one, the so-called Loop Topological Complexity denoted \( TC^L \). We prove that \( TC = TC^L \) and that it leads to a loop motion product which can be extended to a string product similar than that of Chas-Sullivan type.

Numerically Certifying the Completeness of Real Solution Sets
Liddell, Alan
Univ. of Notre Dame

Abstract: The computation of real solutions to a system of polynomial equations presents unique challenges. Since real solutions are often the solutions sought after in applications, one may wish to know if one has computed the complete set of solutions for a given system. In this work, we develop an algorithm certifying that a given set of solutions, including real isolated and positive-dimensional solution components, constitutes a complete real solution set.

Loop Motion Planning Algorithms
Mamouni, My Ismail
CRMERF Rabat, Morocco

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Abstract: We present a realistic direct computational approach to recover the CGO solutions and conductivity from partial Neumann-to-Dirichlet data for electrical impedance tomography. The basic idea is to derive an integral equation involving the ND-map for full boundary data. Instead of solving the integral equations we apply Born approximation for stable and fast computations. Extensions of partial data are computed based on smooth diffusive interpolation of the measurement traces. Computational results from simulated data are presented.

PP-A15-10 Proximal Iterative Hard Thresholding Methods for Wavelet Frame Based Image Restoration
Zhang, Xue
Hou, Likun
Zhang, Xiaoxun
Shanghai Jiao Tong Univ.
Shanghai Jiao Tong Univ.
Shanghai Jiao Tong Univ.

Abstract: Iterative hard thresholding methods are less understood due to its non-convexity and discontinuity. We consider the l0 regularized wavelet frame balanced approach for image restoration. Then we study the convergence rate of proximal iterative hard thresholding algorithm and propose an extrapolated proximal iterative hard thresholding algorithm. Finally, we conduct numerical experiments on compressive sensing, CT reconstruction, image reconstruction, to demonstrate the improvement of l0 regularization models as well as the effectiveness of proposed algorithm.

PP-A14-11 Dynamic SPECT Reconstruction from Few Projections: A Sparsity Enforced Matrix Factorization Approach
Ding, Qiaoqiao
Zhang, Xiaoxun
Shanghai Jiao Tong Univ.
Shanghai Jiao Tong Univ.

Abstract: The reconstruction of dynamic images from few projection data is a challenging problem, especially when noise is present and images are vary fast. We propose a variational model, sparsity enforced matrix factorization (SEMF), based on low-rank matrix factorization of images and enforced sparsity constraints both coefficients and bases. The convergence of proposed model relies upon the Kurdyka - Lojasiewicz property. We show the advantage of proposed model compared to conventional methods. (Joint work with Yunlong Zan and Qiu Huang).

PP-A14-12 Effects of Hall Current on Unsteady MHD Convective Couette Flow of Heat Absorbing Fluid Due to Accelerated Movement of One of the Plates of the Channel in A Porous Medium
Sharma, Rohit
Indian School of Mines Dhanbad

Abstract: An investigation of unsteady MHD convective Couette flow of a viscous, incompressible, electrically conducting and temperature dependent heat generating/absorbing fluid within a rotating vertical channel embedded in a fluid saturated porous medium taking Hall current into account is carried out. Asymptotic behavior of the solution for fluid temperature and fluid velocity are analyzed for small and large values of time to gain some physical insight into to the flow pattern.

PP-A14-13 An Optimal Dispersion for A Dispersive Waves with Non-hydrostatic Model
Magdalena, Ilika
Institut Teknologi Bandung

Abstract: In fluid dynamics, dispersion means that waves of different wavelengths travel with different wave speeds. In this research, we propose a numerical two-layer non-hydrostatic model. Based on it, we derive the numerical dispersion relation which is tuned to approximate well the exact linear dispersion relation. We will compare our result with other approaches by

PP-A14-9 Applications of Matern Functions in Landmark-based Image Registration
Qiao, Hanli
Univ. of Turin

Abstract: Matern functions are quite common in statistics literatures and they have recently received a great deal of attention. In our work, we apply Matern functions to landmark-based image registration and the numerical results show us they have good properties. However, Matern functions have global support, a single landmark pair change the whole registration result. Therefore, we construct novel compactly support functions based on Matern ones and we analyze their properties in image.
using different type model, Nwogu[1993] and Y Bai and K.F.Cheung[2012]. Moreover our result have acheived linear dispersive accuracy up to kd=10.

- PP-A15-3
  Pressure Drop Evaluation During Filling Process of Blind Backfilling Technique
  Panda, Susmita
  Pal, Samir
  Murthy, P V S N
  IIT Kharagpur

Abstract: Blind Backfilling in mine voids is used to avoid the effects of surface subsidence of abandoned mine. Very little amount of theoretical work has been done on blind backfilling in mining industry by others researchers worldwide. Therefore the present work aims in development of mathematical models in the area of simple gravity blind backfilling. Theoretical pressure drop has been evaluated of blind backfilling technique assuming different layer formation during filling process.

- PP-A15-4
  Similarity Solution for the Flow Behind An Exponential Shock in A Rotational Axisymmetric Perfect Gas in the Presence of Magnetic Field
  Sahu, P. K.
  Motilal Nehru National Inst. of Tech. Allahabad
  Nath, G.
  Motilal Nehru National Inst. of Tech. Allahabad

Abstract: We study the propagation of an exponential shock wave in rotating medium under the influence of magnetic field by taking into account the components of vorticity vector. The gas is assumed to be perfect with infinite electrical conductivity. Solutions are obtained under isothermal and adiabatic flow conditions. It is shown that the magnetic field have decaying effects on the shock wave. A comparison is also made between the solutions of isothermal and adiabatic flows.

- PP-A15-5
  Effect of Variable Permeability on Free Convection Boundary Layer over A Vertical Cone in Non-Newtonian Fluid Saturated Porous Medium with Internal Heat Generation
  Bagai, Shobha
  Cluster Innovation Centre, Univ. of Delhi
  Nishad, Chandrashekar
  Department of Mathematics, Univ. of Delhi

Abstract: The analysis is carried out for free convection boundary layer over a vertical cone imbedded in a porous media filled with non-Newtonian fluid incorporating the variation in permeability. An exponentially decaying model is assumed for permeability whereas the well-known power law model is assumed for the non-Newtonian fluid. Similarity solutions are obtained, for two cases - variable wall temperature and variable heat flux). Similarity equations obtained are solved numerically.

