Final Program and Abstracts

SIAM Conference on

Analysis of Partial Differential Equations

December 9–12, 2017
The Baltimore Convention Center
Baltimore, Maryland, USA

Sponsored by the SIAM Activity Group on Analysis of Partial Differential Equations

The Activity Group on Analysis of Partial Differential Equations fosters activity in the analysis of partial differential equations (PDE) and enhances communication between analysts, computational scientists and the broad PDE community. Its goals are to provide a forum where theoretical and applied researchers in the area can meet, to be an intellectual home for researchers in the analysis of PDE, to increase conference activity in PDE, and to enhance connections between SIAM and the mathematics community.

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Table of Contents

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SIAM Registration Desk

The SIAM registration desk is located on Charles Terrace–Level 300. It is open during the following hours:

Friday, December 8
4:00 PM – 8:00 PM

Saturday, December 9
7:30 AM – 3:30 PM

Sunday, December 10
8:00 AM – 3:30 PM

Monday, December 11
8:00 AM – 4:00 PM

Tuesday, December 12
8:00 AM – 3:00 PM

Hotel Address

Hyatt Regency Baltimore Inner Harbor
301 Light Street
Baltimore, Maryland 21202 USA

Conference Location

Technical sessions will be held at the Baltimore Convention Center:

The Baltimore Convention Center
One West Pratt Street
Baltimore, Maryland 21201
Phone: +1-410-649-7000
http://www.bccenter.org

Hotel Telephone Number

To reach an attendee or leave a message, call +1-410-528-1234. If the attendee is a hotel guest, the hotel operator can connect you with the attendee's room.

Hotel Check-in and Check-out Times

Check-in time is 4:00 PM.
Check-out time is 12:00 PM.

Child Care

Visit Baltimore recommends *www.care.com* for attendees interested in child care services. Attendees can search using zip code 21202. Attendees are responsible for making their own child care arrangements.

Corporate Members and Affiliates

SIAM corporate members provide their employees with knowledge about, access to, and contacts in the applied mathematics and computational sciences community through their membership benefits. Corporate membership is more than just a bundle of tangible products and services; it is an expression of support for SIAM and its programs. SIAM is pleased to acknowledge its corporate members and sponsors.
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List current October 2017.

Funding Agency

SIAM and the conference organizing committee wish to extend their thanks and appreciation to U.S. National Science Foundation for its support of this conference.

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If you are not a SIAM member and paid the *Non-Member* or *Non-Member Mini Speaker/Organizer* rate to attend the conference, you can apply the difference between what you paid and what a member would have paid ($130 for a Non-Member and $65 for a *Non-Member Mini Speaker/Organizer*) towards a SIAM membership. Contact SIAM Customer Service for details or join at the conference registration desk.

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19104-2688 USA

Standard Audio/Visual Set-Up in Meeting Rooms

The Plenary Session Room will have two (2) screens, one (1) data projector and one (1) overhead projector. All other concurrent/breakout rooms will have one (1) screen and one (1) data projector. The data projectors support both VGA and HDMI connections. Presenters requiring an alternate connection must provide their own adaptor.

Internet Access

Complimentary wireless Internet access in the meeting space is available to SIAM attendees.

In addition, a limited number of computers with Internet access will be available during registration hours.

Registration Fee Includes

- Admission to all technical sessions
- Business Meeting (open to SIAG/APDE members)
- Coffee breaks daily
- Room set-ups and audio/visual equipment
- Welcome Reception and Poster Session

Job Postings

Please check with the SIAM registration desk regarding the availability of job postings or visit *http://jobs.siam.org*.

Important Notice to Poster Presenters

The poster session is scheduled for Friday, December 8 from 6:00 PM – 8:00 PM. Poster presenters are requested to set-up their poster material no later than 6:00 PM on Friday, the official start time of the session. Posters will remain on display through Tuesday, December 12 and must be removed by 11:00 AM on Tuesday.

SIAM Books and Journals

Display copies of books and complimentary copies of journals are available on site. SIAM books are available at a discounted price during the conference. The books booth will be staffed from 9:00 AM through 5:00 PM. If a SIAM books representative is temporarily away from the booth, completed order forms and payment (credit cards are preferred) may be taken to the SIAM registration desk. The books table will close at 3:00 PM on Tuesday, December 12.

Exhibitor

John Wiley & Sons Ltd

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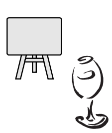
A space for emergency contact information is provided on the back of your name badge. Help us help you in the event of an emergency!

Comments?

Comments about SIAM meetings are encouraged! Please send to: Cynthia Phillips, SIAM Vice President for Programs (*vpp@siam.org*).

Get-togethers

Welcome Reception and Poster Session

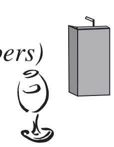


Friday, December 8

6:00 PM – 8:00 PM

Business Meeting

(*open to SIAG/APDE members)*



Monday, December 11

5:30 PM – 6:15 PM

Complimentary beer and wine will be served.

Statement on Inclusiveness

As a professional society, SIAM is committed to providing an inclusive climate that encourages the open expression and exchange of ideas, that is free from all forms of discrimination, harassment, and retaliation, and that is welcoming and comfortable to all members and to those who participate in its activities. In pursuit of that commitment, SIAM is dedicated to the philosophy of equality of opportunity and treatment for all participants regardless of gender, gender identity or expression, sexual orientation, race, color, national or ethnic origin, religion or religious belief, age, marital status, disabilities, veteran status, field of expertise, or any other reason not related to scientific merit. This philosophy extends from SIAM conferences, to its publications, and to its governing structures and bodies. We expect all members of SIAM and participants in SIAM activities to work towards this commitment.

Please Note

SIAM is not responsible for the safety and security of attendees' computers. Do not leave your personal electronic devices unattended. Please remember to turn off your cell phones and other devices during sessions.

Recording of Presentations

Audio and video recording of presentations at SIAM meetings is prohibited without the written permission of the presenter and SIAM.

Social Media

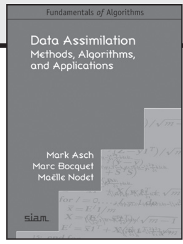
SIAM is promoting the use of social media, such as Facebook and Twitter, in order to enhance scientific discussion at its meetings and enable attendees to connect with each other prior to, during and after conferences. If you are tweeting about a conference, please use the designated hashtag to enable other attendees to keep up with the Twitter conversation and to allow better archiving of our conference discussions. The hashtag for this meeting is #SIAMPD17.

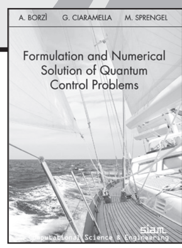
SIAM's Twitter handle is *@TheSIAMNews.*

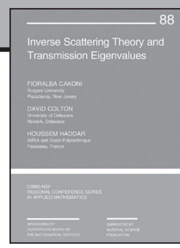
SIAM Titles of Interest to PD17 Attendees

These and other SIAM books are available at the conference

CONFERENCE ATTENDEES RECEIVE DISCOUNTS ON ALL DISPLAYED TITLES.







Data Assimilation: *Methods, Algorithms, and Applications*

Mark Asch, Marc Bocquet, Maëlle Nodet

Fundamentals of Algorithms 11

A comprehensive guide that is accessible to nonexperts. Readers will find numerous examples and diverse applications from a broad range of domains, including geophysics and geophysical flows, environmental acoustics, and medical imaging.

2017 / xviii + 306 pages / Softcover / 978-1-611974-53-9
List $84.00 / Member $58.80 / Attendee $67.20 / FA11

Formulation and Numerical Solution of Quantum Control Problems

Alfio Borzì, Gabriele Ciaramella, and Martin Sprengel

Computational Science and Engineering 16

This self-contained book covers the formulation, analysis, and numerical solution of quantum control problems and bridges scientific computing, optimal control and exact controllability, optimization with differential models, and the sciences and engineering that require quantum control methods.

2017 / x + 390 pages / Hardcover / 978-1-611974-83-6
List $99.00 / Member $69.30 / Attendee $79.20 / CS16

Inverse Scattering Theory and Transmission Eigenvalues

Fioralba Cakoni, David Colton, Houssem Haddar

CBMS-NSF Regional Conference Series in Applied Mathematics 88

The authors begin with a basic introduction to the theory, then proceed to more-recent developments, including a detailed discussion of the transmission eigenvalue problem. They present the new generalized linear sampling method in addition to the well-known linear sampling and factorization methods and in order to achieve clarification of presentation, focus on the inverse scattering problem for scalar homogeneous media.

2016 / x + 193 pages / Softcover / 978-1-611974-45-4
List $59.00 / Member $41.30 / Attendee $47.20 / CB88

Analysis of Hydrodynamic Models

Peter Constantin

CBMS-NSF Regional Conference Series in Applied Mathematics 90

A concise treatment of a number of partial differential equations of hydrodynamic origin, including the incompressible Euler equations, SQG, Boussinesq, incompressible porous medium, and Oldroyd-B. The author's concise, unified approach brings readers up to date on current open problems.

2017 / x + 62 pages / Softcover / 978-1-611974-79-9
List $39.00 / Member $27.30 / Attendee $31.20 / CB90

A Taste of Inverse Problems: *Basic Theory and Examples*

Martin Hanke

This book presents the main achievements that have emerged in regularization theory over the past 50 years, focusing on linear ill-posed problems and the development of methods that can be applied to them. It rigorously discusses state-of-the-art inverse problems theory, focusing on numerically relevant aspects and omitting subordinate generalizations.

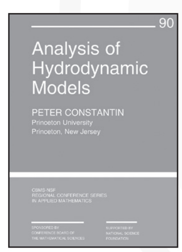
2017 / viii + 162 pages / Softcover / 978-1-611974-93-5
List $59.00 / Member $41.30 / Attendee $47.20 / OT153

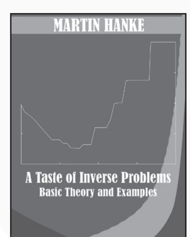
Foundations of Applied Mathematics, *Volume 1: Mathematical Analysis*

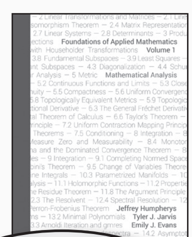
Jeffrey Humpherys, Tyler J. Jarvis, and Emily J. Evans

"Humpherys, Jarvis, and their collaborators are in the process of achieving something extraordinary: the creation of an entire curriculum of rigorous graduate-level applied mathematics with a four-volume series of first-rate books to support it."
—Lloyd N. Trefethen, University of Oxford

2017 /xx + 689 pages / Hardcover / 978-1-611974-89-8
List $89.00 / Member $62.30 / Attendee $71.20 / OT152







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10/17

Invited Plenary Speakers

*** All Invited Plenary Presentations will take place in 307/308 -Level 300 ***

Saturday, December 9

11:00 AM – 11:45 AM

IP1 Travel Time Tomography

Gunther Uhlmann, *Hong Kong University of Science and Technology, Hong Kong and University of Washington, USA*

11:45 AM – 12:30 PM

IP2 Dynamics of Contact Lines

Yan Guo, *Brown University, USA*

Sunday, December 10

11:00 AM – 11:45 AM

IP3 Eulerian and Lagrangian Solutions of the Continuity Equation

Gianluca Crippa, *University of Basel, Switzerland*

11:45 AM – 12:30 PM

IP4 Nonlinear Elliptic Equations with Fractional Diffusion

Xavier Cabré, *ICREA and Universitat Politècnica de Catalunya, Spain*

Invited Plenary Speakers

*** All Invited Plenary Presentations will take place in 307/308 -Level 300 ***

Monday, December 11

11:00 AM – 11:45 AM

IP5 Regularity Theory in Elliptic Free Boundary Problems

Daniela De Silva, *Columbia University, USA*

11:45 AM – 12:30 PM

IP6 Partial Differential Equations of Mixed Elliptic-Hyperbolic Type: From Mechanics to Geometry

Gui-Qiang Chen, *University of Oxford, United Kingdom*

Tuesday, December 12

11:00 AM – 11:45 AM

IP7 Small Scale Formation in Ideal Fluids

Alexander Sasha Kiselev, *Duke University, USA*

11:45 AM – 12:30 PM

IP8 Stability of Prandtl Boundary Layers

Emmanuel Grenier, *Ecole Normale Superieure de Lyon, France*

Prize Lecture

*** Prize Lecture will take place in 307/308 -Level 300 ***

Monday, December 11

2:00 PM – 2:45 PM

SP1 SIAG/Analysis of Partial Differential Equations Prize Lecture

Quantitative Stochastic Homogenization by Variational Methods

Scott Armstrong, *Courant Institute of Mathematical Sciences, New York University, USA*

SIAM Activity Group on Partial Differential Equations(SIAG/APDE)

www.siam.org/activity/pde

A GREAT WAY TO GET INVOLVED!

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ACTIVITIES INCLUDE:

- Special Sessions at SIAM meetings
- Biennial conference
- SIAG/APDE Prize
- SIAG/APDE Website

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- Electronic communications about recent developments in your specialty
- Electronic newsletter
- Eligibility for candidacy for SIAG/APDE office
- Participation in the selection of SIAG/APDE officers

SIAM Conference on

Analysis of Partial Differential Equations

December 9–12, 2017
The Baltimore Convention Center
Baltimore, Maryland, USA

ELIGIBILITY:

- Be a current SIAM member.

COST:

- $15 per year
- Student members can join 2 activity groups for free!

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Secretary:	Alina Chertock, NC State University

TO JOIN:

SIAG/APDE: *my.siam.org/forms/join_siag.htm*
SIAM: *www.siam.org/joinsiam*

Program Schedule

SIAM Conference on

Analysis of
Partial Differential Equations

December 9–12, 2017
The Baltimore Convention Center
Baltimore, Maryland, USA

Friday, December 8

Registration

4:00 PM-8:00 PM

Room:Charles Terrace -Level 300

Friday, December 8

PP1

Welcome Reception and Poster Session

6:00 PM-8:00 PM

Room309/310 -Level 300

Traveling Waves in Mass and Spring Dimer Fermi-Pasta-Ulam-Tsingou Lattices

Timothy E. Faver and Doug Wright, Drexel University, USA

Adi Extrapolated Crank-Nicolson Orthogonal Spline Collocation for Burgers' Equation in Two Space Variables

Nick Fisher, Colorado State University, USA; Bernard Bialecki, Colorado School of Mines, USA

Suppression of Blow-Up in Patlak-Keller-Segel Via Shear Flows

Siming He and Jacob Bedrossian, University of Maryland, USA

Development Towards a Methodology for Predicting Long-Time Algebraic Growth in Linear Wave Equations

Meaghan Hoitt, Colin Huber, Nicole Hill, Nathaniel S. Barlow, and Steve Weinstein, Rochester Institute of Technology, USA

Almost Planar Waves on Square Lattices

Leonardo Morelli and Hermen Jan Hupkes, University of Leiden, The Netherlands

Pulse Solutions for the Discrete FitzHugh-Nagumo Equation with Infinite-Range Interactions

Willem M. Schouten, Leiden University, Netherlands; Hermen Jan Hupkes, University of Leiden, The Netherlands

Modeling the Development of Mutated Patterns on Zebrafish

Alexandria Volkening and Bjorn Sandstede, Brown University, USA

Saturday, December 9

Registration

7:30 AM-3:30 PM

Room:Charles Terrace -Level 300

MS1

Conservation/Dissipation of Energy in Equations of Fluid Mechanics - Part I of II

8:30 AM-10:30 AM

Room:314-Level 300

For Part 2 see MS10

Energy balance forms an unavoidable of the mathematical description of fluids in motion. In view of the recent results in particular for inviscid fluid, a proper formulation of the energy conservation and/or dissipation is crucial for the correct choice of the physically admissible solution. The minisymposium focuses on various aspects of energy conservation/dissipation for both viscous and inviscid fluid models.

Organizer: Eduard Feireisl

Mathematical Institute ASCR, Prague, Czech Republic

Organizer: Agnieszka Swierczewska-Gwiazda

University of Warsaw, Poland

8:30-8:55 Nonuniqueness of Weak Solutions to the SQG Equation

Vlad C. Vicol, Princeton University, USA

9:00-9:25 On the Energy Flux of Homogeneous Solutions to the Euler Equation

Roman Shvydkoy, University of Illinois, Chicago, USA

9:30-9:55 Statistical Solutions and Onsager's Conjecture

Emil Wiedemann, Leibniz University Hannover, Germany; Ulrik S. Fjordholm, University of Oslo, Norway

10:00-10:25 Weak Solutions of Conservation Laws and Energy/Entropy Conservation

Piotr Gwiazda, Warsaw University, Poland

Saturday, December 9

MS2

Multi-species Kinetic and Fluid Models and Applications - Part I of II

8:30 AM-10:30 AM

Room:315-Level 300

For Part 2 see MS11

A kinetic description for evolving gases is given by the Boltzmann equations. This equation is very complicated, so in practice simplifications of the collision operator are considered. Examples are the so called BGK model, or ES-BGK models, or BGK models for a polyatomic gas. To overcome the restriction of this type of model to a single specific gas in applications, where gas mixtures are important, one is lead to multi-species kinetic models. All these models are devised so that they relax towards fluid models, such that correct features of the macroscopic pde (like viscosity coefficients) are recovered. Driven by today's ability to numerically simulate with such models for applications, there has been a recent spur of activity in this field. The goal in this minisymposium is to bring together various models and their applications, to study well-posedness of the models and their numerical simulations. This minisymposium will gather persons from kinetic modeling and their fluid limits, studying the well-posedness of these models, numerical implementations that respect the fluid limit, and applications from biology.

Organizer: Christian F. Klingenberg

Wurzburg University, Germany

continued in next column

8:30-8:55 Multi-Species Kinetic and Fluid Models and Applications

Christian F. Klingenberg, Wurzburg University, Germany

9:00-9:25 A Bgk Model for Polyatomic Gas Flows at High Temperature

Luc Mieussens, Universite de Bordeaux I, France

9:30-9:55 Well-Balanced and Asymptotic Preserving Schemes for Kinetic Models

Min Tang, Shanghai Jiao Tong University, China

10:00-10:25 Self-organized Pattern Formation in a Kinetic Transport Equation for Chemotactic Bacteria

Shugo Yasuda, University of Hyogo, Japan

Saturday, December 9

MS3

Multiscale Analysis and Simulation of Heterogeneous Media - Part I of II

8:30 AM-10:30 AM

Room:316-Level 300

For Part 2 see MS12

In recent years we have witnessed a tremendous growth of activity on developing methods for materials-related phenomena whose essential role extends over multiple scales in time and space. The proposed minisymposium will focus on multiscale modeling, analysis and simulation of the problems arising in composite and other heterogeneous media. In particular, topics that will be discussed include but not limited to are asymptotic analysis, homogenization, inverse problems, and computational tools for complex inhomogeneous media. The purpose of this section is to enable contact between researchers working on multiscale methods with an update on recent progress in this field.

Organizer: Yuliya Gorb

University of Houston, USA

Organizer: Shari Moskow

Drexel University, USA

8:30-8:55 Criteria for Opening Band Gaps in Periodic Media

Robert P. Lipton, Louisiana State University, USA

9:00-9:25 Navier Slip Condition for Viscous Fluids on a Rough Boundary

Silvia Jimenez Bolanos, Colgate University, USA; Bogdan M. Vernescu, Worcester Polytechnic Institute, USA

9:30-9:55 Constraint Energy Minimizing Generalized Multiscale Finite Element Method

Eric Chung, The Chinese University of Hong Kong, Hong Kong

10:00-10:25 Application of Herglotz Functions to the Study of Viscodynamics of Porous Media

Miao-Jung Y. Ou and *Chuan Bi*, University of Delaware, USA

Saturday, December 9

MS5

Free Boundary Problems and Fluid Interfaces - Part I of II

8:30 AM-10:30 AM

Room:317 -Level 300

For Part 2 see MS14

This session will focus on the analysis and control of evolutionary models with a free boundary that arise when a fluid or gas flow moves freely or interacts with a structure through the interface between the two media. Topics considered include, but are not limited to, the following: (i) free-boundary problems, (ii) fluid/gas-structure interaction, (iii) the dynamics of expanding gases, and (iii) fluid flows with phase transition. Physical models covered are ubiquitous in modern technological applications (engineering, biology, medicine). Examples include: controlling pressure in channel flows or veins conducing body fluid; the motion of a gas or liquid in vacuum; water-waves and related systems; the dynamics of multi-phase fluids and phase transitions. Despite the importance of such problems, their mathematical theory is of rather recent origin, with new discoveries appearing in recent literature. The time is ripe and the acquired momentum strong enough to expose this topic to a broader audience, in order to stimulate further research in this important field. In each of the above configurations, the overall model is described by systems of PDEs, which are strongly coupled at the interface (boundary). The emphasis is focused on demonstrating how the coupling at the interface changes drastically the overall coupled dynamics with respect to the behavior enjoyed by each component.