- PP-A15-6
  Bi-Critical States in Temperature Modulated Rayleigh Benard Convection
  Singh, Jitender
  Guru Nanak Dev Univ., Amritsar

Abstract: We investigate the Rayleigh-Bénard convection under sinusoidally varying temperatures of the horizontal rigid-planes bounding a laterally infinite fluid-layer for the bircritical states. The problem is analogous to the well studied Faraday-instability and Rayleigh-Bénard convection under gravity modulation. Under modulation, the neutral instability-curve is found to alternate between the conventional harmonic and subharmonic tongues in the space of the dimensionless wave number of disturbance and the control parameter. The transition between harmonic and subharmonic critical instability

- PP-A15-7
  On the Development of A Nonprimitive Navier-Stokes Formulation Subject to A Rigorous Implementation of Integral Vorticity Boundary Conditions
  Sen, Shuvam
  Tezpur Univ.
  Sheu, Tony
  National Taiwan Univ.

Abstract: A new integral vorticity boundary condition has been developed and implemented to compute solution of Navier-Stokes equation. This procedure is a limiting case of physically correct global integral boundary condition and keeps all merits of the original equation. Here we design and realize a method which is easy to implement and explicit. This algorithm captures accurate vorticity distribution on the boundary of computational flow field and can be used for both wall-bounded and open flows.

- PP-A15-8
  Solvability of One Thermo-viscoelastic Model of Non-Newtonian Hydrodynamics
  Zviagin, Andrei
  Voronezh State Univ.

Abstract: The solvability of initial-boundary value problem for mathematical Voigt model which describes the motion of weakly concentrated aqueous polymers solutions in respect of temperature changes will be considered. The existence of solutions is established by a suitable approximation method applied to regularized system in a suitable functional space, proof of solvability of which is based on appropriately chosen approximations, global a priori estimates, application of a fixed point theorem, and pass to the limit.

- PP-A15-9
  A MODEL FOR DISCRETE HEATER DRIVEN CONVECTION WITH SURFACE RADIATION
  Shanmugam, Saravanan
  Bharathiar Univ.

Abstract: We investigate the changes experienced by a convective flow in a closed square enclosure when surface radiation is taken into account. The flow is driven by a centrally placed discrete heater in an air filled two dimensional enclosure. Symmetrically cooled isothermal vertical walls and insulated horizontal walls are considered. The governing coupled differential equations were solved using a finite volume method. The resulting augmentation of fluid velocities and the factors causing them are discussed.

- PP-A15-10
  Uncertainty Propagation in Airway Liquid
  Xu, Feng
  The Univ. of Manchester

Abstract: Mucus in the lung acts as a barrier that protects the lung from disease and irritations. To quantify the uncertainties arising from imprecise knowledge of mucus rheology, we simulate the flow of a thin liquid film with spatially non-uniform viscosity and track the evolution under flow of a solute that has an initial stochastic spatial distribution, assuming that the solute field determines the local viscosity. We initially examine a drop-spreadning flow.

- PP-A15-11
  Heat Transfer of Weakly Compressible Power-law Flows
  Li, Botong
  Beijing Univ. of Tech.

Abstract: A numerical research on steady momentum and heat transfer in power-law non-Newtonian fluids in a channel is finished. Weakly compressible, laminar fluids are to be studied with no slip at the walls and a uniform wall temperature. The full governing equations are solved by using the continuous finite element method. Three thermal conductivity models are adopted in this paper. The results are compared with each other and the physical characteristics for values of parameters are discussed.

- PP-A15-12
  Thin Films on Spheres: Statics, Dynamics and Instability
  Kang, Di
  Claremont Graduate Univ.

Abstract: We model the dynamics of a thin viscous film on a rotating sphere, under the influence of gravity and surface tension, using lubrication theory with no-slip at the solid surface and kinematic and stress conditions at liquid-air interface. We identify three types of energy-minimizing steady states: one having a uniformly positive thickness, or states with one or two dry zones. A stability analysis including Marangoni effects provides the parameter thresholds and modes of instability.

- PP-A15-13
  Analytical Study for Slow Flow Past An Encapsulated Particle
  Zhao, Longhua
  Case Western Reserve Univ.

Abstract: This work presents an analytic study about a highly viscous, incompressible flow past an encapsulated spherical particle in the Stokes regime. Taking advantage of the symmetry properties, we derive the explicit formulæ of stream functions by considering the no-slip boundary condition for the rigid core and the no interfacial mass transfer and force equilibrium conditions at the fluid interface. Moreover, we investigate the flow properties, drag experienced by the particle and its terminal velocity.

- PP-A15-14
  Mathematical and Experimental Investigation of Ultrasonic Wave in Fluid System
  Ahobilam, Gayathri
  scsuvn Univ., dept. of mathematics
  Thothatri, Venugopal
  scsuvn Univ.

Abstract: The calculation of the speed of ultrasound in the given medium is the fundamental requirement for investigating the transport properties of liquid and solid systems. The speed of ultrasound in the sample can be computed through various mathematical techniques like Jungie equation method, Rao’s specific sound velocity method, Impedance relation and Nomoto’s method. The theoretical values are compared with experimental values. Various elastic properties of Vibhuti, an ash like powder is studied and analysed.

- PP-A15-15
  High-order Accurate Physical-constraints-preserving Finite Difference WENO Schemes for Special Relativistic Hydrodynamics
  Wu, Kailiang
  Peking Univ.
Consequences of QCD Ghost F(T) Gravity

Abstract: This work develops high-order physical-constraints-preserving scheme for special relativistic hydrodynamical equations by extending the positivity-preserving techniques for classic Euler equations. The features due to strong nonlinearity, e.g. no explicit expressions of the conservative vector for the primitive variables and the flux vectors, make related theoretical analysis of the admissible state set and the construction of physical-constraints-preserving limiter challenging. The accuracy, robustness and effectiveness of the proposed scheme are demonstrated by several ultra-relativistic numerical experiments.

Posters

PP-A16-15
Pseudo-spectral Simulations of Two-dimensional Free Decaying Flows on Infinite Domain
Yin, Zhaohua Inst. of Mechanics, Chinese Acad. of Sci.