Organizer: Marcelo Disconzi

Vanderbilt University, USA

Organizer: Irena M. Lasiecka

University of Memphis, USA

continued in next column

8:30-8:55 On Local-in-Time Existence of Solutions to the Free Moving Boundary Incompressible Euler Equations Without Surface Tension

Igor Kukavica, University of Southern California, USA; *Amjad Tuffaha*, American University of Sharjah, United Arab Emirates

9:00-9:25 Two Dimensional Water Waves

Daniel Tataru, University of California, Berkeley, USA

9:30-9:55 Challenges in the Modeling and Analysis of Axial Flow Flutter

Justin T. Webster, University of Maryland, Baltimore County, USA; Daniel Toundykov, University of Nebraska-Lincoln, USA; Jason Howell, College of Charleston, USA

10:00-10:25 Longtime Existence of Models of Water Waves on the Torus

Steve Shkoller, University of California, Davis, USA

Saturday, December 9

MS6

Partial Differential Equations in Machine Learning and Data Science - Part I of II

8:30 AM-10:30 AM

Room:318-Level 300

For Part 2 see MS15

The typical size of problems in machine learning and data science presents serious challenges of both a computational and theoretical nature. As researchers in mathematics, computer science, and statistics have begun collaborating to address foundational issues, new and exciting connections between PDEs and machine learning have begun arising, presenting a new array of interesting problems for the PDE community. This minisymposium aims to bring together researchers working at the intersection of PDEs and machine learning to address foundational issues and identify directions for future research. Topics to be covered include continuum limits of graph-based learning and prediction problems, optimization of deep neural networks, anomaly detection and classification, and PDEs on graphs.

Organizer: Nadejda Drenska

Courant Institute of Mathematical Sciences, New York University, USA

Organizer: Jeff Calder

University of Minnesota, Minneapolis, USA

8:30-8:55 A PDE Approach to Prediction with Mixed Strategies

Nadejda Drenska and Robert V Kohn, Courant Institute of Mathematical Sciences, New York University, USA

continued in next page

9:00-9:25 Anomaly Detection and Classification for Streaming Data Using Partial Differential Equations

Bilal Abbasi, McGill University, Canada

9:30-9:55 Elliptic PDE Tackled by Primal-Dual Optimization

Dominique P. Zosso, Montana State University, USA; Braxton Osting, University of Utah, USA

10:00-10:25 Deep Relaxations: Partial Differential Equations for Optimizing Deep Neural Networks

Pratik A. Chaudhari, University of California, Los Angeles, USA; Adam M. Oberman, McGill University, Canada; Stanley J. Osher and Stefano Soatto, University of California, Los Angeles, USA; Guillaume Carlier, Universite Paris 9 Dauphine, France

Saturday, December 9

MS7

PDE Models for Pattern Forming Systems

8:30 AM-10:30 AM

Room:319-Level 300

The goal of this session is to bring together researchers interested in patterns that arise in material science, chemistry and biology. In particular, different methods for understanding the formation and stability of defects will be discussed. The talks will take a look at recent progress and future directions.

Organizer: Gabriela Jaramillo

University of Arizona, USA

Organizer: Lidia Mrad

University of Arizona, USA

8:30-8:55 A Generalized Swift-Hohenberg Model for Active Liquid Crystal Suspensions

Anand Oza, Courant Institute of Mathematical Sciences, New York University, USA; Jorn Dunkel, Massachusetts Institute of Technology, USA

9:00-9:25 Slow Motion for the 1D Swift--Hohenberg Equation

Gurgen Hayrapetyan, Ohio University, USA; Matteo Rinaldi, Carnegie Mellon University, USA

9:30-9:55 Moduli Spaces of Growth Patterns

Ryan Goh, Boston University, USA; Rafael Monteiro da Silva and Antoine Pauthier, University of Minnesota, USA; *Arnd Scheel,* University of Minnesota, Minneapolis, USA; Jasper Weinburd, University of Minnesota, Twin Cities, USA

10:00-10:25 The Effect of Impurities on Stripes

Qiliang Wu, Michigan State University, USA; Arnd Scheel, University of Minnesota, Minneapolis, USA; Gabriela Jaramillo, University of Arizona, USA

Saturday, December 9

MS8

Recent Results on Navier-Stokes and Related Physical Systems - Part I of II

8:30 AM-10:30 AM

Room:320-Level 300

For Part 2 see MS17

Certain work on basic models from fluid dynamics are naturally connected. Complex singularities, and the radius of analyticity are related to Gevrey regularity. Determining parameters can be used in data assimilation systems, which when studied backward in time, lead to determining forms. This minisymposium explores these connections through recent work on the Navier-Stokes and related physical systems.

Organizer: Jing Tian

Towson University, USA

Organizer: Michael S. Jolly

Indiana University, USA

8:30-8:55 On a Subclass of Solutions of the 2D Navier-Stokes Equations with Constant Energy and Enstrophy

Jing Tian, Towson University, USA; Bingsheng Zhang, Texas A&M University, USA

9:00-9:25 Inertial Manifolds for the Hyperviscous Navier-Stokes Equations

Ciprian Gal and *Yanqiu Guo*, Florida International University, USA

9:30-9:55 Efficient Numerical Algorithms for Approximating Long Time Statistical Behavior of Certain Fluid Models

Xiaoming Wang, Florida State University, USA and Fudan University, China

10:00-10:25 The Lagrangian and Eulerian Analyticity for the Euler Equations

Guher Camliyurt, University of Southern California, USA

Saturday, December 9

MS9

Progress in Non-local Variational Problems - Part I of II

8:30 AM-10:30 AM

Room:321-Level 300

For Part 2 see MS18

This minisymposium brings together recent developments in the studies of variational problems involving non-local effects due to repulsive Coulombic interactions. Such problems are motivated by a variety of applications in physics, from charged liquid drops to dense nuclear matter. In the case of conducting charged liquids, the additional Coulomb repulsion has long been known to produce interfacial instabilities, whose first experimental observations were carried out exactly one hundred years ago this year. Yet rigorous mathematical understanding of these phenomena is only beginning to emerge. This two-part minisymposium features talks focusing on geometric variational problems and their diffuse interface versions in which the perimeter of a set competes with Coulombic repulsive forces of several types.

Organizer: Cyrill B. Muratov

New Jersey Institute of Technology, USA

Organizer: Matteo Novaga

Università di Pisa, Italy

8:30-8:55 A Variational Model for Charged Drops

Matteo Novaga, Università di Pisa, Italy; Michael Goldman, CNRS, France; Cyrill B. Muratov, New Jersey Institute of Technology, USA; Berardo Riffini, Universite de Montpellier II, France

9:00-9:25 Optimal Shape of Isolated Ferromagnetic Domains

Hans Knuepfer, University of Heidelberg, Germany; Cyrill B. Muratov, New Jersey Institute of Technology, USA; Florian Nolte, Heidelberg University, Germany

continued in next column

9:30-9:55 Analysis and Numerics for Induced-charge Electrokinetic Flow with Interfaces

Michael Siegel, Michael R. Booty, and Rui Cao, New Jersey Institute of Technology, USA; Manman Ma, Shanghai Jiao Tong University, China; Qiming Wang, Scotiabank, USA

10:00-10:25 Energy-based Phase Field Model for Two Phase Ferrodroplet Deformation and Breakup under Magnetic Field

Xiaofeng Yang, University of South Carolina, USA

Saturday, December 9

MS38

Multiphysics and Turbulence: Analysis and Simulation - Part I of II

8:30 AM-10:30 AM

Room:322-Level 300

For Part 2 see MS47

Developing accurate, practical tools for understanding and simulating turbulent flows is a major challenge in mathematics and science. Adding to this difficulty is the fact that turbulent flows are often couple with a rich variety of additional physics, as in the study of geophysics, magnetohydrodynamics, porous media, and polymeric flows. This minisymposium aims to increase the interdisciplinary synthesis of analytical and computational methods currently being developed in the theory and application of multiphysical and turbulent flows. Results about large-time behavior, regularity, stability, and accurate capturing of physical phenomena will be among the major topics of interest.

Organizer: Adam Larios

University of Nebraska-Lincoln, USA

Organizer: Yuan Pei

University of Nebraska-Lincoln, USA

8:30-8:55 The Barotropic Guasi-geostrophic Equation under a Free Surface abstract

Qingshan Chen, Clemson University, USA

9:00-9:25 Improved Algebraic Splitting Methods for NSE and MHD

Leo Rebholz, Clemson University, USA

9:30-9:55 Optimal Bounds and Extremal Trajectories for Time Averages in Dynamical Systems

Charles R. Doering, University of Michigan, Ann Arbor, USA

10:00-10:25 Data Assimilation in Ocean and Atmosphere Dynamics

Yuan Pei, University of Nebraska-Lincoln, USA

Saturday, December 9

CP1

Numerical Methods for Fluid Mechanics and Related Models

8:30 AM-10:10 AM

Room:323-Level 300

Chair: Nail Yamaleev, Old Dominion University, USA

8:30-8:45 Computational Analysis of Partial Differential Equation Based on Electro-Magneto-Hydrodynamic Thermo-Fluidic Transport of Biofluids with New Trend of Fractional Derivative Without Singular Kernel

Mohammed Abdulhameed, Federal Polytechnic Bauchi, Nigeria

8:50-9:05 A Bottom-Up Approach to Global Upscaling for Reservoir Simulation

Chuan Chen and James V. Lambers, University of Southern Mississippi, USA

9:10-9:25 Analytical and Numerical Investigation of Euler-Bernoulli Beam Model with Non-Conservative Boundary Conditions

Laszlo P. Kindrat and Marianna Shubov, University of New Hampshire, USA

9:30-9:45 Numerical Solutions of 2-D Unsteady Free Convective Flow With Heat and Mass Transfer In A Rectangular Domain

Ambethkar Vusala and Durgesh Kushawaha, University of Delhi, India

9:50-10:05 Entropy Stable WENO Spectral Collocation Schemes for the 3-D Navier-Stokes Equations

Nail Yamaleev, Old Dominion University, USA; Mark H. Carpenter, NASA Langley Research Center, USA

Saturday, December 9

CP2

Equations from Fluid Mechanics and Related Models

8:30 AM-10:30 AM

Room:324-Level 300

Chair: Gleb Zhelezov, University of Arizona, USA

8:30-8:45 The Class of Conformal Dissipative Relativistic Fluids

Marcelo Enrique Rubio, Universidad Nacional de Cordoba, Argentina

8:50-9:05 A Two Layer Mathematical Model of Blood Flow in Porous Constricted Blood Vessels

Bhupesh D. Sharma, Motilal Nehru National Institute of Technology, India

9:10-9:25 Interior-Exterior Penality Approach for Solving Quasi-Variational Inequality Arising in Elastohydrodynamic Lubrication

Peeyush Singh, Pravir Dutt, and Prawal Sinha, Indian Institute of Technology, Kanpur, India

9:30-9:45 Well-Posedness and Long-Time Dynamics of Geophysical Fluid Flows

Maleafisha Stephen Tladi, University of Limpopo, South Africa

9:50-10:05 Coalescing Particle Systems, and Blow-Up in the Components of the Multispecies Keller-Segel Model

Gleb Zhelezov and Ibrahim Fatkullin, University of Arizona, USA

10:10-10:25 Adaptive Moving Mesh Upwind Scheme for the Two-Species Chemotaxis Model

Alexander Kurganov, Tulane University, USA

Coffee Break

10:30 AM-10:50 AM

Room:309/310 -Level 300

Welcome Remarks

10:50 AM-11:00 AM

Room:307/308 - Level 300

Saturday, December 9

IP1

Travel Time Tomography

11:00 AM-11:45 AM

Room:307/308 - Level 300

Chair: Josselin Garnier, Ecole Polytechnique, France

We will consider the inverse problem of determining the sound speed or index of refraction of a medium by measuring the travel times of waves going through the medium. This problem arises in global seismology in an attempt to determine the inner structure of the Earth by measuring travel times of earthquakes. It has also several applications in optics, medical imaging and ocean acoustics among others. We will apply the results to the inverse problem of determining the elastic parameters of a medium by measuring the traction produced by a displacement at the boundary of the medium. The problem can be recast as a geometric problem: Can one determine a Riemannian metric of a Riemannian manifold with boundary by measuring the distance function between boundary points? This is the boundary rigidity problem. We will also consider the problem of determining the metric from the scattering relation, the so-called lens rigidity problem. The linearization of these problems involve the integration of a tensor along geodesics, similar to the X-ray transform. We will also describe some recent results, joint with Plamen Stefanov and Andras Vasy, on the partial data case, where you are making measurements on a subset of the boundary. No previous knowledge of Riemannian geometry will be assumed.

Gunther Uhlmann

Hong Kong University of Science and Technology, Hong Kong, and University of Washington, USA

Saturday, December 9

IP2

Dynamics of Contact Lines

11:45 AM-12:30 PM

Room:307/308 - Level 300

Chair: Vlad C. Vicol, Princeton University, USA

Dynamics of contact lines (i.e. curves where surface of a cup of coffee meets the coffee cup) plays an crucial role in the understanding of many physical problems with important applications. In this talk, we will report a recent joint work with Ian Tice on global stability of steady contact line configuration for the Ren-E hydrodynamic (fluid) model describing contact line dynamics with varying contact angles.

Yan Guo
Brown University, USA

Lunch Break

12:30 PM-2:30 PM

Attendees on their own

Saturday, December 9

MS10

Conservation/Dissipation of Energy in Equations of Fluid Mechanics - Part II of II

2:30 PM-4:30 PM

Room:314-Level 300

For Part 1 see MS1

Energy balance forms an unavoidable of the mathematical description of fluids in motion. In view of the recent results in particular for inviscid fluid, a proper formulation of the energy conservation and/or dissipation is crucial for the correct choice of the physically admissible solution. The minisymposium focuses on various aspects of energy conservation/dissipation for both viscous and inviscid fluid models.

Organizer: Agnieszka Swierczewska-Gwiazda
University of Warsaw, Poland

Organizer: Eduard Feireisl
Mathematical Institute ASCR, Prague, Czech Republic

2:30-2:55 Inviscid Limit of Viscous Flows in Domains with Rough Boundaries

David Gerard-Varet, Universite Paris 7-Denis Diderot, France

3:00-3:25 A Proof of Onsager's Conjecture

Philip Isett, Massachusetts Institute of Technology, USA

3:30-3:55 Title Not Available At Time Of Publication

Alexis F. Vasseur, University of Texas, Austin, USA

4:00-4:25 On the Riemann Problem for the MultiD Isentropic Euler System

Ondrej Kreml, Mathematical Institute ASCR, Prague, Czech Republic

Saturday, December 9

MS11

Multi-species Kinetic and Fluid Models and Applications - Part II of II

2:30 PM-4:30 PM

Room:315-Level 300

For Part 1 see MS2

A kinetic description for evolving gases is given by the Boltzmann equations. This equation is very complicated, so in practice simplifications of the collision operator are considered. Examples are the so called BGK model, or ES-BGK models, or BGK models for a polyatomic gas. To overcome the restriction of this type of model to a single specific gas in applications, where gas mixtures are important, one is lead to multi-species kinetic models. All these models are devised so that they relax towards fluid models, such that correct features of the macroscopic pde (like viscosity coefficients) are recovered. Driven by today's ability to numerically simulate with such models for applications, there has been a recent spur of activity in this field. The goal in this minisymposium is to bring together various models and their applications, to study well-posedness of the models and their numerical simulations. This minisymposium will gather persons from kinetic modeling and their fluid limits, studying the well-posedness of these models, numerical implementations that respect the fluid limit, and applications from biology.

Organizer: Christian F. Klingenberg
Wurzburg University, Germany

continued on next page

2:30-2:55 A Consistent Kinetic Model for a Two-component Mixture of Polyatomic Molecules

Marlies Pirner, Universitaet Wuerzburg, Germany

3:00-3:25 A Dichotomy in the Dissipation Estimates for the Polatomic BGK Model

Seok-Bae Yun, Sungkyunkwan University, Korea

3:30-3:55 Construction of BGK Models from Entropy Minimization Principles

Stephane Brull, Institut Polytechnique de Bordeaux, France

4:00-4:25 Bgk Models for Mixtures of Polyatomic Gases with Discrete Or Continuous Internal Energy

Marzia Bisi, University of Parma, Italy

Saturday, December 9

MS12

Multiscale Analysis and Simulation of Heterogeneous Media - Part II of II

2:30 PM-4:30 PM

Room:316-Level 300

For Part 1 see MS3

In recent years we have witnessed a tremendous growth of activity on developing methods for materials-related phenomena whose essential role extends over multiple scales in time and space. The proposed minisymposium will focus on multiscale modeling, analysis and simulation of the problems arising in composite and other heterogeneous media. In particular, topics that will be discussed include but not limited to are asymptotic analysis, homogenization, inverse problems, and computational tools for complex inhomogeneous media. The purpose of this section is to enable contact between researchers working on multiscale methods with an update on recent progress in this field.

Organizer: Yuliya Gorb

University of Houston, USA

Organizer: Shari Moskow

Drexel University, USA

2:30-2:55 Homogenization of the Poincaré-Neumann Operator

Eric Bonnetier, Universite Joseph Fourier, France; Charles Dapogny and Faouzi Triki, Université Grenoble Alpes, France

3:00-3:25 Low-Frequency, Low-Wavenumber Approximation of the Willis' Effective Model for Periodic Media

Bojan B. Guzina, University of Minnesota, USA; Shixu Meng, University of Minnesota, USA

3:30-3:55 Effect of Asymmetries on Bulk Resonance in Multi-Scale Periodic Structures

Stephen Shipman, Louisiana State University, USA

4:00-4:25 Data-to-Born Transform for Inversion and Imaging with Waves

Alexander V. Mamonov, University of Houston, USA; Liliana Borcea, University of Michigan, USA; Vladimir L. Druskin and Mikhail Zaslavsky, Schlumberger-Doll Research, USA

Saturday, December 9

MS14

Free Boundary Problems and Fluid Interfaces - Part II of II

2:30 PM-4:30 PM

Room:317 -Level 300

For Part 1 see MS5

This session will focus on the analysis and control of evolutionary models with a free boundary that arise when a fluid or gas flow moves freely or interacts with a structure through the interface between the two media. Topics considered include, but are not limited to, the following: (i) free-boundary problems, (ii) fluid/gas-structure interaction, (iii) the dynamics of expanding gases, and (iii) fluid flows with phase transition. Physical models covered are ubiquitous in modern technological applications (engineering, biology, medicine). Examples include: controlling pressure in channel flows or veins conducing body fluid; the motion of a gas or liquid in vacuum; water-waves and related systems; the dynamics of multi-phase fluids and phase transitions. Despite the importance of such problems, their mathematical theory is of rather recent origin, with new discoveries appearing in recent literature. The time is ripe and the acquired momentum strong enough to expose this topic to a broader audience, in order to stimulate further research in this important field. In each of the above configurations, the overall model is described by systems of PDEs, which are strongly coupled at the interface (boundary). The emphasis is focused on demonstrating how the coupling at the interface changes drastically the overall coupled dynamics with respect to the behavior enjoyed by each component.

Organizer: Marcelo Disconzi

Vanderbilt University, USA

Organizer: Irena M. Lasiecka

University of Memphis, USA

continued on next page

Saturday, December 9

MS14

Free Boundary Problems and Fluid Interfaces - Part II of II

2:30 PM-4:30 PM

continued

2:30-2:55 A Flow Map Approach to the Water Wave Equations

Mihaela Ifrim, University of California, Berkeley, USA

3:00-3:25 Energy Estimates for A Relativistic Liquid

Daniel Ginsberg, Johns Hopkins University, USA

3:30-3:55 Long-time Behavior and Stability of Rigid Bodies with a Fluid-filled Gap

Giusy Mazzone, Vanderbilt University, USA

4:00-4:25 Fluid-Structure and Structure-Structure Interaction with Slip

Suncica Canic, University of Houston, USA; B. Muha, University of Zagreb, Croatia; Martina Bukac, University of Pittsburgh, USA

Saturday, December 9

MS15

Partial Differential Equations in Machine Learning and Data Science - Part II of II

2:30 PM-4:30 PM

Room:318-Level 300

For Part 1 see MS6

The typical size of problems in machine learning and data science presents serious challenges of both a computational and theoretical nature. As researchers in mathematics, computer science, and statistics have begun collaborating to address foundational issues, new and exciting connections between PDEs and machine learning have begun arising, presenting a new array of interesting problems for the PDE community. This minisymposium aims to bring together researchers working at the intersection of PDEs and machine learning to address foundational issues and identify directions for future research. Topics to be covered include continuum limits of graph-based learning and prediction problems, optimization of deep neural networks, anomaly detection and classification, and PDEs on graphs.

Organizer: Nadejda Drenska

Courant Institute of Mathematical Sciences, New York University, USA

Organizer: Jeff Calder

University of Minnesota, Minneapolis, USA

2:30-2:55 The Weighted p-Laplacian and Semi-Supervised Learning

Jeff Calder, University of Minnesota, Minneapolis, USA

3:00-3:25 Gromov-Hausdorff Limit of Wasserstein Spaces on Point Clouds

Nicolas Garcia Trillos, Brown University, USA

3:30-3:55 Auction Dynamics: A Volume Constrained Mbo Scheme

Ekaterina Merkurjev, Michigan State University, USA

4:00-4:25 A Generalized MBO Diffusion Generated Motion for Orthogonal Matrix Valued Fields

Braxton Osting and Dong Wang, University of Utah, USA

Saturday, December 9

MS16

Waves and Patterns

2:30 PM-4:30 PM

Room:319-Level 300

This minisymposium presents new advances in the theory of nonlinear waves and patterns for a range of model equations, posed on both discrete and continuous spatial domains.

Organizer: Hermen Jan Hupkes

University of Leiden, The Netherlands

2:30-2:55 Vortices in Rapidly Rotating Boussinesq Convection

Ryan Goh and C. Eugene Wayne, Boston University, USA

3:00-3:25 Travelling Waves for the Stochastic Nagumo Equation

Christian Hamster, Leiden University, Netherlands; Hermen Jan Hupkes, University of Leiden, The Netherlands

3:30-3:55 Competing Interactions, Patterns, and Traveling Waves in Discrete Systems

Erik Van Vleck, University of Kansas, USA; Anna Vainchtein, University of Pittsburgh, USA; Aijun Zhang, University of Kansas, USA

Saturday, December 9

MS17

Recent Results on Navier-Stokes and Related Physical Systems - Part II of II

2:30 PM-4:30 PM

Room:320-Level 300

For Part 1 see MS8

Certain work on basic models from fluid dynamics are naturally connected. Complex singularities, and the radius of analyticity are related to Gevrey regularity. Determining parameters can be used in data assimilation systems, which when studied backward in time, lead to determining forms. This minisymposium explores these connections through recent work on the Navier-Stokes and related physical systems.

Organizer: Jing Tian
Towson University, USA

Organizer: Michael S. Jolly
Indiana University, USA

2:30-2:55 Gaining Two Derivatives on a Singular Force in the 2D Navier-Stokes Equations

Alexey Cheskidov, University of Illinois, Chicago, USA

3:00-3:25 Numerical Approximations of a Feedback-Control Data Assimilation Algorithm: Uniform in Time Error Estimates

Cecilia F. Mondaini, Texas A&M University, USA; Edriss S. Titi, Texas A&M University, USA and Weizmann Institute of Science, Israel

3:30-3:55 Geometry of 3D Turbulent Flows and the Navier Stokes Regularity Problem

Zachary Bradshaw, University of British Columbia, Canada; *Aseel Farhat* and Zoran Grujić, University of Virginia, USA

4:00-4:25 Asymptotic Enslavement in Hydrodynamic Equations and Applications to Dynamics and Data Assimilation

Vincent R. Martinez, Tulane University, USA

Saturday, December 9

MS18

Progress in Non-local Variational Problems - Part II of II

2:30 PM-4:30 PM

Room:321-Level 300

For Part 1 see MS9

This minisymposium brings together recent developments in the studies of variational problems involving non-local effects due to repulsive Coulombic interactions. Such problems are motivated by a variety of applications in physics, from charged liquid drops to dense nuclear matter. In the case of conducting charged liquids, the additional Coulomb repulsion has long been known to produce interfacial instabilities, whose first experimental observations were carried out exactly one hundred years ago this year. Yet rigorous mathematical understanding of these phenomena is only beginning to emerge. This two-part minisymposium features talks focusing on geometric variational problems and their diffuse interface versions in which the perimeter of a set competes with Coulombic repulsive forces of several types.

Organizer: Cyrill B. Muratov
New Jersey Institute of Technology, USA

Organizer: Matteo Novaga
Università di Pisa, Italy

2:30-2:55 Nonlinear Stability Results for the Nonlocal Mullins-Sekerka Flow

Massimiliano Morini, Universita degli Studi di Parma, Italy; Vesa Julin, University of Jyvaskyla, Finland; Nicola Fusco, University of Naples "Frederico II", Naples, Italy

3:00-3:25 Droplet Breakup in the Liquid Drop Model

Ihsan Topaloglu, Virginia Commonwealth University, USA; Stan Alama and Lia Bronsard, McMaster University, Canada; Rustum Choksi, McGill University, Canada

3:30-3:55 A Universal Thin Film Model for Ginzburg-Landau Energy with Dipolar Interaction

Cyrill B. Muratov, New Jersey Institute of Technology, USA

4:00-4:25 Stability of the Gaussian Isoperimetric Problem

Vesa Julin, University of Jyvaskyla, Finland

Saturday, December 9

MS47

Multiphysics and Turbulence: Analysis and Simulation - Part II of II

2:30 PM-4:30 PM

Room:322-Level 300

For Part 1 see MS38

Developing accurate, practical tools for understanding and simulating turbulent flows is a major challenge in mathematics and science. Adding to this difficulty is the fact that turbulent flows are often couple with a rich variety of additional physics, as in the study of geophysics, magnetohydrodynamics, porous media, and polymeric flows. This minisymposium aims to increase the interdisciplinary synthesis of analytical and computational methods currently being developed in the theory and application of multiphysical and turbulent flows. Results about large-time behavior, regularity, stability, and accurate capturing of physical phenomena will be among the major topics of interest.

Organizer: Adam Larios
University of Nebraska-Lincoln, USA

Organizer: Yuan Pei
University of Nebraska-Lincoln, USA

2:30-2:55 Far Field Regularity for the Supercritical Quasi-Geostrophic Equations

Fei Wang, University of Southern California, USA

3:00-3:25 Data Assimilition for Geophysical Flows Employing Only Surface Measurements

Michael S. Jolly, Indiana University, USA; Vincent R. Martinez, Tulane University, USA; Edriss S. Titi, Texas A&M University, USA and Weizmann Institute of Science, Israel

3:30-3:55 The Stampacchia Maximum Principle for Stochastic Partial Differential Equations and Applications

Mickael Chekroun, University of California, Los Angeles, USA; *Eunhee Park* and Roger M. Temam, Indiana University, USA

4:00-4:25 A Model for Hyporheic Zone

Xiaoming Wang, Florida State University, USA and Fudan University, China

Saturday, December 9

CP3

Numerical Methods

2:30 PM-4:10 PM

Room:323-Level 300

Chair: Andreas Aristotelous,

2:30-2:45 Discontinuous Galerkin Finite Element Methods for the Solution of Diffuse Interface Models

Andreas Aristotelous, West Chester University, USA

2:50-3:05 High-Order, Stable and Conservative Boundary Schemes for Finite Differences

Peter Brady and Daniel Livescu, Los Alamos National Laboratory, USA

3:10-3:25 Mesh Requirements for Transmission Problems with Sign-Changing Coefficients

Camille Carvalho, University of California, Merced, USA; Anne-Sophie Bonnet-Ben Dhia and Patrick Ciarlet, Laboratoire POEMS (CNRS-ENSTA-INRIA), France

3:30-3:45 Well-Balanced Methods for Hyperbolic Systems of Balance Laws

Alina Chertock, North Carolina State University, USA

3:50-4:05 Solution of PDEs in Frequency Space for Photobleaching Kinetics Using Krylov Subspace Spectral Methods

Somayyeh Sheikholeslami and James V. Lambers, University of Southern Mississippi, USA

Saturday, December 9

CP4

Inverse Problems and Control

2:30 PM-4:10 PM

Room:324-Level 300

Chair: Ana Marie Soane, US Naval Academy, USA

2:30-2:45 On the Numerical Solution to the Far Field Refractor Problem

Henok Mawi and Roberto De Leo, Howard University, USA; Cristian Gutierrez, Temple University, USA

2:50-3:05 Pde Systems and Efficient Fire Suppression Allocation

Alex T. Masarie, Yu Wei, and Iuliana Oprea, Colorado State University, USA; Matt Thompson and Erin Belval, Rocky Mountain Research Station, USA

3:10-3:25 Combined Optimal Stopping and Control of Regime Switching Lévy Processes and Applications

Moustapha Pemy, Towson University, USA

3:30-3:45 Nonlinear Magneto-Elasticity: Direct and Inverse Problems

Viatcheslav I. Priimenko, North Fluminense State University, Brazil; Mikhail P. Vishnevskii, North Fluminense State University Darcy Ribeiro, Brazil and Sobolev Institute of Mathematics, Russia

3:50-4:05 Multigrid Methods for Stochastic Optimal Control Problems

Ana Maria Soane, US Naval Academy, USA

Sunday, December 10

Registration

8:00 AM-3:30 PM

Room: Charles Terrace -Level 300

MS4

Analysis, Control and Inverse Theory of Flows, Material Structures, Acoustics, and Their Interactions - Part I of II

8:30 AM-10:30 AM

Room:320-Level 300

For Part 2 see MS13

Recent years have witnessed a surge of activities in the mathematical analysis focused on established physical models arising in flows, material structures, acoustics, and their interactions. In some cases, it is the nature of the coupled problem centered on the interaction of two components through the interface separating their respective media that generates the novelty of the mathematical problem. The elastic structure may be conservative, dissipative, visco-elastic, with memory terms, etc; thus, accordingly, affecting the uncontrolled dynamics. Moreover, the boundary control action may be located either at the external boundary of the outward domain, or else at the interface between the two media. In other cases, it is the model itself, long classical in the engineering literature, which represents the mathematical novelty. An example is the third order equation initially derived by G.G. Stokes in a paper of 1851, describing the radiation of heat on the propagation of sound. Such models have resurfaced since the 1960-70s with more recent contributions in the area of High Intensity Ultrasound. For these systems, a preliminary mathematical

continued on next page

analysis was initiated very recently. It has concentrated so far on linear and nonlinear models with homogeneous boundary conditions. In contrast, a mathematical theory under the action of boundary controls is wholly unexplored. This area opens then unchartered territories in the corresponding study of control and optimal control theory.

Organizer: Lorena Bociu
North Carolina State University, USA

Organizer: Roberto Triggiani
University of Memphis, USA

8:30-8:55 Low Reynolds Number Fluid-Structure Interactions: Modeling the Response of Soft Microfluidic Devices

Ivan C. Christov and Tanmay Shidhore, Purdue University, USA

9:00-9:25 The Einstein-Navier-Stokes System

Marcelo Disconzi, Vanderbilt University, USA

9:30-9:55 Plasticity by a Phase Field Model

Mauro Fabrizio, Università di Bologna, Italy

10:00-10:25 Fluid Flow Through Deformable Porous Media: Analysis, Simulations and Applications

Giovanna Guidoboni, Indiana University - Purdue University Indianapolis, USA; Lorena Bociu, North Carolina State University, USA; Riccardo Sacco and Maurizio Verri, Politecnico di Milano, Italy; Justin Webster, College of Charleston, USA

Sunday, December 10

MS19

Recent Developments in Fluid Dynamics - Theory and Numerical Approximation - Part I of II

8:30 AM-10:30 AM

Room:314-Level 300

For Part 2 see MS28

The main purpose of this minisymposium is to bring together specialists in the field of theoretical and computational fluid dynamics. Over the past decades, mathematics and physics have found successful interactions through the study of various differential equations. In this regard, both the theoretical and applied points of view with topics including the regularity behavior of solutions, dynamics and numerical implementations are been considered. This mini symposium focuses on recent progresses in the development and applications of classical and computational fluid dynamics. The minisymposium aims to address some important issues such as the properties of solutions, existence, regularity, stability, asymptotic behaviors, and numerical approximations arising from nonlinear differential equations.

Organizer: Youngjoon Hong
University of Illinois, Chicago, USA

Organizer: Mimi Dai
University of Illinois, Chicago, USA

8:30-8:55 On Measure-Valued Solutions and Their Applications in Numerical Analysis

Eduard Feireisl, Mathematical Institute ASCR, Prague, Czech Republic

9:00-9:25 Explosion in the Multiplicative Stochastic Process Associated with the 3D Navier-Stokes Equations

Radu Dascaliuc, Oregon State University, USA

9:30-9:55 Adaptive RBF-WENO Methods for Hyperbolic Conservation Laws

Jae-Hun Jung and Jingyang Guo, State University of New York, Buffalo, USA

10:00-10:25 On Stochastic Anisotropic 3D Navier-Stokes Equations

Hakima Bessaih, University of Wyoming, USA

Sunday, December 10

MS20

Mathematical Analysis in Incompressible Fluid Dynamics - Part I of II

8:30 AM-10:30 AM

Room:315-Level 300

For Part 2 see MS29

Understanding the flow of incompressible fluids is at the heart of many problems in the natural sciences, such as aerodynamics, plasma physics, mathematical biology, chemical dynamics. Among the problems of interest, turbulence in fluid flow is particularly noteworthy, in view of its difficulty and its relevance in applications. Mathematically, the motion of incompressible fluids is governed by the incompressible Euler (inviscid) or Navier-Stokes (viscous) equations. The theory for these two systems of partial differential equations is far from complete, despite many decades of concerted effort. Recently, substantial progress has been acheived for the Euler equations, Navier-Stokes equations and related systems. We propose to bring experts from different institutions to discuss recent results and to stimulate closer collaboration among the members of the community.

Organizer: Mimi Dai
University of Illinois, Chicago, USA

Organizer: Helena Nussenzveig Lopes
Universidade Federal de Rio de Janeiro, Brazil

8:30-8:55 Non-Decaying Solutions to the 2D Euler Equations

James P. Kelliher, University of California, Riverside, USA; Elaine Cozzi, Oregon State University, USA

9:00-9:25 On the Convergence of Statistical Solutions of Evolution Equations

Anne Bronzi, Universidade Estadual de Campinas, Brazil

continued on next page

Sunday, December 10

MS20

Mathematical Analysis in Incompressible Fluid Dynamics - Part I of II

8:30 AM-10:30 AM

continued

9:30-9:55 The Lighthill Principle and Vorticity Estimates for Flows with Symmetry

Milton Lopes Filho, Universidade Federal do Rio Grande do Sul, Brazil

10:00-10:25 Finite Time Singularity of a Vortex Patch Model in the Half Plane

Alexander Sasha Kiselev, Duke University, USA; Lenya Ryzhik, Stanford University, USA; *Yao Yao*, Georgia Institute of Technology, USA; Andrej Zlatos, University of California, San Diego, USA

Sunday, December 10

MS21

On Higher Order Methods for Numerical Solution of PDE - Part I of II

8:30 AM-10:30 AM

Room:316-Level 300

For Part 2 see MS30

Due to the computer power, higher order finite elements via Discontinuous Galerkin methods (DG), Weak-Galerkin methods (WG), Virtual finite elements (VFE), and Spline elements (SE) become available for numerical solutions of linear and nonlinear PDE in practice. Not only triangulation/tetrahedral partitions are used for higher order methods, but also use polygonal/polyhedral partitions for numerical solutions of PDE. This minisymposium will discuss recent development and advances in these higher order methods in several directions: numerical solution of Monge-Ampere equations, Maxwell equations in potential function formulation, construction of higher order elements on quadrilaterals and hexahedra, and orthogonal complements. A super convergence phenomenon in higher order method will be discussed.

Organizer: Ming-Jun Lai

University of Georgia, USA

8:30-8:55 Two-Grid Discretization for Interior Penalty and Mixed Finite Elements Methods for the Monge-Ampere Equation

Gerard Awanou, University of Ilinois at Chicago, USA

9:00-9:25 Discrete Theories for Elliptic Problems in Non-divergence Form

Michael J. Neilan, University of Pittsburgh, USA

9:30-9:55 Multivariate Splines for Numerical Solution of Maxwell Equations in Potential Function Formulation

Clayton Mersmann, University of Georgia, USA

10:00-10:25 A Trefftz Discontinuous Galerkin Method for Time Harmonic Waves with Generalized Impedance Boundary Conditions

Shelvean Kapita, University of Georgia, USA

Sunday, December 10

MS22

Recent Developments in Modeling, Control, Theoretical and Numerical Analysis of Complex Systems with Dynamic Boundaries - Part I of II

8:30 AM-10:30 AM

Room:322-Level 300

For Part 2 see MS31

Many outstanding open problems of modern science and engineering involve free boundaries whose dynamics are determined as a part of the solution. The analysis of the underlying PDE systems poses significant mathematical challenges. This minisymposium will highlight some recent advances in analytical and computational studies for such systems. Examples include inverse free boundary problems, optimal control of phase transition processes, projective gradient type methods in Besov-Sobolev spaces, multi-phase fluid mixture flow, inverse scattering problems, stochastic differential equations and optimal control, interfaces for nonlinear degenerate and singular parabolic PDEs, Wiener type criteria in potential theory and its measure theoretical, topological and probabilistic counterparts, classification of singularities for elliptic and parabolic PDEs, cancer detection models through electrical impedance tomography and optimal control theory.

Organizer: Jonathan Goldfarb

Florida Institute of Technology, USA

Organizer: Ugur G. Abdulla

Florida Institute of Technology, USA

continued on next page

8:30-8:55 Recent Advances on Optimal Control of Parabolic Free Boundary Problems

Ugur G. Abdulla, Florida Institute of Technology, USA

9:00-9:25 Stabilization and Control of a 3 D Fluid Structure Interaction

Irena M. Lasiecka, University of Memphis, USA

9:30-9:55 A Two-Fluid Mixture Model of Platelet Aggregation

Jian Du, Florida Institute of Technology, USA; Aaron L. Fogelson, University of Utah, USA

10:00-10:25 Phaseless Scattering and Global Convergence for Coefficient Inverse Problems

Loc Nguyen and Michael V. Klibanov, University of North Carolina, Charlotte, USA

Sunday, December 10

MS23

Nonlinear PDEs in Fluid Mechanics - Part I of IV

8:30 AM-10:00 AM

Room: 317 -Level 300

For Part 2 see MS32

The main purpose of this minisymposium is to bring senior mathematicians and junior researchers together to exchange the new ideas on the study of nonlinear partial differential equations, with emphasis on the models of fluid flows and related topics, especially on the structure of solutions, asymptotic behaviors of solutions, stability of nonlinear waves, and the related numerical computations.

Organizer: Geng Chen
University of Kansas, USA

Organizer: Xiaoqian Xu
Carnegie Mellon University, USA

Organizer: Cheng Yu
The University of Texas at Austin, USA

8:30-8:55 Title Not Available At Time Of Publication

Jian-guo Liu, Duke University, USA

9:00-9:25 Global Existence and Finite Time Singularity for Solutions to Solid Film Model and Tear Film Model

Yuan Gao, Hong Kong University of Science and Technology, Hong Kong; Jian-Guo Liu, Hangjie Ji, and Thomas P. Witelski, Duke University, USA

9:30-9:55 Backward Behavior of Some Dissipative Evolution Equations

Yanqiu Guo, Florida International University, USA; Edriss S. Titi, Texas A&M University, USA and Weizmann Institute of Science, Israel

Sunday, December 10

MS24

Mean Field Games and Applications - Part I of II

8:30 AM-10:30 AM

Room:318-Level 300

For Part 2 see MS33

Mean field games give a tractable way to model interactions among large populations of rational agents, using nonlinear coupled systems of partial differential equations. These models have many applications in economics, finance, and other social and biological sciences. Recent results on existence, regularity, and numerical algorithms for computing solutions rely on a variety of techniques to overcome difficulties created by the nonlinear forward-backward structure of the equations. Different approaches include regularity theory for parabolic equations, fixed point methods, optimal control of infinite dimensional systems, and the calculus of variations. This minisymposium will feature some of the latest advances in this direction, as well as applications related especially to economics.