Abstract: The fluid motion on unbounded domain is a popular and difficult problem in fluid mechanics. Its main difficulty is the treatment of boundary effect which cannot be fully removed by any existing numerical schemes since finite computing grids can never cover an infinite domain. The adoption of the Hermite function can partly resolve the above dilemma. In this paper, the two-dimensional unbounded free decaying flow, which eventually leads to the Oseen vortex, is studied by two different strategies: 1) the new Hermite spectral scheme on the infinite domains; 2) the traditional Fourier spectral scheme on finite but very large extended domain. When there are only same-signed vortices at the beginning of simulations, both methods can give the correct results. On the other hand, when both positive and negative vortices co-exist initially, the Hermite method can still solve the problem efficiently until very late stage, but the Fourier method cannot generate correct results even with an extremely large computing domain and a one-hundred-larger resolution. It is concluded that the Hermite spectral solver has obvious advantages in such simulations on the infinite domains, and some efforts to parallel the code will also be discussed.

PP-A15-17
Mixed Finite Element Method for A Pressure Poisson Equations Reformulation of the Incompressible Navier-Stokes Equations
Zhou, Dong Temple Univ.
Seibold, Benjamin Temple Univ.
Shirokoff, David New Jersey Inst. of Tech.
Chidyagwai, Prince Loyola Univ. Maryland

Abstract: Pressure Poisson equation (PPE) reformulations of the incompressible Navier-Stokes equations represent a class of methods that replace the incompressibility constraint by a Poisson equation for the pressure, with a suitable choice of the boundary condition so that the incompressibility is maintained. We present a mixed finite element method of the Shirokoff-Rosales PPE reformulation with electric boundary conditions, and demonstrate that this approach allows for arbitrary order of accuracy both in space and in time.

PP-A15-18
EFFECTS OF CURVATURE OF STENOSIS AND DAUGHTER TUBE ON FLOW PROFILE AND HEMODYNAMIC INDICATORS IN A BIFURCATING ARTERY HAVING MULTIPLE STENOSIS
SHARMA, MUKESH KUMAR Guru Jambheshwar Univ. of Sci. & Tech., Hisar

Abstract: The bifurcation is composed of the daughter vessels, the parent tube and the flow divider. The calibrating parameters to define flow divider so that the incompressibility is maintained. We present a mixed finite element method of the Shirokoff-Rosales PPE reformulation with electric boundary conditions, and demonstrate that this approach allows for arbitrary order of accuracy both in space and in time.

PP-A15-19
Numerical Solutions of Unsteady Mixed Convection Flow at A Three-dimensional Stagnation Point
Nazar, Roslinha Universiti Kebangsaan Malaysia

Abstract: This paper presents a numerical analysis of an unsteady mixed convection flow at a three-dimensional stagnation point. The governing nonlinear partial differential equations are transformed into a system of ordinary differential equations by a similarity transformation, which are then solved numerically by a Runge-Kutta Fehlberg method with shooting technique. The dual solutions obtained and the effects of the governing parameters on the fluid flow and heat transfer characteristics are analyzed and discussed.

PP-A16-1
Consequences of QCD Ghost F(T) Gravity

Abstract: The present paper reports a reconstruction scheme for (T) gravity based on QCD ghost-dark energy. Two models of f(T) have been generated and the pressure and density contributions due to torsion have been reconstructed. Two realistic models have been obtained and the effective equations of state have been studied. Also, the squared speed of sound has been studied to examine the stability of the models.

PP-A16-2
MATHEMATICAL STUDY OF THE FREE ENERGY OF MIXING FOR THE LEAD-BASED BINARY LIQUID ALLOYS OF ALKALI METALS
Chakrabarti, Swapankumar Tribhuvan Univ.

Abstract: Binary liquid alloys, especially the complex-forming ones, often show anomalous thermodynamic behaviour. There is no unique theory which can explain the thermodynamic properties of mixing for all the alloys. Here we have considered three lead-based alloys of different alkali metals—lithium-lead, sodium-lead and potassium-lead—and used Flory’s model. Accordingly, the method of successive approximations has been applied. Our results explain the variation of the free energy of mixing with concentration for the present molten alloys.

PP-A16-3
IMPACT OF EIGENVALUES ON THE SUPERCONDUCTING STATE PARAMETER FOR MAGNESIUM AND ITS BINARY ALLOYS
Yadav, Rajnaraayan mahendra morang adarsh multiple campus TU

Abstract: Here we have dealt with the impact of eigenvalues on the electron-phonon coupling strength of magnesium and its two binary alloys—magnesium-aluminium and magnesium-indium. For this purpose the form factors for all of them have been computed considering, initially, the orthogonised planar wave parameter as unity. Then the Vashishta-Singwi form of exchange and correlation is employed. Finally, the results have been compared with the theoretical values derived by other researchers and found to be more satisfactory.

PP-A16-4
Linear Response Theory of Time-dependent Time Fractional Fokker-Planck Equation Systems
Kang, Yanmei Xi’an Jiaotong Univ.

Abstract: There are two types of time-dependent time fractional Fokker-Planck equations for modeling subdiffusion modulated by a time-varying external field. Our work proves that the dissipation-fluctuation theorem holds in both cases, but the long time linear response dies out in the one case. Moreover, with the dissipation-fluctuation relation as a bridge, we access the fluctuation spectral density for the time-independent time fractional Fokker-Planck equation systems based on method of weighted series expansion.

PP-A17-1
Data Assimilation Unit for the General Curvilinear Environmental Model
Garcia, Mariangel San Diego state Univ.
Castillo, Jose San Diego State Univ.

Abstract: Existing numerical models of water systems are based on assumptions and simplifications that can result in predictive errors. Data Assimilation can significantly improve the success rate of predictions and operational forecasts; however, implementation is difficult, as physical ocean models are highly nonlinear and require dense spatial discretization to correctly reproduce the dynamics. Our General Curvilinear Environmental Model incorporates measured observation into the dynamical system, and so accurately forecast estimates of variable states in less time.