Organizer: Jameson Graber
Baylor University, USA

Organizer: Maria Gualdani
George Washington University, USA

8:30-8:55 Stationary Mean-Field Games with Congestion

Diogo Gomes, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

9:00-9:25 On the Variational Formulation of Some Stationary Second Order Mean Field Game Systems

Alpar Meszaros, University of California, Los Angeles, USA; Francisco J. Silva, Université de Limoges, France

9:30-9:55 Aggregation in Mean Field Games

Marco Cirant, Universita di Padova, Italy; Daniela Tonon, CEREMADE Universite Paris 9 Dauphine, France

10:00-10:25 Singular Mean Field Games

Hector Sanchez Morgado, National Autonomous University of Mexico, Mexico

Sunday, December 10

MS25

Waves and Imaging Though Complex Media - Part I of II

8:30 AM-10:30 AM

Room:319-Level 300

For Part 2 see MS34

Wave-based imaging is an interdisciplinary area in applied mathematics, with roots in hyperbolic partial differential equations, probability theory, statistics, optimization, and numerical analysis. This minisymposium will present some of the latest advances in this area including inverse boundary value problems, imaging with cross correlation techniques, propagation and imaging in multiscale media and superresolution.

Organizer: Knut Solna
University of California, Irvine, USA

Organizer: Josselin Garnier
Ecole Polytechnique, France

8:30-8:55 Beam-Wave Scattering and Imaging

Knut Solna, University of California, Irvine, USA

9:00-9:25 Fractional White-Noise Limit and Paraxial Approximation for Waves in Random Media

Christophe Gomez, Aix-Marseille Université, France

9:30-9:55 Bubbly Media: From Super-resolution to Metamaterials

Brian Fitzpatrick, ETH Zürich, Switzerland; Habib Ammari, CNRS & Ecole Polytechnique, France; Hyundae Lee, Inha University, Korea; Sanghyeon Yu, ETH Zürich, Switzerland; Hai Zhang, Hong Kong University of Science and Technology, Hong Kong

10:00-10:25 Title Not Available At Time Of Publication

Laure Giovangigli, University of California, Irvine, USA

Sunday, December 10

MS27

Graph Laplacians, Spectral Graph Theory, and Applications - Part I of II

8:30 AM-10:30 AM

Room:321-Level 300

For Part 2 see MS36

The Laplacian has dominated the theory of partial differential equations. Recently, its discrete analogues have turned out to be extremely versatile tools on graphs and have reinvigorated the field of classical spectral theory and given rise to the spectral theory of graphs with tremendous applications in pure and applied mathematics: most notably, we refer to new interactions with classical elliptic equations and the application in problems of dimensionality reduction. In the context of data, the spectrum and eigenvectors of the Laplacian characterizes the data's global properties while preserving the geometric and topological structure of the neighborhoods. When the geometry of the points is not simple, open questions emerge about localization of the eigenfunctions, and about using the eigenfunctions to efficiently represent signals on the points. Recently, ideas from the discrete setting have been successfully used to derive new results in the theory of classical elliptic equations, and some of the discrete ideas may have further impact in the classical continuous theory. Applications using the eigendecomposition of the Laplacian range from remote sensing and medical imaging to shape matching and unstructured tensor co-clustering. The goal of this workshop is to bring together theoretical and applied researchers to present and discuss recent advances in applied spectral graph theory, and to enable and facilitate future collaboration of the participants.

continued in next column

Organizer: Alexander Cloninger
University of California, San Diego, USA

Organizer: Stefan Steinerberger
Yale University, USA

8:30-8:55 Interactions Between Graph Laplacians and Elliptic Pdes

Stefan Steinerberger, Yale University, USA

9:00-9:25 No Equations, No Variables, No Parameters, No Space, No Time: Data and the Computational Modeling of Complex/multiscale Systems

Ioannis Kevrekidis, Princeton University, USA

9:30-9:55 How Can We Order and Organize Laplacian Eigenfunctions Naturally?

Naoki Saito, University of California, Davis, USA

10:00-10:25 Common Variable Learning Using Alternating Diffusion and Deep Siamese Networks

Roy Lederman, Princeton University, USA

Sunday, December 10

CP5

Numerical Methods for Reaction Diffusion Equations and Related Models

8:30 AM-10:30 AM

Room:323-Level 300

Chair: Pedro Ascencio, University of Warwick, United Kingdom

8:30-8:45 Virtual Element Methods for Time Dependent Convection Diffusion Reaction Equation with Supg Stabilization

Dibyendu Adak, Sarvesh Kumar, and E. Natarajan, Indian Institute of Space, Science and Technology, India

8:50-9:05 A Numerical Solution for a Class of Differential Initial-Boundary Value Problems Via Convex Optimization

Pedro A. Ascencio and W.D. Widanage, University of Warwick, United Kingdom

9:10-9:25 Invariant Subspace and Functionally Generalized Separable Solutions of *n*-Dimensional PDEs

Muhammad D. Khan, Institute of Business Management, Pakistan

9:30-9:45 Lie Symmetry Analysis and Dust-Acoustic Waves in Dusty Plasma Modeled by Burgers' Type Equation

Vikas Kumar, D. A. V. College Pundri, India

9:50-10:05 A Numerical Algorithm for Computational Modeling of Reaction-Diffusion Models Arising in Chemical Processes

Ram Jiwari, Indian Institute of Technology Roorkee, India

10:10-10:25 Numerical Study of Reaction Diffusion Fisher's Equation by Fourth Order Cubic B-Spline Collocation Method

Rajni Rohila and R. C. Mittal, IIT Roorkee, India

Sunday, December 10

CP6

Parabolic, Elliptic Equations, and Related Models

8:30 AM-9:50 AM

Room:324-Level 300

Chair: Mauricio Rivas, Wake Forest University, USA

8:30-8:45 Cell-Centered Finite Volume Element Methods for Elliptic Equations

Yujie Liu, Sun Yat-sen University, China; Junping Wang, National Science Foundation, USA; Qingsong Zou, Sun Yat-sen University, China

8:50-9:05 Eigencurves for Linear Elliptic Equations

Mauricio A. Rivas and Stephen Robinson, Wake Forest University, USA

9:10-9:25 Liouville Type Theorem for Some Nonlocal Elliptic Equations

Xiaohui Yu, Shenzhen University, China

9:30-9:45 A Multiscale Approximation of a Cahn-Larché System with Phase Separation on the Microscale

Lisa Reischmann and Malte A. Peter, University of Augsburg, Germany

Coffee Break

10:30 AM-10:55 AM

Room:309/310 -Level 300

Announcements

10:55 AM-11:00 AM

Room:307/308 - Level 300

Sunday, December 10

IP3

Eulerian and Lagrangian Solutions of the Continuity Equation

11:00 AM-11:45 AM

Room:307/308 - Level 300

Chair: Eduardo Feireisl, Academy of Sciences of the Czech Republic, Prague, Czech Republic

It is well known that the motion of an incompressible fluid can be described in Eulerian variables (as a solution of a PDE, namely the continuity equation), or alternatively in Lagrangian variables (as a flow of an ODE). The classical DiPerna-Lions-Ambrosio theory ensures well-posedness and provides structural properties for solutions of the continuity equation, under suitable regularity assumptions on the velocity field and integrability assumptions on the solution. In my talk I will focus on the "Lagrangianity" of solutions, that is, on the property of being transported by an ODE flow, hence addressing the question whether an Eulerian solution is automatically a Lagrangian solution. After a brief summary of the DiPerna-Lions-Ambrosio theory, I will present two examples which are outside of the assumptions of such a theory, and in which nevertheless we can prove the Lagrangianity of solutions. The first one concerns vanishing viscosity solutions of the two-dimensional Euler equations, where we can use suitable duality methods (joint work with Stefano Spirito). The second example involves general continuity equations, and requires the proof of a new Lipschitz extension lemma (joint work with Laura Caravenna).

Gianluca Crippa
University of Basel, Switzerland

Sunday, December 10

IP4

Nonlinear Elliptic Equations with Fractional Diffusion

11:45 AM-12:30 PM

Room:307/308 - Level 300

Chair: Yannick Sire, Johns Hopkins University, USA

In this talk I will explain basic ideas concerning fractional Laplacians (in particular, their relation with Lévy flights in Probability) and present the essential tools to treat nonlinear equations involving fractional Laplacians and other elliptic integro-differential operators. We will review their Lagrangian and Hamiltonian structures -- two very important tools. The last part of the talk will concern recent developments on fractional perimeters and nonlocal minimal surfaces -- a fractional extension of the classical theory of minimal surfaces.

Xavier Cabré
ICREA and Universitat Politècnica de Catalunya, Spain

Lunch Break

12:30 PM-2:30 PM

Attendees on their own

SIMA Editorial Board Meeting

12:30 PM-2:30 PM

325 -Level 300

Sunday, December 10

MS13

Analysis, Control and Inverse Theory of Flows, Material Structures, Acoustics, and Their Interactions - Part II of II

2:30 PM-4:00 PM

Room:320-Level 300

For Part 1 see MS4

Recent years have witnessed a surge of activities in the mathematical analysis focused on established physical models arising in flows, material structures, acoustics, and their interactions. In some cases, it is the nature of the coupled problem centered on the interaction of two components through the interface separating their respective media that generates the novelty of the mathematical problem. The elastic structure may be conservative, dissipative, visco-elastic, with memory terms, etc; thus, accordingly, affecting the uncontrolled dynamics. Moreover, the boundary control action may be located either at the external boundary of the outward domain, or else at the interface between the two media. In other cases, it is the model itself, long classical in the engineering literature, which represents the mathematical novelty. An example is the third order equation initially derived by G.G. Stokes in a paper of 1851, describing the radiation of heat on the propagation of sound. Such models have resurfaced since the 1960-70s with more recent contributions in the area of High Intensity Ultrasound. For these systems, a preliminary mathematical analysis was initiated very recently. It has concentrated so far on linear and nonlinear models with homogeneous boundary conditions. In contrast, a mathematical theory under the action of boundary controls is wholly unexplored. This area opens then unchartered territories in the corresponding study of control and optimal control theory.

continued in next column

Organizer: Lorena Bociu
North Carolina State University, USA

Organizer: Roberto Triggiani
University of Memphis, USA

2:30-2:55 Global Existence for Fluid-Structure Models

Mihaela Ignatova, Princeton University, USA; Igor Kukavica, University of Southern California, USA; Amjad Tuffaha, American University of Sharjah, United Arab Emirates; Irena M. Lasiecka, University of Memphis, USA

3:00-3:25 On the Muskat Flow

Gieri Simonett, Vanderbilt University, USA

3:30-3:55 Stabilization of Maxwell's Equations

Matthias Eller, Georgetown University, USA

Sunday, December 10

MS28

Recent Developments in Fluid Dynamics - Theory and Numerical Approximation - Part II of II

2:30 PM-4:30 PM

Room:314-Level 300

For Part 1 see MS19

The main purpose of this minisymposium is to bring together specialists in the field of theoretical and computational fluid dynamics. Over the past decades, mathematics and physics have found successful interactions through the study of various differential equations. In this regard, both the theoretical and applied points of view with topics including the regularity behavior of solutions, dynamics and numerical implementations are been considered. This minisymposium focuses on recent progresses in the development and applications of classical and computational fluid dynamics. The minisymposium aims to address some important issues such as the properties of solutions, existence, regularity, stability, asymptotic behaviors, and numerical approximations arising from nonlinear differential equations.

Organizer: Youngjoon Hong
University of Illinois, Chicago, USA

Organizer: Mimi Dai
University of Illinois, Chicago, USA

2:30-2:55 New Unilateral Problems Related to the Humid Atmosphere

Roger M. Temam, Indiana University, USA

3:00-3:25 Global Solutions for Active Hydrodynamics

Dehua Wang and *Rongfang Zhang*, University of Pittsburgh, USA

3:30-3:55 A Hamiltonian Preserving Discontinuous Galerkin Method for the Generalized Korteweg-De Vries Equation

Hailiang Liu, Iowa State University, USA

4:00-4:25 On the Local Well-posedness and a Prodi-Serrin Type Regularity Criterion of the Three-dimensional MHD-Boussinesq System without Thermal Diffusion

Adam Larios, University of Nebraska-Lincoln, USA

Sunday, December 10

MS29

Mathematical Analysis in Incompressible Fluid Dynamics - Part II of II

2:30 PM-4:30 PM

Room:315-Level 300

For Part 1 see MS20

Understanding the flow of incompressible fluids is at the heart of many problems in the natural sciences, such as aerodynamics, plasma physics, mathematical biology, chemical dynamics. Among the problems of interest, turbulence in fluid flow is particularly noteworthy, in view of its difficulty and its relevance in applications. Mathematically, the motion of incompressible fluids is governed by the incompressible Euler (inviscid) or Navier-Stokes (viscous) equations. The theory for these two systems of partial differential equations is far from complete, despite many decades of concerted effort. Recently, substantial progress has been acheived for the Euler equations, Navier-Stokes equations and related systems. We propose to bring experts from different institutions to discuss recent results and to stimulate closer collaboration among the members of the community.

Organizer: Mimi Dai
University of Illinois, Chicago, USA

Organizer: Helena Nussenzveig Lopes
Universidade Federal de Rio de Janeiro, Brazil

2:30-2:55 On the Hall-Magneto-Hydrodynamics System

Mimi Dai, University of Illinois, Chicago, USA

3:00-3:25 The Surface Quasi-geostrophic Equation in Domains with Boundaries

Huy Nguyen, Princeton University, USA

3:30-3:55 Non-decaying Solutions to the Euler Equations Part II: Uniqueness and Stability

Elaine Cozzi, Oregon State University, USA; James P. Kelliher, University of California, Riverside, USA

4:00-4:25 2D Incompressible Euler with Singular Vorticity

Tarek M. Elgindi, Princeton University, USA

Sunday, December 10

MS30

On Higher Order Methods for Numerical Solution of PDE - Part II of II

2:30 PM-4:30 PM

Room:316-Level 300

For Part 1 see MS21

Due to the computer power, higher order finite elements via Discontinuous Galerkin methods (DG), Weak-Galerkin methods (WG), Virtual finite elements (VFE), and Spline elements (SE) become available for numerical solutions of linear and nonlinear PDE in practice. Not only triangulation/tetrahedral partitions are used for higher order methods, but also use polygonal/polyhedral partitions for numerical solutions of PDE. This minisymposium will discuss recent development and advances in these higher order methods in several directions: numerical solution of Monge-Ampere equations, Maxwell equations in potential function formulation, construction of higher order elements on quadrilaterals and hexahedra, and orthogonal complements. A super convergence phenomenon in higher order method will be discussed.

Organizer: Ming-Jun Lai
University of Georgia, USA

2:30-2:55 Bernstein Bezier Basis for High Order Finite Elements on Tetrahedra and Hexahedra

Guosheng Fu, Brown University, USA

3:00-3:25 Construction of Smooth Gbc over Quadrilateral Partitions

James Lanterman, University of Georgia, USA

3:30-3:55 A New Regularity of the Solution to Dirichlet Problem of Poisson Equations and Its Applications

Ming-Jun Lai, University of Georgia, USA

4:00-4:25 A Primal-Dual Weak Galerkin Finite Element Method for Fokker-Planck Type Equations

Chunmei Wang, Texas State University, USA

Sunday, December 10

MS31

Recent Developments in Modeling, Control, Theoretical and Numerical Analysis of Complex Systems with Dynamic Boundaries - Part II of II

2:30 PM-4:30 PM

Room:322-Level 300

For Part 1 see MS22

Many outstanding open problems of modern science and engineering involve free boundaries whose dynamics are determined as a part of the solution. The analysis of the underlying PDE systems poses significant mathematical challenges. This minisymposium will highlight some recent advances in analytical and computational studies for such systems. Examples include inverse free boundary problems, optimal control of phase transition processes, projective gradient type methods in Besov-Sobolev spaces, multi-phase fluid mixture flow, inverse scattering problems, stochastic differential equations and optimal control, interfaces for nonlinear degenerate and singular parabolic PDEs, Wiener type criteria in potential theory and its measure theoretical, topological and probabilistic counterparts, classification of singularities for elliptic and parabolic PDEs, cancer detection models through electrical impedance tomography and optimal control theory.

Organizer: Jonathan Goldfarb
Florida Institute of Technology, USA

Organizer: Ugur G. Abdulla
Florida Institute of Technology, USA

continued in next column

2:30-2:55 Frechet Differentiability in Besov Spaces in the Optimal Control of Parabolic Free Boundary Problems

Jonathan Goldfarb and Ugur G. Abdulla, Florida Institute of Technology, USA

3:00-3:25 The Bayesian Formulation of EIT

Matthew M. Dunlop, California Institute of Technology, USA

3:30-3:55 Breast Cancer Detection through Electrical Impedance Tomography and Optimal Control Theory: Theoretical and Computational Analysis

Ugur G. Abdulla, Vladislav Bukshtynov, and *Saleheh Seif*, Florida Institute of Technology, USA

4:00-4:25 Evolution of Interfaces for the Nonlinear Double Degenerate Parabolic Equation of Turbulent Filtration with Absorption

Adam Prinkey, Ugur G. Abdulla, and Jian Du, Florida Institute of Technology, USA

Sunday, December 10

MS32

Nonlinear PDEs in Fluid Mechanics - Part II of IV

2:30 PM-4:30 PM

Room:317 -Level 300

For Part 1 see MS23
For Part 3 see MS41

The main purpose of this minisymposium is to bring senior mathematicians and junior researchers together to exchange the new ideas on the study of nonlinear partial differential equations, with emphasis on the models of fluid flows and related topics, especially on the structure of solutions, asymptotic behaviors of solutions, stability of nonlinear waves, and the related numerical computations.

Organizer: Geng Chen
University of Kansas, USA

Organizer: Xiaoqian Xu
Carnegie Mellon University, USA

Organizer: Cheng Yu
The University of Texas at Austin, USA

2:30-2:55 Critical Thresholds, Spectral Gap and Singular Kernels in Flocking Hydrodynamics

Eitan Tadmor, University of Maryland, USA

3:00-3:25 Barotropic Instability of Shear Flows

Zhiwu Lin, Georgia Institute of Technology, USA

3:30-3:55 Title Not Available At Time Of Publication

Ming Chen, University of Pittsburgh, USA

4:00-4:25 On the Muskat Problem with Viscosity Jump: Global in Time Results

Robert M. Strain, University of Pennsylvania, USA

Sunday, December 10

MS33

Mean Field Games and Applications - Part II of II

2:30 PM-4:30 PM

Room:318-Level 300

For Part 1 see MS24

Mean field games give a tractable way to model interactions among large populations of rational agents, using nonlinear coupled systems of partial differential equations. These models have many applications in economics, finance, and other social and biological sciences. Recent results on existence, regularity, and numerical algorithms for computing solutions rely on a variety of techniques to overcome difficulties created by the nonlinear forward-backward structure of the equations. Different approaches include regularity theory for parabolic equations, fixed point methods, optimal control of infinite dimensional systems, and the calculus of variations. This minisymposium will feature some of the latest advances in this direction, as well as applications related especially to economics.

Organizer: Jameson Graber
Baylor University, USA

Organizer: Maria Gualdani
George Washington University, USA

2:30-2:55 Energy Production and Mean Field Game Models

Ronnie Sircar, Princeton University, USA

3:00-3:25 Balanced Growth Path Solutions of a Boltzmann Mean Field Game for Knowledge Growth

Marie-Therese Wolfram, University of Warwick, United Kingdom

3:30-3:55 Singular Mean Field Games

Edgard Pimentel, Pontifical Catholic University of Rio de Janeiro, Brazil

4:00-4:25 Existence Theory for Mean Field Games with Non-Separable Hamiltonians

David Ambrose, Drexel University, USA

Sunday, December 10

MS34

Waves and Imaging Though Complex Media - Part II of II

2:30 PM-4:30 PM

Room:319-Level 300

For Part 1 see MS25

Wave-based imaging is an interdisciplinary area in applied mathematics, with roots in hyperbolic partial differential equations, probability theory, statistics, optimization, and numerical analysis. This minisymposium will present some of the latest advances in this area including inverse boundary value problems, imaging with cross correlation techniques, propagation and imaging in multiscale media and superresolution.