PP-A17-2
Sensitivity to Cumulus Convection in Simulating Indian Summer Monsoon Using RegCM4
Maiti, Suman Indian Inst. of Tech. Kharagpur
Mandal, Manobattam Indian Inst. of Tech. Kharagpur

Abstract: Indian summer monsoon (ISM) is originated and accelerated by large scale convection and hence its simulation is expected to depend on appropriate representation of cumulus convection in climate models. Numerical experiments are conducted in simulating ISM for three consecutive years 2007, 2008 and 2009. RegCM4 at 30 km resolution and 23 vertical levels is integrated for the period 1st May to 30th September in these three years using five convection schemes available in RegCM4.

PP-A17-3
Consistent Approximation of the Water Velocity Including the Wet-Dry Front
Chen, Guoxian Wuhuan Univ.

Abstract: In finite volume schemes, the flow velocity is computed as $m/h$. 

Chattopadhyay, Surajit Palai College of Management & Tech., Kolkata

Abstract: The present paper reports a reconstruction scheme for (T) gravity based on QCD ghost-dark energy. Two models of f(T) have been generated and the pressure and density contributions due to torsion have been reconstructed. Two realistic models have been obtained and the effective equations of state have been studied. Also, the squared speed of sound has been studied to examine the stability of the models.
This becomes singular at the wet-dry front, and may lead to oscillations. Sophisticated cut-off functions may suppress the oscillations, but may lose consistency with the physics. We study this problem for HLL-type schemes using continuous bottom topography. We prove that the water height is positive and the velocity possesses a natural physical upper bound, which is only increased due to gravitational acceleration.
Interdisciplinary Teaching: the Mathematical Component of Ecology of Homelessness are investigated. Then, two cooperative strategies and their possible strategies is described. Also, the decisions of the supply chain with noncooperative analysis of Schloegl (regression analysis) and epidemiology.

Lattice Differential Equation analysis of Schloegl and Voronoi tessellation, data for volunteer program used math/stat tools and created solutions for local services facilities, such as food and service maps. We can improve the design system constantly by knowing the condition of all key elements. A Bayesian inference procedure is developed to estimate the parameters of the joint model. The proposed model and method are applied to a real AIDS clinical study and various comparisons of a few models are performed.

A Computational Framework for the Simulation of Atherosclerotic Plaques

A Computational Framework for the Simulation of Atherosclerotic Plaques

Modelling of TESLA Cavities’ Eccentricity with Isogeometric Analysis

RESEARCH ON KEY TECHNOLOGY OF UNIVERSAL SIMULATION PLATFORM: MOLTEN IRON IN THE RAILWAY SCHEDULING SYSTEM

Poster Abstract: We consider the portfolio problem in the Mean-Risk framework and propose a risk measure calculated only with the downside part of the portfolio return distribution. We establish the properties of the proposed risk measure, study the link with stochastic dominance criteria, point out the relations with Conditional Value at Risk and Lower Partial Moment of first order, and give the explicit formula for the case of scenario-based portfolio optimization.

Different Solution of Option Pricing: Black-Scholes Model

Diffusion process to create a smaller set of independent parameters in the stochastic model. A Bayesian inference procedure is developed to estimate the parameters in the joint model. The proposed model and method are applied to a real AIDS clinical study and various comparisons of a few models are performed.

Two-sex Mosquito Model for the Persistence of Wolbachia

Evaluation of Salinity by Using Wavelet Modelling

Cooperative Strategies for Sustainability in A Decentralized Supply Chain with Competing Suppliers

Interdisciplinary Teaching: the Mathematical Component of Homelessness

Lattice Differential Equation analysis of Schloegl’s second model for particle creation and annihilation

Bayesian Inference on Mixed-effects Varying-coefficient Joint Models with skew-t Distribution for Longitudinal Data with Multiple Features

Competing Suppliers

Abstract of the paper is to offer a rather different method in handling the task at hand. We analyze the scheme for its stability with its applications to FX option pricing PDEs in the Heston framework.

Stability of ADI Schemes with Applications in FX Options Pricing

Different Solution of Option Pricing: Black-Scholes Model

Abstract: In this study, firstly, the mechanism on the selection of cooperative strategies is described. Also, the decisions of the supply chain with noncooperation are investigated. Then, two cooperative strategies and their possible combinations are proposed, and the decisions of the supply chain are analyzed. Lump sum transfer contracts are designed for supply chain coordination. The results suggest that cooperative strategies are critically important in terms of enhancing sustainability.

Competitive Strategies for Sustainability in A Decentralized Supply Chain with Competing Suppliers

Abstract: In this study, firstly, the mechanism on the selection of cooperative strategies is described. Also, the decisions of the supply chain with non-cooperation are investigated. Then, two cooperative strategies and their possible combinations are proposed, and the decisions of the supply chain are analyzed. Lump sum transfer contracts are designed for supply chain coordination. The results suggest that cooperative strategies are critically important in terms of enhancing sustainability.
An Improved Strategy for Solving Sudoku by Sparse Optimization Methods
Yuchao Tang  Nanchang Univ.

Abstract: We proposed several strategies to improve the sparse optimization methods for solving Sudoku puzzles. Further, we define a new difficult level for Sudoku. We tested our proposed methods on Sudoku puzzles dataset. Numerical results showed that we can improve the accurate recovery rate from 84.89 percent to 99.02 percent by the L1 sparse optimization method.

Model Reduction of Kinetic Equations by Operator Projection
Fan, Yuwei  School of Mathematical Sci., Peking Univ.
Li, Jun  Peking Univ.
Ruo, Li  Peking Univ.

Abstract: Designing optimal hyperbolic regularized method for moment system of kinetic equations is a challenging problem, which has been studied in different reduction models for many years. Developing from NRhx method, we present a uniform framework to derive globally hyperbolic models using an operator projection method. Like simple algorithm, the framework is concise with only four inputs and almost cover all existing globally hyperbolic models, while can also derived some new ones as well.

Mathematical Models for Environmental Decision-making under Uncertainty
Zhang, Xiaodong  Los Alamos National Laboratory
Velimir, Vesselinov  Los Alamos National Laboratory

Abstract: Environmental decision-making processes are very complicated, involving numerous economic, environmental, societal, technical, and political factors, parameters, and objectives coupled with complex uncertainties such as probabilistic and non-probabilistic (i.e. fuzzy and/or interval) ones. This necessitates effective methods and techniques. Mathematical models are valuable tools for addressing and quantifying the uncertainties. This study will investigate mathematical models and their applications in environmental decision-making with a representative case study.