Organizer: Knut Solna
University of California, Irvine, USA

Organizer: Josselin Garnier
Ecole Polytechnique, France

2:30-2:55 Intensity Correlation Imaging in Random Media

Josselin Garnier, Ecole Polytechnique, France; Knut Solna, University of California, Irvine, USA

3:00-3:25 A One-step Reconstruction Method for Photoacoustics with Multispectral Data

Kui Ren, University of Texas at Austin, USA

3:30-3:55 Inverse Boundary Problems for Magnetic Schrodinger Operators in Transversally Anisotropic Geometries

Katya Krupchyk, University of California, Irvine, USA

4:00-4:25 Inverse Boundary Value Problem for the Anisotropic Elastic Wave Equation

Maarten de Hoop, Rice University, USA

Sunday, December 10

MS36

Graph Laplacians, Spectral Graph Theory, and Applications - Part II of II

2:30 PM-4:30 PM

Room:321-Level 300

For Part 1 see MS27

The Laplacian has dominated the theory of partial differential equations. Recently, its discrete analogues have turned out to be extremely versatile tools on graphs and have reinvigorated the field of classical spectral theory and given rise to the spectral theory of graphs with tremendous applications in pure and applied mathematics: most notably, we refer to new interactions with classical elliptic equations and the application in problems of dimensionality reduction. In the context of data, the spectrum and eigenvectors of the Laplacian characterizes the data's global properties while preserving the geometric and topological structure of the neighborhoods. When the geometry of the points is not simple, open questions emerge about localization of the eigenfunctions, and about using the eigenfunctions to efficiently represent signals on the points. Recently, ideas from the discrete setting have been successfully used to derive new results in the theory of classical elliptic equations, and some of the discrete ideas may have further impact in the classical continuous theory. Applications using the eigendecomposition of the Laplacian range from remote sensing and medical imaging to shape matching and unstructured tensor co-clustering. The goal of this workshop is to bring together theoretical and applied researchers to present and discuss recent advances in applied spectral graph theory, and to enable and facilitate future collaboration of the participants.

continued on next page

Sunday, December 10

MS36

Graph Laplacians, Spectral Graph Theory, and Applications - Part II of II

continued

Organizer: Alexander Cloninger
University of California, San Diego, USA

Organizer: Stefan Steinerberger
Yale University, USA

2:30-2:55 Laplacian Regularization for Localized Function Models

Alexander Cloninger, University of California, San Diego, USA

3:00-3:25 Jigsaw Puzzle and Graph Connection Laplacian

Vahan Huroyan, University of Minnesota, USA

3:30-3:55 Hierarchical Geometric Organization of Tensors

Gal Mishne, Yale University, USA

4:00-4:25 An Overview of Numerical Acceleration Techniques for Nonlinear Dimension Reduction

Wojciech Czaja, University of Maryland, College Park, USA

Sunday, December 10

CP7

Dispersive Equations

2:30 PM-4:30 PM

Room:323-Level 300

Chair: David W. Sulon, Drexel University, USA

2:30-2:45 A Determination and Comparison of Analytical and Numerical Soliton Solutions of the Coupled Nonlinear Klein-Gordon Equations As Used in Condensed Matter Physics

Matthew E. Edwards and Samuel Uba, Alabama A&M University, USA

2:50-3:05 Fractional Real and Distributed Order Models of Wave Propagation in Viscoelastic Media

Sanja Konjik, University of Novi Sad, Serbia

3:10-3:25 Soliton-Like Behavior in Fast Two-Pulse Collisions in Weakly Perturbed Linear Systems of Coupled-Pdes

Quan M. Nguyen, Vietnam National University at Ho Chi Minh City, Vietnam; Avner Peleg, Afeka-Tel-Aviv Academic College of Engineering, Israel; Toan Huynh, Vietnam National University at Ho Chi Minh City, Vietnam

3:30-3:45 Haar Wavelets Based Algorithms for Simulation of Hyperbolic Type Wave Equations

Sapna Pandit and Ramesh Chand Mittal, Indian Institute of Technology Roorkee, India

3:50-4:05 Small Amplitude Wave Propagation in Heterogeneous Media with Cracks: High and Low Frequency Approximations.

Viktoria Savatorova and Alexey Talonov, National Research Nuclear University, Russia

4:10-4:25 Periodic Traveling Interfacial Hydroelastic Waves with or Without Mass

David W. Sulon, Drexel University, USA; Benjamin Akers, Air Force Institute of Technology, USA; David Ambrose, Drexel University, USA

Sunday, December 10

CP8

Stability and Instability

2:30 PM-4:10 PM

Room:324-Level 300

Chair: Rana Parshad, Clarkson University, USA

2:30-2:45 Morphological Evolution of Crystal Surfaces below the Roughening Temperature:from Mesoscopic and Macroscopic View

Yuan Gao, Hong Kong University of Science and Technology, Hong Kong; Jian-guo Liu and Jianfeng Lu, Duke University, USA

2:50-3:05 A Class of Linear PDEs Describing Asymptotically Algebraically Unstable Waves

Nathaniel S. Barlow, Rochester Institute of Technology, USA; Kristina King, University of Virginia, USA; Steven Weinstein, Paula Zaretzky, and Michael Cromer, Rochester Institute of Technology, USA

3:10-3:25 Instability and Dynamics of a Generalized Volatile Thin Film Model

Hangjie Ji and Thomas P. Witelski, Duke University, USA

3:30-3:45 On the Explosive Instability in a Three-Species Food Chain Model with Modified Holling Type IV Functional Response

Rana Parshad, Clarkson University, USA; Ranjit Upadhyay, Swati Mishra, and Satish Ttiwari, Indian Institute of Technology, Dhanbad, India; Swarnali Sharma, Bengal Engineering and Science University, India

3:50-4:05 A Three-Field Formulation for Poroelasticity Equations and Its Solvability Via Fredholm Alternative

Ricardo Ruiz Baier, University of Oxford, United Kingdom; Ricardo Oyarzua, Universidad del Bío-Bío, Chile

Monday, December 11

Registration

8:00 AM-4:00 PM

Room:Charles Terrace -Level 300

MS26

Geometric Analysis and Analysis in Geometry - Part I of II

8:30 AM-10:30 AM

Room:315-Level 300

For Part 2 see MS35

The goal of this minisymposium is to bring together researchers that work on current trends in Geometric Analysis. In particular, the goal is to adress progress related to variational problems such as harmonic maps and minimal surfaces, and discuss related analytical problems and geometric questions.

Organizer: Armin Schikorra
University of Pittsburgh, USA

Organizer: Yannick Sire
Johns Hopkins University, USA

8:30-8:55 A Minimizing Problem Involving Nematic Liquid Crystal Droplets

Chang You Wang, Purdue University, USA

9:00-9:25 Lojasiewicz Inequalities for Yang-Mills and Harmonic Map Energy Functions

Paul Feehan, Rutgers University, USA

9:30-9:55 On Free Boundary Problems for Conformally Invariant Variational Functionals

Armin Schikorra, University of Pittsburgh, USA

10:00-10:25 Lavrentiev Gap Phenomena for Harmonic Maps

Katarzyna Mazowiecka, University of Warsaw, Poland

Monday, December 11

MS37

Regularity and Long-time Behavior of Fluid Flows - Part I of II

8:30 AM-10:30 AM

Room:314-Level 300

For Part 2 see MS46

This minisymposium will first and foremost address recent results regarding the regularity theory and qualitative or long-time behavior of solutions of hydrodynamic equations, especially the Navier-Stokes, Euler equations, and related equations. It will display several threads of inquiry into these issues, from many points of view. In addition to the classical incompressible setting, these perspectives are taken from the point of view of local and geometric frameworks, through density-dependent or compressible settings, as well as through the mechanisms of dispersion or stochastic forcing. The conception of this minisymposium was inspired by recent breakthrough works surrounding the Onsager conjecture, and more generally, of turbulent flows. Turbulence remains a rich source for several outstanding and important problems in both physics and mathematics. Indeed, it is well-known that the notion of turbulence is tied closely with the regularity and uniqueness of solutions to the equations of motion of, for instance, an incompressible fluid. This theme ultimately lies at the heart of this symposium. Lastly, our participants form a diverse group that includes both young and experienced researchers, from grad students to post-docs, and junior to senior faculty, each of whom have made contributions in the the above directions. We hope to inspire both collaboration and discussion among everyone involved.

continued in next column

Organizer: Aseel Farhat
University of Virginia, USA

Organizer: Vincent R. Martinez
Tulane University, USA

8:30-8:55 Eventual Regularity of Infinite Energy Solutions to the Navier-Stokes Equations

Zachary Bradshaw and Tai-Peng Tsai, University of British Columbia, Canada

9:00-9:25 The Energy Measure for the Euler and Navier-Stokes Equations

Trevor Leslie and Roman Shvydkoy, University of Illinois, Chicago, USA

9:30-9:55 An Onsager Singularity Theorem for the Compressible Euler Equations

Theodore D. Drivas, Princeton University, USA; Gregory L. Eyink, Johns Hopkins University, USA

10:00-10:25 Geometric Function Theory and Navier-Stokes Equations

Zoran Grujic, University of Virginia, USA; Zachary Bradshaw, University of British Columbia, Canada; Aseel Farhat, University of Virginia, USA

Monday, December 11

MS39

Recent Developments in Numerical Methods for PDEs and Their Applications - Part I of II

8:30 AM-10:30 AM

Room:316-Level 300

For Part 2 see MS48

Numerical Methods for partial differential equations and their analysis are important and challenging topics in applied and computational mathematics. This minisymposium is focused on recent developments in numerical methods for PDEs, including new developments in finite element methods and relevant applications. The goal of this minisymposium is to bring together leading researchers in the field of numerical methods to discuss and disseminate the latest results and envisage future challenges in traditional and new areas of science. The topics of the minisymposium covers a broad range of numerical methods, including but not limited to finite element methods, finite difference methods, discontinuous Galerkin methods, weak Galerkin methods, virtual element methods, and anisotropic methods. A wide range of application fields will also be covered, such as viscoelastic wave propagation, convection diffusion equations, Fokker-Planck equations and their application in stochastic systems and uncertainty quantification.

Organizer: Chunmei Wang

Texas State University, USA

8:30-8:55 Weak Galerkin Finite Element Methods

Junping Wang, National Science Foundation, USA

9:00-9:25 Saddle Point Least Squares Methods for Mixed Variational Formulations

Bacuta Constantin and Jacob Jacavage, University of Delaware, USA

9:30-9:55 Mathematical Analysis and Numerical Methods for an Underground Oil Recovery Model

Ying Wang, University of Oklahoma, USA

10:00-10:25 Macro Element Analysis for Axisymmetric Stokes Equations

YoungJu Lee, Texas State University, USA

Monday, December 11

MS40

Recent Advances in Conservation Laws and Transport Equations: Theory and Applications - Part I of II

8:30 AM-10:30 AM

Room:322-Level 300

For Part 2 see MS49

Nonlinear Conservation Laws result from the balance laws of continuum physics and govern a broad spectrum of physical phenomena in compressible fluid dynamics, nonlinear materials science, particle physics, semiconductors, combustion, multi-phase flows, astrophysics, and other applied areas. Typical examples are the Euler equations, MHD equations, Navier Stokes equations, Boltzmann equation, and other important models arising in Elasticity, Fluid Dynamics, Combustion, and Kinetic theory. The minisymposium is focused on recent advances on conservation laws and kinetic equations and aims to bring together researchers working in different aspects of field. There would be eight talks by distinguished mathematicians spread in two sessions on topics that include both theoretical and numerical results on nonlinear conservation laws. The minisymposium will highlight the role of PDEs in these application areas, bring together prominent mathematicians and also serve as a forum for the dissemination of new scientific ideas and discoveries and will enhance scientific communication. The theme of the workshop deals with several aspects of the theory of weak solutions for hyperbolic systems, the mathematical theory of transport equations that arise in the kinetic theory of gases, the investigation of the multidimensional Euler, relativistic Euler,Euler-Poisson, and Navier-Stokes equations, and related applications of nonlinear conservation laws to physical and geometric problems.

continued in next column

Organizer: Cleopatra Christoforou

University of Cyprus, Cyprus

Organizer: Konstantina Trivisa

University of Maryland, USA

8:30-8:55 Challenges to the Theory of Conservation Laws Posed by the Problem of Fracture

Athanasios Tzavaras, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

9:00-9:25 Transonic Solutions to Multidimensional Riemann Problems

Eun Heui Kim, California State University, Long Beach, USA

9:30-9:55 Radial Solutions to the Cauchy Problem for the Wave Equation as Limits of Exterior Solutions

Charis Tsikkou, West Virginia University, USA

10:00-10:25 On the Relative Entropy Method for Thermoviscoelasticity

Cleopatra Christoforou, University of Cyprus, Cyprus

Monday, December 11

MS41

Nonlinear PDEs in Fluid Mechanics - Part III of IV

8:30 AM-10:30 AM

Room:317 -Level 300

For Part 2 see MS32
For Part 4 see MS50

The main purpose of this minisymposium is to bring senior mathematicians and junior researchers together to exchange the new ideas on the study of nonlinear partial differential equations, with emphasis on the models of fluid flows and related topics, especially on the structure of solutions, asymptotic behaviors of solutions, stability of nonlinear waves, and the related numerical computations.

Organizer: Geng Chen
University of Kansas, USA

Organizer: Xiaoqian Xu
Carnegie Mellon University, USA

Organizer: Cheng Yu
The University of Texas at Austin, USA

8:30-8:55 Incompressible MHD Without Resistivity on Periodic Boxes
Ronghua Pan, Georgia Institute of Technology, USA

9:00-9:25 Energy Conservation for the Compressible Navier-Stokes Equations
Cheng Yu, The University of Texas at Austin, USA

9:30-9:55 Second Proof of the Global Regularity of the Two-Dimensional Mhd System with Full Diffusion and Arbitrary Weak Dissipation
Kazuo Yamazaki, University of Rochester, USA

10:00-10:25 Global Strong Solution to Compressible Navier-Stokes Equations with Heat Conduction in Three Dimensions
Huanyao Wen, South China University of Technology, China

Monday, December 11

MS42

Kinetic and Mean-field Models in Socio-economics and Life Sciences - Part I of II

8:30 AM-10:30 AM

Room:318-Level 300

For Part 2 see MS51

Real-world systems in socio-economics and life sciences often consist of a large number of interacting individuals or particles. These interactions often initiate formation of complex patterns, such as aggregation or segregation. Kinetic and mean-field models allow to describe and analyse these complex macroscopic phenomena, rather than following the individual dynamics. This approach was initially developed in the field of statistical physics, but has been used successfully for different applications in socio-economic and life sciences. This minisymposium will highlight recent advances in this area, with applications like congestion models, population dynamics, price and opinion formation. It aims to initiate discussions of researchers in the field of mathematical modelling, analysis of nonlinear PDE and numerical methods to advance further on important questions on linear stability of stationary solutions, aggregation phenomena or the development of efficient numerical methods.

Organizer: Bertram Düring
University of Sussex, United Kingdom

Organizer: Marie-Therese Wolfram
University of Warwick, United Kingdom

8:30-8:55 Inhomogeneous Boltzmann-Type Equations Modelling Opinion Leadership and Political Segregation
Bertram Düring, University of Sussex, United Kingdom

9:00-9:25 On a Boltzmann Mean Field Model for Knowledge Growth
Alexander Lorz, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

continued in next column

9:30-9:55 Traveling Waves in Myxobacteria - An Age-Structured Model
Angelika Manhart, Courant Institute of Mathematical Sciences, New York University, USA; Pierre Degond, Imperial College of London, United Kingdom; Hui Yu, RWTH Aachen University, Germany

10:00-10:25 Opinion Dynamics over Kinetic Networks
Mattia Zanella, Politecnico di Torino, Italy

Monday, December 11

MS43

Coupled Nonlinear PDEs, Solitons, and Nonlinear Dynamics - Part I of II

8:30 AM-10:30 AM

Room:319-Level 300

For Part 2 see MS52

Systems of coupled nonlinear PDEs play an important role in a wide range of fields, including optics, water waves, Bose Einstein condensates, and elastic materials. This minisymposium will present progress in research in this area, covering both analysis and results obtained by numerical simulations. The focus will be on systems of PDEs possessing soliton solutions, stability analysis for these solutions, and reduced dynamical descriptions. Other topics that will be covered are soliton collisions, destabilization due to four-wave resonances, stabilization methods, formation of rogue waves, and chaotic and turbulent dynamics.

Organizer: Avner Peleg

Afeka-Tel-Aviv Academic College of Engineering, Israel

Organizer: Debananda Chakraborty

New Jersey City University, USA

Organizer: Quan M. Nguyen

Vietnam National University at Ho Chi Minh City, Vietnam

8:30-8:55 Wave Turbulence: A Story Far from Over

Alan Newell, University of Arizona, USA

9:00-9:25 Orbital Stability of Domain Walls in Coupled Gross-Pitaevskii Systems

Dmitry Pelinovsky, McMaster University, Canada

9:30-9:55 Coupling Between Internal and Surface Waves

Philippe Guyenne, University of Delaware, USA

continued in next column

10:00-10:25 Coupled Nonlinear Schrödinger Equations, Lotka-Volterra Models, and Nonlinear Dynamics of Optical Soliton Amplitudes

Avner Peleg, Afeka-Tel-Aviv Academic College of Engineering, Israel; Quan M. Nguyen, Vietnam National University at Ho Chi Minh City, Vietnam; Debananda Chakraborty, New Jersey City University, USA; Toan Huynh, Vietnam National University at Ho Chi Minh City, Vietnam

Monday, December 11

MS44

Recent Development of the Mathematical Theory in Complex Fluids - Part I of II

8:30 AM-10:30 AM

Room:320-Level 300

For Part 2 see MS53

Complex fluids have been extremely important subjects in material sciences and fluid mechanical engineering. They include viscoelastic fluids, magneto-hydrodynamic fluids, liquid crystal flow, two-phase flow, etc. A common feature of complex fluids are different elastic effects, in which competition between kinetic energy and elastic energy produces many different rheological and hydrodynamic properties. Recently, they have generated great research interests to mathematically analyze such systems by many people. As consequences, there have seen many exciting works in last few years. This session intends to bring some active researchers in the field together to share their new findings, exchange new ideas, and propose some new directions and problems for future studies.

Organizer: Xiang Xu

Old Dominion University, USA

8:30-8:55 Vortex Filament Clustering in 3D Ginzburg-Landau

Andres A. Contreras, New Mexico State University, USA

9:00-9:25 External Field Response of Smectic A Liquid Crystals in Three Dimensions

Sookyung Joo, Old Dominion University, USA

9:30-9:55 High Dimensional Ginzburg-Landau Equations under Weak Anchoring Boundary Conditions

Changyou Wang, Purdue University, USA

10:00-10:25 (-1)-Homogeneous Solutions of Stationary Incompressible Navier-Stokes Equations with Singular Rays

Xukai Yan, Georgia Institute of Technology, USA; Li Li, Harbin Institute of Technology, China; YanYan Li, Rutgers University, USA

Monday, December 11

MS45

Analysis, Control, and Long-time Behavior of Fluid and Flow-Structure Models - Part I of II

8:30 AM-10:30 AM

Room:321-Level 300

For Part 2 see MS54

The minisymposium will feature researchers who will present their recent results for those evolution PDE's that describe: (i) fluid flows, as they occur in nature or within a given engineered mechanical system; (ii) coupled fluid-structure PDE models, in which the coupling between the PDE components generally takes place on a boundary interface between two geometrical domains, domains within which each PDE evolves (e.g., a fluid PDE in a three dimensional cavity interacting with a structural plate PDE which evolves on a portion of the two dimensional cavity wall). With respect to these classes of PDE dynamics, the minisymposium speakers will address issues of wellposedness, qualitative analysis---including issues of long time behavior and stability -- and numerical analysis. In addition, we anticipate that some of the Speakers will discuss their recent work on answering certain control theoretic questions for fluid and fluid-structure PDE models, e.g.: (i) the minimization of some associated and physically relevant cost functional, which generally quantifies the underlying energy of the PDE system, and which penalizes the state of the equation as well as the control term within the PDE; (ii) subsequent optimal control synthesis.