Approximate Second Order Maximum Entropy Model in Radiative Transfer
Li, Weiming  Peking Univ.
Ruo, Li  Peking Univ.

Abstract: The maximum entropy closure is widely regarded as the most reasonable candidate for modelling radiative transfer, but its implementation suffers huge numerical difficulties. We discovered an approximation of M2 in slab geometry. Its closure is given analytically to ensure an easy implementation, while to one’s surprise, it closely resembles that of M2. Moreover, it shares the major advantages of maximal entropy closure, providing us a positive distribution and a globally hyperbolic model.

Simulations of Hydrogen-added Gasoline Engine Combustion
Lin, Kuang C.  Department of Mechanical & Electro-Mechanical Engineering, National Sun Yat-Sen Univ.
Chen, Kang-Shin  Inst. of Environmental Engineering, National Sun Yat-Sen Univ.
Lin, Yuan-Chung  Inst. of Environmental Engineering, National Sun Yat-Sen Univ.
Zhou-Hung, Cun-Yan  Department of Mechanical & Electro-Mechanical Engineering, National Sun Yat-Sen Univ.
Jiang, Syu-Ruei  Inst. of Environmental Engineering, National Sun Yat-Sen Univ.

Abstract: Using addition of hydrogen in gasoline fuels, this study aims at re-volving and curl. Optimal control approach to medical image registration based on the di-vergence and curl.

New Developments in Mesh Generation with Applications to Image Registration
Liao, Guojun  Univ. of Texas at Arlington

Abstract: Despite remarkable progress achieved in past decades, mesh generation and adaptation remain significant bottlenecks of large scale simulations on complex geometries. In this poster, we illustrate our group’s recent developments in this area: (1) Triangular meshes with prescribed boundary nodes (2) Higher order triangular meshes (3) Multi-block structured grids (4) Mesh deformations with prescribed Jacobian determinant and prescribe curl (5) Optimal control approach to medical image registration based on the divergence and curl.

Numerical Simulation of Nematic Liquid Crystals under An Electric Field
Ridder, Johanna  Univ. of Oslo

Abstract: We use finite difference methods to investigate the dynamics of the director field of a one-dimensional nematic cell without flow. Simulations of the Frédérickz transition that include the rotational inertia of the director show that inertia can become significant under strong electric fields. For the dissipa- tion dominated model, we include weak anchoring boundary conditions to simulate the transition to excited equilibrium states of odd parity, which have been observed in experiments.

Computing Band Structures of Two-dimensional Honeycomb Photonic Crystals by Dirichlet-to-Neumann Maps
Hu, Zhen  Hohai Univ.

Abstract: An efficient numerical method is developed for computing the band structures of two-dimensional photonic crystals which are honeycomb lattices of circular cylinders. Using the Dirichlet-to-Neumann (DtN) map of the unit cell which consists of three hexagons, the problem can be formulated as a linear eigenvalue problem for relatively small matrices, where the eigenvalue is a function of the Bloch wave vector and the frequency is a given parameter.

Detecting the Growth of Groups Based on Social Network
Guo, Yuanpan  Hangzhou Normal Univ.
You, Zhigiang  hangzhou normal univ.
Han, Xiao-Pu  Hangzhou Normal Univ.

Abstract: Focusing on the group structures of social networks and utilizing the dataset of QQ friendship network, we propose a model considering that users in the network join a group with a probability exponentially proportional to the influence of their friends within their own interest to detect the mecha-nism how groups grow based on social network; the statistical characteristics of hypergraph generated from our model are consistent with the empirical results.

Positivity Preserving High-order Local Discontinuous Galerkin Method for Parabolic Equations with Blow-up Solutions
Guo, Li  Univ. of Sci. & Tech. of China

Abstract: We apply positivity-preserving high order local discontinuous Galerkin methods to solve parabolic equations with blow-up solutions. This model is commonly used in combustion problems. The positivity-preserving property can hardly be satisfied for high-order methods, leading to incorrect blow-up time and blow-up sets. Therefore, we construct special limiters to keep the positivity of the numerical approximations. Due to the Dirichlet boundary conditions, we have to modify the numerical fluxes and the limiters used in the schemes.

Using Polar Axis Transport Model and Cell Lineage Model to Explain Feedback Regulation of Organs on Shoot Apical Meristem
Guo, Xiaolu  Peking Univ.
Lei, Jinzhi  Tsinghua Univ.
Zhang, Lei  Peking Univ.

Abstract: The population of shoot apical stem cells are negatively feedback regulated by lateral organs through the auxin regulation. We modified the flux-based polar axis transport model by changing the auxin production rate term to a Hill equation term, which captures the bi-stable state of distribution of auxin. Then cell lineage model is used to simulate the stem cell population variation. The simulation results are according to the experimental results and well explain the negative regulation.

Computation and Visualization of Local Deformation for Multiphase Metallic Materials by Infrmal Convolution of TV-type Functionals
Fitschen, Jan Henrik  Univ. of Kaiserslautern

Abstract: Estimating the local strain tensor from a sequence of microstruc-tural images, realized during a tensile test, is a challenging problem. Here we propose to compute the strain tensor by a variational optical flow model. To separate the global displacement during in situ tensile testing from the local displacement we use an infimal convolution regularization of first and second order terms. Numerical examples with simulated and experimen-tal data demonstrate the advantageous performance of our algorithm.

Violent Elastoplastic Wave Interactions
Abstract: At very high stress metals can be modelled as barotropic compressible fluids in which the strength, measured by the ratio of the yield stress to the imposed stress, is negligible. This work considers the elastic/plastic waves that can propagate in violent uniaxial compression of a finite bar and shows 1) how shock waves are formed which may be either overdriven or underdriven and 2) the effect of stress on waves reflected from the stress-free end.

> PP-A24-3
Efficient Methods for Homogenization of Random Heterogeneous Materials
Nie, Yufeng Northwestern Polytechnical Univ.
Abstract: Homogenization has been widely used for predicting effective coefficients of random heterogeneous materials. Under common Dirichlet boundary condition and Neumann boundary condition, Richardson extrapolation method is introduced to improve the convergence rate of effective coefficients. For random heterogeneous materials with a high contrast of constituent properties, above two boundary conditions cannot provide accurate effective coefficients. A new Robin boundary condition is proposed for the auxiliary problem.

> PP-A24-4
Reflection/refraction of a Dilatational Wave at Elastic/porous Interface
Goyal, Suraj DAV Univ. Jalandhar
Abstract: Reflection and refraction phenomena of a plane dilatational wave striking obliquely at a plane interface between a uniform elastic half-space and a swelling porous elastic half-space has been studied. The swelling porous half-space consists of solid, liquid (viscous) and gas (inviscid) constituents. The equations giving the amplitude ratios and the expressions for the partition of incident energy among various reflected/refracted waves have been presented. Numerical computations have been performed for a specific model.

> PP-A24-5
Directional Decomposition of the Acoustic Wave Equation for Fluids And receiver Interactions in Spherical Geometries
Olsson, Peter Chalmers Univ. of Tech.
Abstract: A new directional decomposition of the acoustic 3D wave equation is derived for spherically symmetric geometries, where the wave fields do not need to possess such a symmetry. The wave equation considered incorporates effects from radially varying compressibility and density, but also from an anisotropic compressibility, making the equation applicable for certain so-called metalfluids. Contrary to previous results on such wave splittings, the new decomposition can be given a very explicit form.

> PP-A24-6
Three Dimensional Coupling Model with Potential Function Vanishing Ghost Forces
Fang, Lidong Shanghai Jiao Tong Univ.
Abstract: In three dimensional atomistic to continuum coupling model, we construct potential functions for atomic region, continuum region and interface elements, so that the ghost forces vanish in the uniform deformation. The potential functions are the same in the formula, but they are different from the parameters.

> PP-A24-7
Simulation and Analysis of 2D Granular System
WANG, HAOLEI Shanghai Jiao Tong Univ.
Abstract: The study of physical and mechanical properties of granular materials is of great importance. We use a discrete element method (DEM) to simulate a 2D bi-disperse granular systems under pure shear. We study the formation and evolution of force chain in this simulation. Moreover, a continuum model can be constructed by random homogenization methods. Both discrete model and continuum model can be compared with experimental data.

> PP-A25-1
Quantifying Changes Exhibited During Ecological Rehabilitation with Wearable Inertial Sensors
Sprint, Gina Washington State Univ.
Abstract: This paper derives the coil scheduling problem with consideration of energy consumption from production in continuous annealing line. The problem is characterized by uncertain energy and technical parameters. Firstly, it is formulated as an optimization via simulation model, in which the uncertain parts are considered as black box. Then, it is solved by sample approximation algorithm combined with column generation. Finally, computational experiments are carried out to verify the performance of the proposed method.

> PP-A25-2
Derivative Free Optimization and Its Application in the Basic Oxygen Furnace
Liu, Yongxia Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.
Tang, Linxin Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.
Cheng, Cong Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.
Abstract: This paper is to solve the operation optimization problem refined from the basic oxygen furnace process based on the derivative-free optimization. In the process, data have been collected adequate. Then the relationship function between the input variables and output variable can be found based on these historical data. The objective of this paper is to find the value of the input variables to minimize the least-square of the relationship function and expected temperature value.

> PP-A25-3
Coil Scheduling Problem with Consideration of Energy Consumption in Iron & Steel Industry
Yang, Yang Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.
Tang, Linxin Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.
Wang, Gongshu Inst. of Industrial Engineering & Logistics Optimization, Northeastern Univ.
Abstract: This work considers the coil scheduling problem with consideration of energy consumption from production in continuous annealing line. The problem is characterized by uncertain energy and technical parameters. Firstly, it is formulated as an optimization via simulation model, in which the uncertain parts are considered as black box. Then, it is solved by sample approximation algorithm combined with column generation. Finally, computational experiments are carried out to verify the performance of the proposed method.
Abstract: The behaviors of convective enhancement due to types of nano-fluid and location of the discrete heat sources on an unsteadily stretching plate embedded in a porous medium are investigated. The governing equations are solved numerically and effects of various physical parameters on flow are shown through graphs. The Skin-friction, Nusselt number and Sherwood number are computed for analyzing stress on the plat, heat convection and mass diffusion in the medium.

Abstract: The simplified mechanical model of a basic problem of electroacoustics is considered. The corresponding governing equation is the 1D wave equation with delayed boundary conditions. By means of the D’ Alembert solution, the system can be transformed into a delay differential equation of neutral type that includes two time delays. The intricate stability chart is constructed to achieve the PLS with time-varying delay coupling. Finally analytical results show that the states of the dynamic network with delayed coupling can be asymptotically synchronized onto a desired scaling factor under the designed controller.

Abstract: We mainly focus our attention on the global dynamical behaviour of some ubiquitous nonlinear oscillators with nonlinear dissipation. We particularly consider the parametrically driven Duffing oscillator and externally driven Helmholtz Duffing oscillators with nonlinear damping term proportional to the power of velocity. We obtain the threshold condition for the occurrence of chaos analytically and also analyze the 2D parameter space consists of external forcing amplitude and damping coefficient corresponding to various asymptotic dynamics.

Abstract: We develop a model for the dynamics of transmission of Hepatitis B virus. Our model takes into account age specific & differential susceptibility as well as two classes of infected individuals: the chronic carriers and the acute infected human. Based on the low infectivity of chronic carriers, we study the asymptotic behavior of the system and, under some suitable assumptions, we prove the global stability of the endemic equilibrium point using perturbation arguments. An application is done on data for a & #171;Baka & #187; pygm group in the East of Cameroon. We see numerically the fact that ignoring the vertical transmission and vaccination doesn’t lead to a good approximation of reality in a region with endemic HBV.

Abstract: We investigate the dynamics of traveling spots with oscillatory tails for the generalized three-component FitzHugh-Nagumo equations. The main aim is to show numerically that such solution display a wave-particle duality, quantum-like behavior. Moreover by center manifold reduction theory, the dynamics of single spot dynamics can be reduced to a 4D system of ODEs. This is a joint work with Yasumasu Nishiura. The research is supported by KAKENHI A 26247015.

Abstract: We examine a dynamical systems model of predator-prey interactions, governed by isometric interaction kernels incorporating classical swarming for the prey. Since many parameter values lead to the predator splitting the swarm into smaller, unevenly-sized groups, we investigate the effects of heterogeneity among predator-prey interactions in small swarms. We show that a variety of behaviors, including oscillations, are possible in the small swarm case. Joint work with Bard Ermentrout.