Organizer: Justin T. Webster
University of Maryland, Baltimore County, USA

Organizer: George Avalos
University of Nebraska-Lincoln, USA

continued in next column

8:30-8:55 H^2 Solutions and z-Weak Solutions for 3D Viscous Primitive Equations

Ning Ju, Oklahoma State University, USA

9:00-9:25 The Data Assimilation Map and Its Applications to the Foias-Prodi Statistical Solutions of the Navier-Stokes Equations

Animikh Biswas, University of Maryland, Baltimore County, USA

9:30-9:55 Porous Media Flow: Analysis and Applications in Biomechanics

Lorena Bociu, North Carolina State University, USA

10:00-10:25 Exponential Stability Analysis for a Compressible Flow-Structure Pde Model

Pelin Guven Geredeli and George Avalos, University of Nebraska-Lincoln, USA

Monday, December 11

CP9

Reaction Diffusion Systems and Pattern Formation

8:30 AM-10:10 AM

Room:323-Level 300

Chair: Judith R. Miller, Georgetown University, USA

8:30-8:45 Controllability of Nonlinear Reaction-Diffusion Equations

Giuseppe Floridia, University of Naples "Frederico II", Naples, Italy

8:50-9:05 Homogenization and Concentrated Capacity for the Heat Equation with Two Kinds of Microstructures

Laura Keller, ETH Zürich, Switzerland

9:10-9:25 The Kirkpatrick-Barton Reaction-Diffusion System in Spatial Evolutionary Ecology

Judith R. Miller, Georgetown University, USA

9:30-9:45 Global Existence and Uniform Estimates for Volume Surface Reaction Diffusion Systems

Vandana Sharma, Arizona State University, USA; Jeff Morgan, University of Houston, USA

9:50-10:05 Numerical Simulation to Capture the Pattern Formation

Sukhveer Singh, Thapar University, India

Coffee Break

10:30 AM-10:55 AM

Room:309/310 -Level 300

Announcements

10:55 AM-11:00 AM

Room:307/308 - Level 300

Monday, December 11

IP5

Regularity Theory in Elliptic Free Boundary Problems

11:00 AM-11:45 AM

Room:307/308 - Level 300

Chair: Changyou Wang, Purdue University, USA

In this talk, we will describe several examples of free boundary problems motivated by problems in the applied sciences. In particular, we will discuss the so-called two-phase free boundary problem, the thin free boundary problem, the obstacle problem and the two-membranes problem. We will focus mainly on the question of regularity of weak solutions and their free boundaries. Some open problems will also be highlighted. The most recent results in the talk are part of joint works with L. Caffarelli and O. Savin.

Daniela De Silva
Columbia University, USA

Monday, December 11

IP6

Partial Differential Equations of Mixed Elliptic-Hyperbolic Type: From Mechanics to Geometry

11:45 AM-12:30 PM

Room:307/308 - Level 300

Chair: Athanasios Tzavaras, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

As is well-known, two of the basic types of linear PDEs are elliptic and hyperbolic types, following the classification for linear PDEs proposed by Jacques Hadamard in the 1920s; and linear theories of PDEs of these two types have been considerably established, respectively. On the other hand, many nonlinear PDEs arising in many areas from mechanics to geometry naturally are of mixed elliptic-hyperbolic type. The solution of some longstanding fundamental problems in these areas greatly requires a deep understanding of such nonlinear PDEs of mixed type. Important examples include transonic shock problems in fluid mechanics (the Euler equations) and isometric embedding problems in differential geometry (the Gauss-Codazzi-Ricci equations). In this talk, we will present natural connections of nonlinear PDEs of mixed elliptic-hyperbolic type with these longstanding problems and will then discuss some of the most recent developments in the analysis of these nonlinear PDEs through the examples with emphasis on developing and identifying mathematical approaches, ideas, and techniques for dealing with the mixed-type problems. Further trends, perspectives, and open problems in this direction will also be addressed.

Gui-Qiang Chen
University of Oxford, United Kingdom

Lunch Break

12:30 PM-2:00 PM

Attendees on their own

Monday, December 11

SP1

SIAG/Analysis of Partial Differential Equations Prize Lecture: Stochastic Homogenization

2:00 PM-2:45 PM

Room:307/308 - Level 300

Chair: Eitan Tadmor, University of Maryland, USA

Several years ago, with Charles Smart we revisited a variational approach to random homogenization introduced by Dal Maso and Modica in the 1980s for elliptic equations in divergence form. We showed that their old ideas could be combined with some new convex analytic methods to obtain quantitative estimates on the rate of homogenization. Furthermore, we showed that these quantitative estimates imply regularity results for the solutions on large scales. In this talk I will review these results and explain how in recent joint work with Kuusi and Mourrat we have taken them further: the variational perspective leads to a rigorous "renormalization group' argument, eventually yielding an optimal theory of stochastic homogenization for linear elliptic equations.

Scott Armstrong
Courant Institute of Mathematical Sciences, New York University, USA

Coffee Break

2:45 PM-3:15 PM

Room:Charles Terrace -Level 300

Monday, December 11

MS35

Geometric Analysis and Analysis in Geometry - Part II of II

3:15 PM-5:15 PM

Room:315-Level 300

For Part 1 see MS26

The goal of this minisymposium is to bring together researchers that work on current trends in Geometric Analysis. In particular, the goal is to adress progress related to variational problems such as harmonic maps and minimal surfaces, and discuss related analytical problems and geometric questions.

Organizer: Armin Schikorra
University of Pittsburgh, USA

Organizer: Yannick Sire
Johns Hopkins University, USA

3:15-3:40 A Fully Nonlinear Sobolev Trace Inequality

Wang Yi, Johns Hopkins University, USA

3:45-4:10 Harmonic Maps into Metric Spaces with Upper Curvature Bounds

Christine Breiner, Fordham University, USA

4:15-4:40 Almgren-Pitts Min-Max and the Space of Minimal Hypersurfaces

Nicolau Aiex, University of British Columbia, Canada

4:45-5:10 Rigidity in Npc Metric Spaces

Giorgios Daskalopoulos, Brown University, USA

Monday, December 11

MS46

Regularity and Long-time Behavior of Fluid Flows - Part II of II

3:15 PM-5:15 PM

Room:314-Level 300

For Part 1 see MS37

This minisymposium will first and foremost address recent results regarding the regularity theory and qualitative or long-time behavior of solutions of hydrodynamic equations, especially the Navier-Stokes, Euler equations, and related equations. It will display several threads of inquiry into these issues, from many points of view. In addition to the classical incompressible setting, these perspectives are taken from the point of view of local and geometric frameworks, through density-dependent or compressible settings, as well as through the mechanisms of dispersion or stochastic forcing. The conception of this minisymposium was inspired by recent breakthrough works surrounding the Onsager conjecture, and more generally, of turbulent flows. Turbulence remains a rich source for several outstanding and important problems in both physics and mathematics. Indeed, it is well-known that the notion of turbulence is tied closely with the regularity and uniqueness of solutions to the equations of motion of, for instance, an incompressible fluid. This theme ultimately lies at the heart of this symposium. Lastly, our participants form a diverse group that includes both young and experienced researchers, from grad students to post-docs, and junior to senior faculty, each of whom have made contributions in the the above directions. We hope to inspire both collaboration and discussion among everyone involved.

continued in next column

Organizer: Aseel Farhat
University of Virginia, USA

Organizer: Vincent R. Martinez
Tulane University, USA

3:15-3:40 Global Stability of Solutions to a Beta-Plane Equation

Klaus Widmayer, Brown University, USA; Fabio Pusateri, Princeton University, USA

3:45-4:10 Dispersion of Vorticity in Solutions of the Euler-Alpha Equations

Helena Nussenzveig Lopes, Universidade Federal de Rio de Janeiro, Brazil

4:15-4:40 Numerical Analysis of the Stochastic Navier-Stokes Equation

Nathan Glatt-Holtz, Tulane University, USA

4:45-5:10 Global Regularity for Burgers Equation with Density Dependent Fractional Dissipation

Changhui Tan, Rice University, USA

Monday, December 11

MS48

Recent Developments in Numerical Methods for PDEs and Their Applications - Part II of II

3:15 PM-5:15 PM

Room:316-Level 300

For Part 1 see MS39

Numerical Methods for partial differential equations and their analysis are important and challenging topics in applied and computational mathematics. This minisymposium is focused on recent developments in numerical methods for PDEs, including new developments in finite element methods and relevant applications. The goal of this minisymposium is to bring together leading researchers in the field of numerical methods to discuss and disseminate the latest results and envisage future challenges in traditional and new areas of science. The topics of the minisymposium covers a broad range of numerical methods, including but not limited to finite element methods, finite difference methods, discontinuous Galerkin methods, weak Galerkin methods, virtual element methods, and anisotropic methods. A wide range of application fields will also be covered, such as viscoelastic wave propagation, convection diffusion equations, Fokker-Planck equations and their application in stochastic systems and uncertainty quantification.

Organizer: Chunmei Wang

Texas State University, USA

3:15-3:40 High Order Scheme with Exponential Fitting for Convection Diffusion Equations

Ludmil Zikatanov, Pennsylvania State University, USA

continued in next column

3:45-4:10 Fully Discrete Models in Viscoelastic Wave Propagation

Thomas S. Brown and Francisco J. Sayas, University of Delaware, USA

4:15-4:40 New Anisotropic Fems on Polyhedral Domains

Hengguang Li, Wayne State University, USA

4:45-5:10 Lowest-order Weak Galerkin Finite Element Method for Darcy Flow on General Polygonal Meshes

James Liu, Colorado State University, USA

Monday, December 11

MS49

Recent Advances in Conservation Laws and Transport Equations: Theory and Applications - Part II of II

3:15 PM-5:15 PM

Room:322-Level 300

For Part 1 see MS40

Nonlinear Conservation Laws result from the balance laws of continuum physics and govern a broad spectrum of physical phenomena in compressible fluid dynamics, nonlinear materials science, particle physics, semiconductors, combustion, multi-phase flows, astrophysics, and other applied areas. Typical examples are the Euler equations, MHD equations, Navier Stokes equations, Boltzmann equation, and other important models arising in Elasticity, Fluid Dynamics, Combustion, and Kinetic theory. The minisymposium is focused on recent advances on conservation laws and kinetic equations and aims to bring together researchers working in different aspects of field. There would be eight talks by distinguished mathematicians spread in two sessions on topics that include both theoretical and numerical results on nonlinear conservation laws. The minisymposium will highlight the role of PDEs in these application areas, bring together prominent mathematicians and also serve as a forum for the dissemination of new scientific ideas and discoveries and will enhance scientific communication. The theme of the workshop deals with several aspects of the theory of weak solutions for hyperbolic systems, the mathematical theory of transport equations that arise in the kinetic theory of gases, the investigation of the multidimensional Euler, relativistic Euler,Euler-Poisson, and Navier-Stokes equations, and related applications of nonlinear conservation laws to physical and geometric problems.

continued on next page

Organizer: Cleopatra Christoforou
University of Cyprus, Cyprus

Organizer: Konstantina Trivisa
University of Maryland, USA

3:15-3:40 Eulerian and Lagrangian Solutions to the Continuity and Euler Equations with L^1 Vorticity

Gianluca Crippa and Camilla Nobili, University of Basel, Switzerland; Christian Seis, Universität Bonn, Germany; Stefano Spirito, University of L'Aquila, Italy

3:45-4:10 Recent Progress for Large Solutions of the p-system

Geng Chen, University of Kansas, USA

4:15-4:40 Invariant Measures for the Stochastic One-dimensional Compressible Navier-Stokes Equations

Michele Coti Zelati, University of Maryland, USA

4:45-5:10 Convergence Rates of Finite Difference Schemes for the Linear Advection and Wave Equation with Rough Coefficient

Franziska Weber, University of Maryland, USA

MS50

Nonlinear PDEs in Fluid Mechanics-Part iv of iv

CANCELLED

Monday, December 11

MS51

Kinetic and Mean-field Models in Socio-economics and Life Sciences - Part II of II

3:15 PM-5:15 PM

Room:318-Level 300

For Part 1 see MS42

Real-world systems in socio-economics and life sciences often consist of a large number of interacting individuals or particles. These interactions often initiate formation of complex patterns, such as aggregation or segregation. Kinetic and mean-field models allow to describe and analyse these complex macroscopic phenomena, rather than following the individual dynamics. This approach was initially developed in the field of statistical physics, but has been used successfully for different applications in socio-economic and life sciences. This minisymposium will highlight recent advances in this area, with applications like congestion models, population dynamics, price and opinion formation. It aims to initiate discussions of researchers in the field of mathematical modelling, analysis of nonlinear PDE and numerical methods to advance further on important questions on linear stability of stationary solutions, aggregation phenomena or the development of efficient numerical methods.

Organizer: Bertram Düring
University of Sussex, United Kingdom

Organizer: Marie-Therese Wolfram
University of Warwick, United Kingdom

continued in next column

3:15-3:40 Agent-based Model of the Effect of Globalization on Inequality and Class Mobility

Theodore Kolokolnikov, Joep Evers, John Rumsey, and David Iron, Dalhousie University, Canada

3:45-4:10 Variational Mean Field Games for Market Competition with Renewable Resources

Jameson Graber, Baylor University, USA; Charafeddine Mouzouni, Ecole Centrale de Lyon, France

4:15-4:40 Continuum Descriptions of the Vicsek Model

Alethea Barbaro, Case Western Reserve University, USA

4:45-5:10 Kinetic Games and Insurance Plans

Daniel Brinkman, San Jose State University, USA; Christian Ringhofer, Arizona State University, USA

Monday, December 11

MS52

Coupled Nonlinear PDEs, Solitons, and Nonlinear Dynamics - Part II of II

3:15 PM-5:15 PM

Room:319-Level 300

For Part 1 see MS43

Systems of coupled nonlinear PDEs play an important role in a wide range of fields, including optics, water waves, Bose Einstein condensates, and elastic materials. This minisymposium will present progress in research in this area, covering both analysis and results obtained by numerical simulations. The focus will be on systems of PDEs possessing soliton solutions, stability analysis for these solutions, and reduced dynamical descriptions. Other topics that will be covered are soliton collisions, destabilization due to four-wave resonances, stabilization methods, formation of rogue waves, and chaotic and turbulent dynamics.

Organizer: Avner Peleg

Afeka-Tel-Aviv Academic College of Engineering, Israel

Organizer: Debananda Chakraborty

New Jersey City University, USA

Organizer: Quan M. Nguyen

Vietnam National University at Ho Chi Minh City, Vietnam

3:15-3:40 Rogue Waves and Large Deviations in Nonlinear Schroedinger Models

Eric Vanden-Eijnden, Courant Institute of Mathematical Sciences, New York University, USA

3:45-4:10 Multi-Component Nonlinear Waves in Optics and Atomic Condensates: Theory, Computations and Experiments

Panayotis Kevrekidis, University of Massachusetts, USA

continued in next column

4:15-4:40 Nonlinear Optics Models in Some Nonperturbative Regimes

Emmanuel Lorin, Carleton University, Canada

4:45-5:10 Stabilizing the Propagation of Colliding Soliton Sequences of Nonlinear Schrödinger Models with Frequency Dependent Linear Gain-Loss

Debananda Chakraborty, New Jersey City University, USA; Avner Peleg, Afeka-Tel-Aviv Academic College of Engineering, Israel; Quan M. Nguyen., Vietnam National University at Ho Chi Minh City, Vietnam

Monday, December 11

MS53

Recent Development of the Mathematical Theory in Complex Fluids - Part II of II

3:15 PM-5:15 PM

Room:320-Level 300

For Part 1 see MS44

Complex fluids have been extremely important subjects in material sciences and fluid mechanical engineering. They include viscoelastic fluids, magneto-hydrodynamic fluids, liquid crystal flow, two-phase flow, etc. A common feature of complex fluids are different elastic effects, in which competition between kinetic energy and elastic energy produces many different rheological and hydrodynamic properties. Recently, they have generated great research interests to mathematically analyze such systems by many people. As consequences, there have seen many exciting works in last few years. This session intends to bring some active researchers in the field together to share their new findings, exchange new ideas, and propose some new directions and problems for future studies.

Organizer: Xiang Xu

Old Dominion University, USA

3:15-3:40 Global Well-Posedness for Dynamical Models of Nematic Liquid Crystals

Francesco de Anna, Pennsylvania State University, USA

3:45-4:10 Least Action Principles for Incompressible Flows and Optimal Transport Between Shapes

Jian-guo Liu, Duke University, USA

4:15-4:40 Analysis of a One-Dimensional Landau-De Gennes Model for Bent-Core Liquid Crystals

Tiziana Giorgi, New Mexico State University, USA

4:45-5:10 Liquid Crystal Electrokinetics

Carme Calderer, University of Minnesota, USA

Monday, December 11

MS54

Analysis, Control, and Long-time Behavior of Fluid and Flow-Structure Models - Part II of II

3:15 PM-5:15 PM

Room:321-Level 300

For Part 1 see MS45

The minisymposium will feature researchers who will present their recent results for those evolution PDE's that describe: (i) fluid flows, as they occur in nature or within a given engineered mechanical system; (ii) coupled fluid-structure PDE models, in which the coupling between the PDE components generally takes place on a boundary interface between two geometrical domains, domains within which each PDE evolves (e.g., a fluid PDE in a three dimensional cavity interacting with a structural plate PDE which evolves on a portion of the two dimensional cavity wall). With respect to these classes of PDE dynamics, the minisymposium speakers will address issues of wellposedness, qualitative analysis--- including issues of long time behavior and stability -- and numerical analysis. In addition, we anticipate that some of the Speakers will discuss their recent work on answering certain control theoretic questions for fluid and fluid-structure PDE models, e.g.: (i) the minimization of some associated and physically relevant cost functional, which generally quantifies the underlying energy of the PDE system, and which penalizes the state of the equation as well as the control term within the PDE; (ii) subsequent optimal control synthesis.

Organizer: Justin T. Webster

University of Maryland, Baltimore County, USA

Organizer: George Avalos

University of Nebraska-Lincoln, USA

continued in next column

3:15-3:40 Distributed Controllability of Elastic Systems Enclosing a Linear Potential Fluid

Scott Hansen, Iowa State University, USA

3:45-4:10 Uniform Stability to Non-Trivial Equilibrium of a Fluid-Structure Interaction Via Interior Feedback Control

Yongjin Lu, Virginia State University, USA

4:15-4:40 Spectral Analysis and Control Problems for Mathematical Model of Energy Harvester

Marianna Shubov, University of New Hampshire, USA

4:45-5:10 Analyticity, Spectral Analysis, and Uniform Stability of a Heat-viscoelastic Plate Interaction Model

Roberto Triggiani, University of Memphis, USA

Monday, December 11

CP10

Boundary Condition Problems

3:15 PM-5:15 PM

Room:323-Level 300

Chair: Xin Yang, Michigan State University, USA

3:15-3:30 How Robin Meets Dirichlet

Giles Auchmuty, University of Houston, USA

3:35-3:50 Recent Development in the Boltzmann Equation in Bounded Domains

Donghyun Lee and Chanwoo Kim, University of Wisconsin, Madison, USA

3:55-4:10 Asymptotic Investigation of a Nonlinear Initial-Boundary-Value Problem for a Light Multi-Tethered Sphere in Uniform and Modulated Flows

La Mi and Oded Gottlieb, Technion Israel Institute of Technology, Israel

4:15-4:30 A Generalization of the Lions-Aubin-Simon Compactness Lemma to Problems on Moving Domains

Boris Muha, University of Zagreb, Croatia

4:35-4:50 L^p Estimates and Higher Regularity for Semilinear Spdes with Monotone Semilinearity

Neelima Neelima and David Siska, University of Edinburgh, United Kingdom

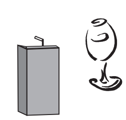
4:55-5:10 Lower Bounds of the Blow-Up Time under the Local Nonlinear Neumann Boundary Condtions

Xin Yang and Zhengfang Zhou, Michigan State University, USA

Intermission

5:15 PM-5:30 PM

SIAG/APDE Business Meeting



5:30 PM-6:15 PM

Room:307/308 - Level 300

Complimentary beer and wine will be served.

Tuesday, December 12

Registration

8:00 AM-3:00 PM

Room:Charles Terrace -Level 300

MS55

Modeling and Analysis of Condensed Matter Systems - Part I of II

8:30 AM-10:30 AM

Room:314-Level 300

For Part 2 see MS63

The minisymposium will focus on investigations of phases of condensed mater systems such as liquid crystals, superconductors, and ferromagnets. These materials are the subject of intense scientific work, since they have a wide range of significant technological applications. However, understanding their interesting physical behaviors is challenging both in the modeling and in the analysis. The objective of our minisymposium is to provide a forum via a diverse dynamic group of junior scientists, who have already shown an ability to make significant contributions to the area, to discuss recent advances in the mathematical study of these materials.