Abstract: A non-autonomous food-chain system incorporating discrete time delay and stage-structure for each species has been presented in this paper. The sufficient conditions are derived for permanence and non-permanence of the considered system by applying the lemma and standard comparison theorem.

Abstract: We study the dynamics of a network-based SIS epidemic model with nonmonotone incidence rate. A threshold value for the transmission rate is obtained. This value completely determines the dynamics of the model and interestingly, the threshold is not dependent on the functional form of the nonlinear incidence rate. Numerical experiments are given to illustrate the theoretical results.

Abstract: The sufficient conditions are derived for permanence and non-permanence of infected individuals: the chronic carriers and the acute infected human. The framework established in this investigation can accommodate a wide range of coupled systems, such as chaotic oscillators, neuronal models, and neural networks.
the expected infection period can be formulated by an exponentially distributed variable. We formulate the mean infection period when the treatment rates are density-dependent. The results are applied to the transmission of gonorrhea in China. We conclude that Chinese gonorrhea patients may not seek medical treatments in a timely manner.

**PP-A26-14**

**Analysis of A Standard Incidence Model for HIV/AIDS with Case Detection and Treatment**

Singaram, Athithan  
VIT Univ., Chennai Campus

Ghosh, Mini  
VIT Univ., Chennai Campus, Chennai-600127, India

Abstract: In this paper, a simple non-linear mathematical model for HIV/AIDS is formulated and analyzed by assuming that only some fraction of total HIV and AIDS infected are detected and are subjected to proper counseling. The existence and stability of different equilibria of this model are discussed. Next we formulated the optimal control problem which is analyzed using Pontryagin’s maximum principle. It is observed that optimal control strategy gives a better result in minimizing the infectives.

**PP-A26-15**

**Common Fixed Point Theorems for Two Hybrid Pairs of Mappings in Menger PM-spaces**

Zhaqiqi, Wu  
Nanchang Univ.

Chuanxi, Zhu  
Nanchang Univ.

Abstract: In this paper, a new concept of the common property (EA) for two hybrid pairs of mappings is introduced in Menger PM-spaces. Utilizing this concept, some common fixed point theorems are obtained under strict contractive conditions, which shed some new light on the study of fixed point results for hybrid pairs in Menger PM-spaces. The corresponding results in metric spaces are also obtained, which generalize many known results.

**PP-A27-1**

**Certain Families of Generalized Mittag-Leffler Functions and Their Integral Representations**

Menaria, Naresh  
Mewar Univ.

Abstract: In this paper integral representations and some other results are established for some families of Mittag-Leffler function which are introduced by Shukla et al. and Saxena et al. respectively. The results are expressed in form of six theorems.

**PP-A27-2**

**On Minimal Geodetic Domination in Graphs**

Nuenay, Hearty  
Mindanao State Univ.- Iligan Inst. of Tech.

Abstract: Let G be a connected graph. For two vertices u and v in G, a u-v geodetic is any shortest path joining u and v. The closed geodetic interval I(G)[u,v] consists of all vertices of G lying on any u-v geodesic. For S&8838;8838;V(G), S is a geodetic set in G if \( \cup \{u, v\} \subseteq S \cup \{u, v\} \subseteq V(G) \). Vertices u and v of G are neighbors if u and v are adjacent. The closed neighborhood N(G)[v] of vertex v consists of all neighbors of v. For S&8838;8838;V(G), S is a dominating set in G if \( \cup \{u, v\} \subseteq \cup \{u, v\} \subseteq V(G) \). A geodetic dominating set in G is any geodetic set in G which is at the same time a dominating set in G. A geometric dominating set in G is a minimal geometric dominating set if it does not have a proper subset which is itself a geometric dominating set in G. The maximum cardinality of a minimal geometric dominating set in G is the upper geometric domination number of G. This paper initiates the study of minimal geometric dominating sets and upper geometric domination numbers of connected graphs.

**PP-A27-3**

**Convergence of Wavelet Expansions**

Sheikh, Neyaz  
National Inst. of Tech.

Abstract: In this paper we will show the convergence rate of wavelet series on different function spaces like FLS(S), where FL2(S) is a subspace of a Hilbert space L2(R). The convergence properties have been studied by various authors particularly by Kon & Raphael.

**PP-A27-4**

**SOME WEAKER FORMS OF FUZZY FAINTLY OPEN MAPPINGS**

ALI, Hakeem Ahmed Othman  
Univ. College of Al-Qunfudah, Umm Alqura Univ.

Abstract: This paper is devoted to introduce and investigate some weak forms of fuzzy open mappings, namely fuzzy faintly semi open (fuzzy faintly semi closed), fuzzy faintly preopen (fuzzy faintly preclosed), fuzzy faintly alpha-open (fuzzy faintly alpha-closed), fuzzy faintly semi preopen (fuzzy faintly semi preclosed) and fuzzy faintly sp-open (fuzzy faintly sp-closed) mappings and their fundamental properties are obtained. Moreover, their relationship with other types of fuzzy open (closed) mappings are discussed.

**PP-A27-5**

**Realized Laplace Transform of Volatility with Microstructure Noise**

Xiaochao, Xia  
College of Mathematics & Statistics, Chongqing Univ.

Abstract: In this paper, we consider the problem of estimating the Laplace transform of volatility in Todorov and Tauchen (2012b) by allowing the presence of microstructure noise, within a fixed time interval \([0,T]\) and under high frequency sampling. We use the pre-averaging approach to remove the effect of microstructure noise, and under the high frequency scenario, we obtain a consistent estimator with convergence rate \(n^{-1/6}\). The simulation studies justify the finite sample performance of our methods.

**PP-A27-6**

**Bio-heat Transfer Problem for One-Dimensional Spherical Biological Tissues**

Kengne, Emmanuel  
Univ. of Quebec at Outaouais

Lakhsassa, Ahmed  
Univ. of Quebec at Outaouais

Abstract: Based on the Pennes bio-heat transfer equation with constant blood perfusion, we set up a simplified one-dimensional bio-heat transfer model of the spherical living biological tissues for application in bio-heat transfer problems. We present in a simple way the analytical solution of the problem which is used to investigate the effects of tissue properties, the cooling medium temperature, and the point-heating on the temperature distribution in living bodies.

**PP-A27-7**

**Behavior Pattern Discovery Using Behavior Matrices and Behavior Prediction Relationships**

Ventura, Jade  
Univ. of the Philippines

Abstract: Let \( B_1, \ldots, B_m \) be behaviors observed over \( n \) consecutive time units. Set \( a_{ij} = 1 \) if \( B_i \) is present at time \( j \) and \( a_{ij} = 0 \) otherwise. Then \( O = [a_{ij}] \) is an observed behavior matrix. Let the data set \( D \) be a finite collection of observed behavior matrices. We present a behavior pattern discovery algorithm which takes \( D \) as an input and outputs a collection of expected behavior matrices. We then apply it to Philippine eagle prey delivery instances.

**PP-A27-8**

**Effect of Non-uniform Heating on Thermal Instability in A Horizontal Porous Layer**

MATTA, ANJANNA  
IIT Hyderabad

Abstract: In this study deals with the effect of non-uniform heating on the onset of Hadley-Prats flow in a horizontal fluid-saturated porous medium. In this study the non-linear stability analysis carried out for a large number of parameter values. The horizontal components of these gradients induce a Hadley circulation, which becomes unstable when vertical components are sufficiently large and this instability is analyzed by using three dimensional normal modes. The system that constitutes an eigenvalue problem.

**PP-A27-9**

**On Relationship between Fractal Complexities of Built and Natural Landscapes**

Naoumova, Natalia  
Pelotas State Univ.

Bourcheit, Andrei  
Pelotas State Univ.

Abstract: Problematic points associated with the application of the box-counting method for the evaluation of the visual complexity of historic buildings and their surrounding environments are analyzed. Different options for the choice of the box sizes and locations are considered and tested in the case of classical fractals. The proposed optimized algorithm applied to evaluation of the fractal material shows that there is a strong similarity between the fractal measures of built and natural landscapes.

**PP-A27-10**

**A New Kind of Fibonacci-like Sequence of Composite Numbers**
Abstract: An integer sequence is said to be Fibonacci-like if it satisfies the binary recurrence relation: $X_n=X_{n-1}+X_{n-2}$. Graham proved that there exist two relatively prime positive integers such that the Fibonacci-like sequence contains no primes. The common feature of all the above constructions is the existence of a finite covering set of primes such that every term is divisible by a prime in the set. In this paper we construct a Fibonacci-like sequence of composite numbers for which such a covering set does not appear to exist.

PP-A27-11
Study of Estimation and Selection of Variables in Semi-parametric Model
Jingwen, Tu
Chongqing Univ.
Abstract: The subject of this paper is to obtain the convergence results for an iterative process for contractive type mappings in CAT(0) spaces. In this paper, we analyze the Ishikawa type iteration scheme for a finite family of semi-contractive mappings in CAT(0) space. Our results are the generalization of several recent results in the current literature.

PP-A27-12
Convergence of An Iterative Scheme for Contractive Type Mappings in Non-linear Domain
KUMARI, MANDEEP
Maharshi Dayanand Univ., Rohtak
Abstract: The subject of this paper is to obtain the convergence results for an iterative process for contractive type mappings in CAT(0) spaces. In this paper, we analyze the Ishikawa type iteration scheme for a finite family of semi-contractive mappings in CAT(0) space. Our results are the generalization of several recent results in the current literature.

PP-A27-13
On Stability of Fixed Point Iterative Schemes in Convex Metric Spaces
Malik, Preety
Maharshi Dayanand Univ., Rohtak
Abstract: In 1970, Takahashi introduced the notion of convexity in metric space and studied some fixed point theorems for nonexpansive mappings in such spaces. The aim of this paper is to prove the stability results for fixed point iterative schemes for a pair of nonself mappings using iterative schemes and a certain contractive condition in Convex metric spaces. These results extend and improve the existing results in current literature.

PP-A27-14
Anti-dark and Mexican-hat Solitons in the Sasa-Satsuma Equation on the Continuous Wave Background
Xu, Tao
China Univ. of Petroleum-Beijing
Li, Min
North China Electric Power Univ.
Abstract: We use the Darboux transformation to construct new analytic soliton solutions for the Sasa-Satsuma equation. We reveal the anti-dark and Mexican-hat solitons on a continuous wave background, and examine their stability under small initial perturbations. Such two types of solitons can exhibit both the resonant and elastic interactions, as well as various partially/completely inelastic interactions. We also show that the soliton shape change may take place due to the energy exchange with the background.

PP-A27-15
A Recursive Formula for the Circumradius of the N-Simplex
Kobayashi, Kenta
Hitotsubashi Univ.
Abstract: We present a recursive formula which gives the circumradius of the n-simplex in terms of the circumradius of its facets. Our formula shows that the circumradius of the n-simplex is closely related to the distances from each vertex to the circumcenter of the opposite facet. We could only prove the formula for $n=5$ by the aid of computer algebra system, but numerical results strongly suggest that our formula holds true for any $n$.

PP-A27-16
A Note on Special Functions and Integrable Systems of Lotka-Volterra Type
Fujiiwara, Takashi
Amity Univ. Rajasthan
Abstract: There are many investigations of the relationships between special functions and integrable systems. For example, there are the relationships between Toda molecule equations and orthogonal polynomials, and so on. In this poster we consider the relationships between special function satisfying three term recurrences and integrable systems of Lotka-Volterra type.

PP-A28-1
On An Arithmetic Convolution
Singh, Jitender
Guru Nanak Dev Univ., Amritsar
Abstract: The Cauchy-type product of two arithmetic functions $f$ and $g$ on nonnegative integers is defined by $(f \bullet g)(k) := \sum_{m=0}^{k} \binom{k}{m} f(m) g(k-m)$. We explore some algebraic properties of the aforementioned convolution, which is a fundamental characteristic of the identities involving the Bernoulli numbers, the Bernoulli polynomials, the power sums, the sums of products, and so forth.

PP-A28-2
Contiguous Functions Relations: A Combinatorial Approach
Harsh, Harsh Vardhan
Amity Univ. Rajasthan
Abstract: Contiguous function relation play an important role in the theory of hypergeometric function and q-hypergeometric function theory. Recently few development has done by Wei. C. et.al. in this present note we apply some combinatorial techniques to evaluate the countability of contiguous function relations. we also evaluate some new contiguous function relations for hypergeometric function and q-hypergeometric function.
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