Organizer: Tiziana Giorgi
New Mexico State University, USA

Organizer: Sookyung Joo
Old Dominion University, USA

8:30-8:55 Force Convergence in Phase Field Models

Shibin Dai, University of Alabama, USA; Bo Li, University of California, San Diego, USA; Jianfeng Lu, Duke University, USA

continued in next column

9:00-9:25 An Elementary Proof to the Eigenvalue Preservation Property in the Beris-Edwards System

Xiang Xu, Old Dominion University, USA

9:30-9:55 Gradient Flow for a Relaxed Model for Bent-Core Liquid Crystals

Tiziana Giorgi, New Mexico State University, USA; Sookyung Joo, Old Dominion University, USA; *Lidia Mrad*, University of Arizona, USA

10:00-10:25 Evolution Equations from Epitaxial Growth

Xin Yang Lu, McGill University, Canada

Tuesday, December 12

MS56

PDEs Arising from the Self-organization of Agents

8:30 AM-10:30 AM

Room:315-Level 300

Self-organization and collective motion describe many applications, including traffic flow, swarming and flocking, vasculogenesis, and early development. Many of these emergent dynamics and patterns, though disparate in application, share similar features: long-range communication, repulsive and attractive forces, noise, fluctuations in population size, and multiple types of agents. While discrete approaches allow for a detailed description of agent interactions, these models are typically not analytically tractable. PDEs, in contrast, lend themselves to analysis, but it is less clear how to account for features of the underlying application (e.g. long-range interactions) and what overarching mechanism is present (e.g. short-range activation and long-range inhibition or density-dependent motion). Motivated by this challenge, this minisymposium presents a range of PDE approaches to agent-based dynamics, including aggregation equations, conservation laws, and reaction-diffusion frameworks. By bringing together researchers exploring continuum limits of discrete dynamics from different perspectives, we hope to enable a cross-fertilization of ideas between applications and continuum approaches.

Organizer: Alexandria Volkening
Brown University, USA

8:30-8:55 Agent-Based and Continuum Models for Stripe Formation on the Fins of Zebrafish

Alexandria Volkening, and Bjorn Sandstede, Brown University, USA

continued in next page

9:00-9:25 Agent-Based and Continuous Models of Locust Hopper Bands: The Role of Intermittent Motion, Alignment and Attraction

Andrew J. Bernoff, Harvey Mudd College, USA; Chad Topaz, Williams College, USA

9:30-9:55 Macroscopic Models for Mixed Human-Autonomous Vehicle Traffic Flow

Benjamin Seibold, Temple University, USA

10:00-10:25 Small Noise - Huge Pattern Changes: Predicting Large Fluctuations in High Dimensional Systems

Ira B. Schwartz, Jason Hindes, and Klementyna Szwaykowska, US Naval Research Laboratory, USA

Tuesday, December 12

MS57

Recent Development in Numerical Methods for Optics and Plasmonics - Part I of II

8:30 AM-10:30 AM

Room:316-Level 300

For Part 2 see MS64

The main purpose of this mini-symposium is to bring together specialists in the numerical simulation of optical phenomena. The past few decades have seen impressive advances in the understanding of electromagnetics at the nanoscale. Driven by spectacular discoveries in the design capabilities of materials at these scales, there has been significant recent growth in the field of nano-optics. In particular, algorithm design, analysis, application, and implementations of mathematical models in the area are now at the heart everyday technologies such as extraordinary optical transmission, surface enhanced spectroscopy, and surface plasmon resonance biosensing. Nevertheless, some very important issues still remain open. It is anticipated that participants will report on their latest developments, interact with one another, and chart future research agendas. This mini symposium will be designed around important areas of application where applied and computational mathematics has a large role to play.

Organizer: David P. Nicholls

University of Illinois, Chicago, USA

Organizer: Youngjoon Hong

University of Illinois, Chicago, USA

8:30-8:55 Well-Conditioned Boundary Integral Equation Formulations and Nystrom Discretizations for the Solution of Helmholtz Problems with Impedance Boundary Conditions in Two-Dimensional Lipschitz Domains

Catalin Turc, New Jersey Institute of Technology, USA

continued in next column

9:00-9:25 Modeling and Computation of Nano-Optics

Di Liu, Michigan State University, USA

9:30-9:55 Heterogeneous Fast Multipole Method for 2-D Wave Scattering in Layered Media

Min Hyung Cho, University of Massachusetts, Lowell, USA; Jinfang Huang and Dangxing Chen, University of North Carolina at Chapel Hill, USA; Wei Cai, University of North Carolina, Charlotte, USA

10:00-10:25 Stable, High-Order Computation of Impedance-Impedance Operators

David P. Nicholls, University of Illinois, Chicago, USA

Tuesday, December 12

MS58

Singular Solutions of Parabolic and Elliptic Problems and their Applications

8:30 AM-10:30 AM

Room:322-Level 300

Formation and dynamics of singularities play an important role in quantitative analysis of wide variety of phenomena arising in physics, biology, chemistry and other disciplines.The minisymposium will focus on new results in the analysis of singular solutions of local and non-local parabolic and elliptic problems. Specifically, speakers will address questions regarding free discontinuity problems for singular integral operators, regimes with blow up in models arising in mathematical theories of chemotaxis and thermal explosion and singular solutions arising in density functional theory of charge screening in graphene.

Organizer: Peter Gordon

Kent State University, USA

8:30-8:55 Suppression of Chemotactic Explosion by Mixing

Alexander Sasha Kiselev, Duke University, USA

9:00-9:25 Free Discontinuity Problems Associated to Singular Integral Operators

Benjamin Jaye, Kent State University, USA

9:30-9:55 Density Functional Theory of Charge Screening in Graphene

Vitaly Moroz, Swansea University of South Wales, United Kingdom

10:00-10:25 Gelfand Type Problems for Reactive Turbulent Jets

Peter Gordon, Kent State University, USA

Tuesday, December 12

MS59

Nonlinear PDEs in Fluid Dynamics: Deterministic and Probabilistic Approaches - Part I of II

8:30 AM-10:30 AM

Room:317 -Level 300

For Part 2 see MS66

Stochastic Partial Differential Equations find application in diverse disciplines such as mechanical engineering, economics and finance, signal processing, physics and chemistry. Note that it is natural to introduce stochastic evolution equations to model physical systems whenever relevant sources of noise, instability and perturbations are present, as is the case, for example, in modeling of complex ocean-atmospheric phenomena.

Fluid dynamics is a rich field of classical and modern scientific investigation both because of important applications in engineering and meteorology and because of certain fundamental open questions of mathematical and physical nature.

The aim of the minisymposium is to bring together researchers working on nonlinear PDEs with application to fluids. Some of the presenters are using probabilistic tools while others are using deterministic ones. The common goal is to get a better understanding of the behavior of fluid flows and their coherent structures.

Organizer: Hakima Bessaih

University of Wyoming, USA

Organizer: Erika Hausenblas

Montanuniversität Leoben, Austria

continued in next column

8:30-8:55 Mathematical Aspects of Distributed Control for Compressible Fluids

Stefan Doboszczak, Air Force Institute of Technology, USA

9:00-9:25 Large Deviations for Landau-Lifschitz-Gilbert Equations with Pure Jump Noise

Utpal Manna, Indian Institute of Science Education and Research, India

9:30-9:55 Mean Field Limit of Interacting Filaments and Vector Valued Non Linear PDEs

Michele Coghi, University of Bielefeld, Germany

10:00-10:25 Title Not Available At Time Of Publication

Peter Constantin, Princeton University, USA

Tuesday, December 12

MS60

PDEs and SDEs for Materials Science - Part I of II

8:30 AM-10:00 AM

Room:318-Level 300

For Part 2 see MS67

The objective of the minisymposium is to bring together researchers in field of mathematical material sciences and to review recent advances in the field. Various topics will be covered in the presentations, for instance analysis and numerical methods for multiscale partial differential equations, derivation of reduced models from first principles, ab-initio calculations, accelerated transition path sampling for molecular dynamics, and homogenization and regularity of defects on multilattices.

Organizer: David Aristoff

Colorado State University, USA

Organizer: Olivier Pinaud

Colorado State University, USA

8:30-8:55 Quantum and Kinetic Models in Spin-magnetization Coupling

Lihui Chai, Carlos Garcia-Cevera, and Xu Yang, University of California, Santa Barbara, USA

9:00-9:25 Title Not Available At Time Of Publication

Florian Mehats, Université de Rennes 1, France

9:30-9:55 The Derivation of Heat Conduction Models with Fluctuations

Weiqi Chu, Pennsylvania State University, USA

Tuesday, December 12

MS61

Waves and Patterns - Part I of II

8:30 AM-10:30 AM

Room:319-Level 300

For Part 2 see MS68

Traveling waves and spatially localized patterns are critical for understanding of many natural phenomena. This minisymposium is devoted to recent results on the formation and qualitative properties of waves and localized patterns in nonlinear partial differential equations. Various aspects of these special solutions will be addressed from analytical and numerical points of view.

Organizer: Vahagn Manukian

Miami University Hamilton, USA

Organizer: Anna Ghazaryan

Miami University and University of Kansas, USA

Organizer: Alin Pogan

Miami University, USA

8:30-8:55 Optimal Damping for Exponential Energy Decay in 1D Wave Equation

Milena Stanislavova, University of Kansas, USA

9:00-9:25 Spectral Stability of Solutions to the Vortex Filament Hierarchy

Stephane Lafortune and Thomas Ivey, College of Charleston, USA

9:30-9:55 Center Manifolds for a Class of Degenerate Evolution Equations and Existence of Small Amplitude Kinetic Shocks

Alin Pogan, Miami University, USA; Kevin Zumbrun, Indiana University, USA

10:00-10:25 Nonlinear Stability of Bilayers under Geometric Flow

Keith Promislow, Michigan State University, USA; Gurgen Hayrapetyan, Ohio University, USA

Tuesday, December 12

MS62

Iterative Solutions for Variational Inclusions Problems in Banach Spaces

8:30 AM-10:30 AM

Room:320-Level 300

Variational inclusion problems has become the apparatus that is generally used to constrain sundry mathematical equations in other to guarantee the uniqueness and existence of their solutions. The existence of these solutions was earlier studied and proven for uniform Banach Spaces using accretive operators. In this study, we extend the conditions to hold for arbitrary Banach Spaces using uniform accretive operators.

Organizer: Oriehi E. D. Anyaiwe

Oakland University, USA

8:30-8:55 Iterative Solutions for Variational Inclusions Problems in Banach Spaces

Oriehi E. D. Anyaiwe, Oakland University, USA; Chika Moore, Nnamdi Azikiwe University, Nigeria

9:00-9:25 Accretive Operators

Andrew W. Moore, Google Pittsburgh, USA

9:30-9:55 Banach Spaces

Luis M. Abia, Universidad de Valladolid, Spain

10:00-10:25 Iterative Solutions

Breno Giacchini, Universidade Federal de Minal Gerais, Brazil

Tuesday, December 12

CP11

Equations from Fluid Mechanics

8:30 AM-10:30 AM

Room:323-Level 300

Chair: Joshua Hudson, University of Maryland, Baltimore County, USA

8:30-8:45 On the Wellposedness of Generalized Darcy-Forchheimer Equation

Johnson D. Audu and Faisal A. Fairag, King Fahd University of Petroleum and Minerals, Saudi Arabia

8:50-9:05 Multilayered Flows in the Shallow-Water Limit: Dynamics and Loss of Hyperbolicity

Francisco De Melo Virissimo and Paul A. Milewski, University of Bath, United Kingdom

9:10-9:25 Continuous Data Assimilation for the Magnetohydrodynamic Equations in 2D

Joshua Hudson and Animikh Biswas, University of Maryland, Baltimore County, USA; Adam Larios and Yuan Pei, University of Nebraska-Lincoln, USA

9:30-9:45 Flows of Immiscible Fluids Through the Channels with Porous Media in the Presence of Magnetic Field

Sneha Jaiswal and Pramod Kumar Yadav, Mnnit Allahabad, India

9:50-10:05 Mathematical and Numerical Analysis of Some Viscoelastic Flows

Maria Lukacova, University of Mainz, Germany

10:10-10:25 Fracture Modeling and Optimization for Nonlinear Flows in Coupled Fracture Porous Media

Pushpi J. Paranamana, Eugenio Aulisa, Magdalena Toda, and Akif Ibraguimov, Texas Tech University, USA

Coffee Break

10:30 AM-10:55 AM

Room:309/310-Level 300

Tuesday, December 12

Closing Remarks

10:55 AM-11:00 AM

Room:307/308 - Level 300

IP7

Small Scale Formation in Ideal Fluids

11:00 AM-11:45 AM

Room:307/308 - Level 300

Chair: Dehua Wang, University of Pittsburgh, USA

I will overview some recent progress in understanding creation of small scales and singularity formation in equations of fluid dynamics such as incompressible Euler and surface quasi-geostrophic (SQG) equations. In particular, I will discuss an example of very fast small scale creation in solutions of 2D Euler equation, which achieves an optimal double exponential in time rate. I will also talk about several simplified models that have been designed to better understand the process of possible singularity formation for solutions of 3D Euler equation in a scenario proposed by Tom Hou and Guo Luo.

Alexander Sasha Kiselev

Duke University, USA

Tuesday, December 12

IP8

Stability of Prandtl Boundary Layers

11:45 AM-12:30 PM

Room:307/308 - Level 300

Chair: Helena Nussenzveig Lopes, Universidade Federal de Rio de Janeiro, Brazil

Prandtl boundary layers arise when we consider Navier Stokes equations in the inviscid limit, with Dirichlet boundary conditions. Formally the inviscid limit is the Euler equations for incompressible fluids. However, the boundary conditions differ between Euler and Navier Stokes equations. As a consequence, as the viscosity goes to 0, a boundary layer appears, called Prandtl boundary layer. The mathematical study of this boundary layers appears to be delicate, despite many recent attempts. In this talk we will discuss recent results on the linear and nonlinear instability of this boundary layers. This is a joint work with T. Nguyen (Penn State University)

Emmanuel Grenier

Ecole Normale Superieure de Lyon, France

Lunch Break

12:30 PM-2:30 PM

Attendees on their own

Tuesday, December 12

MS63

Modeling and Analysis of Condensed Matter Systems - Part II of II

2:30 PM-4:00 PM

Room:314-Level 300

For Part 1 see MS55

The minisymposium will focus on investigations of phases of condensed mater systems such as liquid crystals, superconductors, and ferromagnets. These materials are the subject of intense scientific work, since they have a wide range of significant technological applications. However, understanding their interesting physical behaviors is challenging both in the modeling and in the analysis. The objective of our minisymposium is to provide a forum via a diverse dynamic group of junior scientists, who have already shown an ability to make significant contributions to the area, to discuss recent advances in the mathematical study of these materials.

Organizer: Tiziana Giorgi
New Mexico State University, USA

Organizer: Sookyung Joo
Old Dominion University, USA

2:30-2:55 Gamma-convergence of an Anisotropic Superconductivity Model with Magnetic Fields Near H{c^1}

Guanying Peng, University of Cincinnati, USA

3:00-3:25 Mathematical Models of Bi-layer Nanostructures

Dmitry Golovaty, University of Akron, USA

3:30-3:55 Analysis and Stability of a Landau-de Gennes Model for the Switching Mechanism in the *B* Phase of Bent-Core Liquid Crystals

Feras Yousef, The University of Jordan, Jordan

Tuesday, December 12

MS64

Recent Development in Numerical Methods for Optics and Plasmonics - Part II of II

2:30 PM-4:30 PM

Room:316-Level 300

For Part 1 see MS57

The main purpose of this mini symposium is to bring together specialists in the numerical simulation of optical phenomena. The past few decades have seen impressive advances in the understanding of electromagnetics at the nanoscale. Driven by spectacular discoveries in the design capabilities of materials at these scales, there has been significant recent growth in the field of nano-optics. In particular, algorithm design, analysis, application, and implementations of mathematical models in the area are now at the heart everyday technologies such as extraordinary optical transmission, surface enhanced spectroscopy, and surface plasmon resonance biosensing. Nevertheless, some very important issues still remain open. It is anticipated that participants will report on their latest developments, interact with one another, and chart future research agendas. This minisymposium will be designed around important areas of application where applied and computational mathematics has a large role to play.

Organizer: David P. Nicholls
University of Illinois, Chicago, USA

Organizer: Youngjoon Hong
University of Illinois, Chicago, USA

2:30-2:55 The Imaging of Small Perturbations in An Anisotropic Media

Shari Moskow, Drexel University, USA

3:00-3:25 Improved Non-Overlapping Domain Decomposition Algorithms for the Eddy Current Problem

Yassine Boubendir, New Jersey Institute of Technology, USA

continued in next column

3:30-3:55 Scattering by a Periodic Array of Narrow Slits: Field Enhancement and Anomalous Diffraction

Junshan Lin, Auburn University, USA

4:00-4:25 A High-Order Perturbation of Surfaces Method for Scattering of Linear Waves by Periodic Multiply Layered Gratings in Two and Three Dimensions

Youngjoon Hong, University of Illinois, Chicago, USA

Tuesday, December 12

MS65

Fluid-Boundary Interactions

2:30 PM-4:30 PM

Room:322-Level 300

We seek to understand the influence of boundaries and boundary conditions in a variety of fluid flows and tracers to predict and control the outcome of a system. This minisymposium will explore this in several contexts. For microfluidics applications, this takes the form of asking how tracers can be controlled through the channel's shape and boundary conditions when modeled as an advection-diffusion process. In what ways can solutions for idealized cases, such as infinite parallel plates, be used to inform predictions for general confined geometries? For analyzing mucus flow in the trachea towards treating diseases like cystic fibrosis, it is important to understand how boundary forcing by the tracheal wall, as well as breathing, affect the mucus flow, and what analysis can be done on the nonlinear model equations. When modeling the settling of material such as marine snow in the ocean, understanding the effects of material boundary layers and pore space is critically important, as the background density stratification of the ocean results in an increased effective buoyancy of the particle as it sinks. Understanding this phenomenon both quantitatively and qualitatively is important for modeling vertical carbon flux in the ocean. We seek to better understand the commonalities and differences between these topics, and what theoretical and computational tools can be shared under this common theme of fluid-boundary interactions.

Organizer: Manuchehr Aminian

Colorado State University, USA

Organizer: Francesca Bernardi

University of North Carolina, Chapel Hill, USA

continued in next column

2:30-2:55 Precise Asymptotics of the Aris Equations Via Poisson Summation

Manuchehr Aminian, Colorado State University, USA; Roberto Camassa and Richard McLaughlin, University of North Carolina at Chapel Hill, USA

3:00-3:25 Modeling Viscous Film Flows Driven by Oscillatory Airflow in a Tube

H. Reed Ogrosky, Virginia Commonwealth University, USA; Roberto Camassa and Jeffrey Olander, University of North Carolina at Chapel Hill, USA

3:30-3:55 How Boundaries Shape Chemical Deliveries in Microfluidics

Francesca Bernardi, University of North Carolina, Chapel Hill, USA; Manuchehr Aminian, Colorado State University, USA; Roberto Camassa, Daniel Harris, and Richard McLaughlin, University of North Carolina at Chapel Hill, USA

4:00-4:25 Porous Spheres Settling in Stratified Fluids

Shilpa Khatri, University of North Carolina at Chapel Hill, USA

Tuesday, December 12

MS66

Nonlinear PDEs in Fluid Dynamics: Deterministic and Probabilistic Approaches - Part II of II

2:30 PM-4:30 PM

Room:317 -Level 300

For Part 1 see MS59

Stochastic Partial Differential Equations find application in diverse disciplines such as mechanical engineering, economics and finance, signal processing, physics and chemistry. Note that it is natural to introduce stochastic evolution equations to model physical systems whenever relevant sources of noise, instability and perturbations are present, as is the case, for example, in modeling of complex ocean-atmospheric phenomena. Fluid dynamics is a rich field of classical and modern scientific investigation both because of important applications in engineering and meteorology and because of certain fundamental open questions of mathematical and physical nature. The aim of the minisymposium is to bring together researchers working on nonlinear PDEs with application to fluids. Some of the presenters are using probabilistic tools while others are using deterministic ones. The common goal is to get a better understanding of the behavior of fluid flows and their coherent structures.

Organizer: Hakima Bessaih

University of Wyoming, USA

Organizer: Erika Hausenblas

Montanuniversität Leoben, Austria

2:30-2:55 Fast Flow Asymptotics for Stochastic Incompressible Viscous Fluids in the Plane and Spdes on Graphs

Sandra Cerrai, University of Maryland, USA

3:00-3:25 Data Assimilation Algorithm Based on Feedback Control Theory

Evelyn Lunasin, United States Naval Academy, USA

3:30-3:55 Stochastic Damped Navier-Stokes in R^d

Benedetta Ferrario, University of Pavia, Italy

4:00-4:25 Existence of a Density on Finite Projections of the 2D Stochastic Navier Stokes Equation Driven by Lévy Processes or Fractional Brownian Motion

Erika Hausenblas, Montanuniversität Leoben, Austria

Tuesday, December 12

MS67

PDEs and SDEs for Materials Science - Part II of II

2:30 PM-5:00 PM

Room:318-Level 300

For Part 1 see MS60

The objective of the minisymposium is to bring together researchers in field of mathematical material sciences and to review recent advances in the field. Various topics will be covered in the presentations, for instance analysis and numerical methods for multiscale partial differential equations, derivation of reduced models from first principles, ab-initio calculations, accelerated transition path sampling for molecular dynamics, and homogenization and regularity of defects on multilattices.

Organizer: David Aristoff
Colorado State University, USA

Organizer: Olivier Pinaud
Colorado State University, USA

2:30-2:55 Accelerated Transition Path Sampling for Molecular Dynamics
Gideon Simpson, Drexel University, USA

3:00-3:25 Spectrwm: Spectral Random Walk Method for Stochastic Partial Differential Equations
Nawaf Bou-Rabee, Rutgers University, Camden, USA

3:30-3:55 Homogenization Theory for Biased Random Walks on Graphs Embedded in the Euclidean Space
Muruhan Rathinam and Preston Donovan, University of Maryland, Baltimore County, USA

4:00-4:25 Regularity and Decay Results for Point Defects in Complex Crystals
Derek Olson, Rensselaer Polytechnic Institute, USA; Christoph Ortner, University of Warwick, United Kingdom

4:30-4:55 First-principle Modeling of Large-scale Atomistic Systems with Applications
Eric Polizzi, University of Massachusetts, Amherst, USA

Tuesday, December 12

MS68

Waves and Patterns - Part II of II

2:30 PM-4:30 PM

Room:319-Level 300

For Part 1 see MS61

Traveling waves and spatially localized patterns are critical for understanding of many natural phenomena. This minisymposium is devoted to recent results on the formation and qualitative properties of waves and localized patterns in nonlinear partial differential equations. Various aspects of these special solutions will be addressed from analytical and numerical points of view.

Organizer: Vahagn Manukian
Miami University Hamilton, USA

Organizer: Anna Ghazaryan
Miami University and University of Kansas, USA

Organizer: Alin Pogan
Miami University, USA

2:30-2:55 Defects in Oscillating Spatially Extended Systems
Gabriela Jaramillo, University of Arizona, USA

3:00-3:25 The Maslov Index and the Spectra of Second Order Elliptic Operators
Selim Sukhtaiev, University of Missouri, USA

3:30-3:55 Stability of Fast Traveling Waves for a Doubly-Diffusive FitzHugh-Nagumo System
Paul Cornwell and Chris Jones, University of North Carolina at Chapel Hill, USA

4:00-4:25 Traveling Waves in Gray-Scott Model in Bistable Regime
Vahagn Manukian, Miami University Hamilton, USA; Anna R. Ghazaryan, Miami University, USA

PD17 Abstracts

SIAM Conference on

Analysis of
Partial Differential Equations

December 9–12, 2017
The Baltimore Convention Center
Baltimore, Maryland, USA

Abstracts are printed as submitted by the authors.

IP1

Travel Time Tomography

We will consider the inverse problem of determining the sound speed or index of refraction of a medium by measuring the travel times of waves going through the medium. This problem arises in global seismology in an attempt to determine the inner structure of the Earth by measuring travel times of earthquakes. It has also several applications in optics, medical imaging and ocean acoustics among others. We will apply the results to the inverse problem of determining the elastic parameters of a medium by measuring the traction produced by a displacement at the boundary of the medium. The problem can be recast as a geometric problem: Can one determine a Riemannian metric of a Riemannian manifold with boundary by measuring the distance function between boundary points? This is the boundary rigidity problem. We will also consider the problem of determining the metric from the scattering relation, the so-called lens rigidity problem. The linearization of these problems involve the integration of a tensor along geodesics, similar to the X-ray transform. We will also describe some recent results, joint with Plamen Stefanov and Andras Vasy, on the partial data case, where you are making measurements on a subset of the boundary. No previous knowledge of Riemannian geometry will be assumed.

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IP2

PD17 Invited Speaker - Guo

Abstract not available at time of publication.

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IP3

Eulerian and Lagrangian Solutions of the Continuity Equation

It is well known that the motion of an incompressible fluid can be described in Eulerian variables (as a solution of a PDE, namely the continuity equation), or alternatively in Lagrangian variables (as a flow of an ODE). The classical DiPerna-Lions-Ambrosio theory ensures well-posedness and provides structural properties for solutions of the continuity equation, under suitable regularity assumptions on the velocity field and integrability assumptions on the solution. In my talk I will focus on the "Lagrangianity" of solutions, that is, on the property of being transported by an ODE flow, hence addressing the question whether an Eulerian solution is automatically a Lagrangian solution. After a brief summary of the DiPerna-Lions-Ambrosio theory, I will present two examples which are outside of the assumptions of such a theory, and in which nevertheless we can prove the Lagrangianity of solutions. The first one concerns vanishing viscosity solutions of the two-dimensional Euler equations, where we can use suitable duality methods (joint work with Stefano Spirito). The second example involves general continuity equations, and requires the proof of a new Lipschitz extension lemma (joint work with Laura Caravenna).

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IP4

Nonlinear Elliptic Equations with Fractional Diffusion

In this talk I will explain basic ideas concerning fractional Laplacians (in particular, their relation with Lvy flights in Probability) and present the essential tools to treat nonlinear equations involving fractional Laplacians and other elliptic integro-differential operators. We will review their Lagrangian and Hamiltonian structures – two very important tools. The last part of the talk will concern recent developments on fractional perimeters and nonlocal minimal surfaces – a fractional extension of the classical theory of minimal surfaces.

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IP5

Regularity Theory in Elliptic Free Boundary Problems

In this talk, we will describe several examples of free boundary problems motivated by problems in the applied sciences. In particular, we will discuss the so-called two-phase free boundary problem, the thin free boundary problem, the obstacle problem and the two-membranes problem. We will focus mainly on the question of regularity of weak solutions and their free boundaries. Some open problems will also be highlighted. The most recent results in the talk are part of joint works with L. Caffarelli and O. Savin.

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IP6

Partial Differential Equations of Mixed Elliptic-Hyperbolic Type: From Mechanics to Geometry

As is well-known, two of the basic types of linear PDEs are elliptic and hyperbolic types, following the classification for linear PDEs proposed by Jacques Hadamard in the 1920s; and linear theories of PDEs of these two types have been considerably established, respectively. On the other hand, many nonlinear PDEs arising in many areas from mechanics to geometry naturally are of mixed elliptic-hyperbolic type. The solution of some longstanding fundamental problems in these areas greatly requires a deep understanding of such nonlinear PDEs of mixed type. Important examples include transonic shock problems in fluid mechanics (the Euler equations) and isometric embedding problems in differential geometry (the Gauss-Codazzi-Ricci equations). In this talk, we will present natural connections of nonlinear PDEs of mixed elliptic-hyperbolic type with these longstanding problems and will then discuss some of the most recent developments in the analysis of these nonlinear PDEs through the examples with emphasis on developing and identifying mathematical approaches, ideas, and techniques for dealing with the mixed-type problems. Further trends, perspectives, and open problems in this direction will also be addressed.

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IP7

Small Scale Formation in Ideal Fluids

I will overview some recent progress in understanding creation of small scales and singularity formation in equations of fluid dynamics such as incompressible Euler and surface quasi-geostrophic (SQG) equations. In particular, I will discuss an example of very fast small scale creation in solutions of 2D Euler equation, which achieves an optimal double exponential in time rate. I will also talk about several simplified models that have been designed to better understand the process of possible singularity formation for solutions of 3D Euler equation in a scenario proposed by Tom Hou and Guo Luo.

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IP8

Stability of Prandtl Boundary Layers

Prandtl boundary layers arise when we consider Navier Stokes equations in the inviscid limit, with Dirichlet boundary conditions. Formally the inviscid limit is the Euler equations for incompressible fluids. However, the boundary conditions differ between Euler and Navier Stokes equations. As a consequence, as the viscosity goes to 0, a boundary layer appears, called Prandtl boundary layer. The mathematical study of this boundary layers appears to be delicate, despite many recent attempts. In this talk we will discuss recent results on the linear and nonlinear instability of this boundary layers. This is a joint work with T. Nguyen (Penn State University)

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SP1

SIAG/Analysis of Partial Differential Equations Prize Lecture: Quantitative Stochastic Homogenization by Variational Methods

Several years ago, with Charles Smart we revisited a variational approach to random homogenization introduced by Dal Maso and Modica in the 1980s for elliptic equations in divergence form. We showed that their old ideas could be combined with some new convex analytic methods to obtain quantitative estimates on the rate of homogenization. Furthermore, we showed that these quantitative estimates imply regularity results for the solutions on large scales. In this talk I will review these results and explain how in recent joint work with Kuusi and Mourrat we have taken them further: the variational perspective leads to a rigorous "renormalization group' argument, eventually yielding an optimal theory of stochastic homogenization for linear elliptic equations.

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CP1

Computational Analysis of Partial Differential Equation Based on Electro-Magneto-Hydrodynamic Thermo-Fluidic Transport of Biofluids with New Trend of Fractional Derivative Without Singular Kernel

In this work, the electro-magneto-hydrodynamic flow of the non-Newtonian behavior of biofluids, through a cylindrical microchannel was derived based on partial differential equation of fractional order. The governing equations are considered as fractional partial differential equations based on the Caputo-Fabrizio time-fractional derivatives without singular kernel. The most common time-fractional derivative used in Continuum Mechanics is Caputo derivative. However, two disadvantages appear when this derivative is used. First, the definition kernel is a singular function and, secondly, the analytical expressions of the problem solutions are expressed by generalized functions (Mittag-Leffler, Lorenzo-Hartley, Robotnov, etc.) which, generally, are not adequate to numerical calculations. The new time-fractional derivative Caputo-Fabrizio, without singular kernel, is more suitable to solve various theoretical and practical problems which involve fractional differential equations. Using the Caputo-Fabrizio derivative, calculations are simpler and, the obtained solutions are expressed by elementary functions. Analytical solutions of the biofluid velocity and thermal transport are obtained by means of the Laplace and finite Hankel transforms. The influence of the fractional parameter, Eckert number and Joule heating parameter on the biofluid velocity and thermal transport are numerically analyzed and graphic presented.

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CP1

A Bottom-Up Approach to Global Upscaling for Reservoir Simulation

Our aim is to develop an efficient yet robust algorithm for solving flow equations in the context of reservoir simulation, which has a vast domain in both space and time. We begin with a global fine-scale model, constructed using established finite volume methods. Using this model, we compute global fine-scale solutions with generic (that is, constant-pressure/no-flow) boundary conditions. We then use the computed pressure and velocity fields, in conjunction with spatially varying, compact multi-point stencils, to determine how to combine grid cells and coarsen the model, while maintaining the accuracy and robustness of the underlying fine-scale model. Numerical experiments will demonstrate the effectiveness of this approach.

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CP1

Analytical and Numerical Investigation of Euler-

Bernoulli Beam Model with Non-Conservative Boundary Conditions

Analytic and numerical results on the Euler-Bernoulli beam model with a two-parameter family of boundary conditions will be discussed. The beam equation is equipped with the boundary conditions given in the form of the co-diagonal matrix depending on two control parameters (k_1 and k_2) that relates a two-dimensional input vector (the shear and the moment at the right end) and the observation vector (the time derivatives of displacement and the slope at the right end). The following results will be presented: (i) high accuracy numerical approximations for the eigenvalues of the discretized differential operator (the dynamics generator of the model); (ii) the formula for the number of the *deadbeat modes* for the case when one control parameter, k_1, is positive and another one, k_2, is zero; (It has been shown that the number of the deadbeat modes tends to infinity, as $k_1 \to 1^+$ and $k_2 = 0$.) (iii) the asymptotic formula for the *double deadbeat modes* for the model. The numerical results corroborating all analytic findings have been produced by using Chebyshev polynomial approximations for the continuous problem.

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CP1

Numerical Solutions of 2-D Unsteady Free Convective Flow With Heat and Mass Transfer In A Rectangular Domain

In this paper, we have implemented a finite volume method to discretize the governing equations of the problem of an unsteady 2-D incompressible flow with heat and mass transfer at different Reynolds and Rayliegh numbers with mixed boundary conditions. We have used the SIMPLE algorithm of QUICK SCHEME to solve the discretized equations along with the boundary conditions and thereby to compute the flow variables, viz. u-velocity, v-velocity, P, T, and C. A SIMPLE algorithm was used to compute the numerical solutions of the flow variables for different Reynolds numbers (Re) and the Rayliegh(Ra) numbers. Local as well as average Nusselt(Nu) and Sherwood numbers(Sh) were computed for fixed Pr=7.2 and Sc=340 for four grid systems at different times.We have used appropriate Prandtl (Pr) and Schmidt (Sc) numbers in consistent with relevancy of the physical problem considered. We have depicted the lines, isotherms,iso-concentric lines.Heat and mass lines are also determined.The entropy generation during free convection is studied due to fluid friction irreversibility and heat transfer irreversibility is studied.Our numerical solutions for u and v velocities along the vertical and horizontal line through the geometric center of the square cavity for different Ra(Rayleigh number) has been compared with benchmark solutions available in the literature and it has been found that they are in good agreement.

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CP1

Entropy Stable WENO Spectral Collocation Schemes for the 3-D Navier-Stokes Equations

High-order numerical methods that satisfy a discrete analog of the entropy inequality are uncommon. Indeed, no proofs of nonlinear entropy stability currently exist for high-order Weighted Essentially Non-Oscillatory (WENO) finite volume or weak-form finite element methods. In this talk, we present a new family of fourth-order WENO spectral collocation schemes that are provably stable in the entropy sense for the three-dimensional Navier-Stokes equations. Individual spectral elements are coupled using penalty type interface conditions. The resulting entropy-stable WENO spectral collocation schemes achieve design order accuracy, maintain the WENO stencil biasing properties across element interfaces, and satisfy the summation-by-parts (SBP) operator convention, thereby ensuring nonlinear entropy stability in a diagonal norm. Numerical results demonstrating accuracy and non-oscillatory properties of the new schemes are presented for both continuous and discontinuous flows.

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CP2

Adaptive Moving Mesh Upwind Scheme for the Two-Species Chemotaxis Model

A common property of all chemotaxis systems is their ability to model a concentration phenomenon—rapid growth of the cell density in small neighborhoods of concentration points/curves (the solution may develop a singular, spiky structures or even blow up within finite time). Therefore, development of accurate and computationally efficient numerical methods for the chemotaxis models is a challenging task. We study the two-species Patlak-Keller-Segel type chemotaxis system, in which the two spieces do not compete, but have different chemotactic sensitivity, which may lead to a significantly different density growth rate. This phenomenon was numerically investigated in [Kurganov and Lukáčová-Medviďová, Discrete Contin. Dyn. Syst. Ser. B, 19 (2014), pp. 131–152] and [Chertock *et al.*, Adv. Comput. Math., to appear], where second- and higher-order methods on uniform Cartesian grids were developed. However, in order to achieve high resolution of the density spikes developed by the species with a lower chemotactic sensitivity, a very fine mesh had to be utilized and thus the efficiency of the numerical method was affected. In this work, we develop an adaptive moving mesh finite-volume semi-discrete upwind method for the two-species chemotaxis system. This approach leads to the concentration of the mesh cells at the blowup region, which allows us to substantially improve the resolution while using relatively small number of finite-volume cells.

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CP2

The Class of Conformal Dissipative Relativistic Fluids

Motivated by the fluid/gravity correspondence and the AdS/CFT correspondence conjectured by Maldacena, we study the class of conformal dissipative relativistic fluids of divergence type, from the perspective proposed by Geroch and Lindblom in the early 90's; that is, theories in which dynamics is governed by differential equations that can be written as total divergence equations. More specifically, we give a characterization of the whole family of conformal fluids in terms of a single master scalar function χ, up to second order in dissipative variables. In particular, we identify the equilibrium states, derive the corresponding constitutive relations and analyze the hyperbolicity of these theories, i.e., under what algebraic conditions there exists a well posed initial value problem. This construction allows to generalize a number of previous works in which dissipative relativistic fluids are studied in a frame dependent scheme.

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CP2

A Two Layer Mathematical Model of Blood Flow in Porous Constricted Blood Vessels

In this paper, we discussed a mathematical model for two layered non Newtonian blood flow through porous constricted blood vessels. The core region of blood flow consisting the suspension of erythrocytes as non Newtonian Casson fluid and the peripheral region of plasma flow as Newtonian fluid. The wall of porous constricted blood vessel configured as thin transition Brinkman layer over layered by Darcy region. The boundary of fluid layer is defined as stress jump condition of Ocha-Tapiya and Beavers-Joseph. In this paper, we obtained an analytic expression for velocity, flow rate, wall shear stress. The effect of permeability, plasma layer thickness, yield stress and shape of the constriction on velocity in core & peripheral region, wall shear stress and flow rate discussed graphically. This is found throughout the discussion that permeability and plasma layer thickness have accountable effect on various flow parameters which gives an important observation for diseased blood vessels.

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CP2

Interior-Exterior Penality Approach for Solving Quasi-Variational Inequality Arising in Elastohydrodynamic Lubrication

In this article we propose interior-exterior penalty method for solving quasi-variational inequality arising in Elasto-hydrodynamic Lubrication (EHL) problems using discontinuous-Galerkin finite volume method (DG-FVM) or DG-FEM. Stability and convergence analysis are derived here for proposed method. We derived a priori error estimates in the the broken H^1 norm. Furthermore, we derived hp error estimate in L^2 norm. The method presented is robust and easily parallelized in MPI environment. GMRES technique is implemented to solve the matrix obtained after the formulation. Film thickness calculation is done using singular quadrature approach. Numerical results illustrating the theoretical results are provided graphically and discussed. This method is well suited for solving EHL point contact problem and can probably be used as commercial software.

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CP2

Well-Posedness and Long-Time Dynamics of Geophysical Fluid Flows

The author elucidate in a concrete way dynamical challenges concerning approximate inertial manifolds (AIMS), i.e., globally invariant, exponentially attracting, finite-dimensional smooth manifolds, for nonlinear dynamical systems on Hilbert spaces. The goal of this theory is to prove the basic theorem of approximation dynamics, wherein it is shown that there is a fundamental connection between the order of the approximating manifold and the well-posedness and long-time dynamics of the rotating Boussinesq and quasi-geostrophic equations. Abreast of these results, the author presents a new technique for the construction of AIMS that preserve the structure of attractors for the flow in the thermal convection of Oldroyd-B fluids. Although this article is motivated by challenges in partial differential equations, we consider a two-mode Faedo-Galerkin approximation given by a system of singularly perturbed ordinary differential equations. We note that the foundation for the study of the low-dimensional model of turbulence, which capture the dominant focus energy bearing scales, from the flow for the thermal convection of viscoelastic fluids with a differential constitutive law, is the Lorenz equations extended through singular perturbation. In order to utilize geometric singular perturbation (GSP) theory and Melnikov techniques, we perturb the problem and carry the nonlinear analysis further to the question of the persistence of inclination-flip homoclinic orbits.

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CP2

Coalescing Particle Systems, and Blow-Up in the Components of the Multispecies Keller-Segel Model

We study a stochastic particle system with a logarithmically-singular inter-particle interaction potential which allows for inelastic particle collisions. We relate the squared Bessel process to the evolution of localized clusters of particles, and develop a numerical method capable of detecting collisions of many point particles without the use of pairwise computations, or very refined adaptive timestepping. We show that when the system is in an appropriate parameter regime, the hydrodynamic limit of the empirical mass density of the system is a solution to a nonlinear Fokker-Planck equation, such as the Patlak-Keller-Segel (PKS) model, or its multispecies variant. We then show that the presented numerical method is well-suited for the simulation of the formation of finite-time singularities in the PKS, as well as PKS pre- and post-blow-up dynamics. Additionally, we present numerical evidence that blow-up with an increasing total second moment in the two species Keller-Segel system occurs with a linearly increasing second moment in one component, and a linearly decreasing second moment in the other component.

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CP3

Discontinuous Galerkin Finite Element Methods for the Solution of Diffuse Interface Models

Partial differential equation models based on Cahn-Hilliard type equations coupled with fluid flow will be introduced and numerically solved. Discontinuous Galerkin Finite Element Methods for the numerical solution of the equations will be presented. For the underline schemes: solvability, energy stability, convergence and error estimates will be established. Simulation results will be provided.

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CP3

High-Order, Stable and Conservative Boundary Schemes for Finite Differences

Stable and conservative numerical boundary schemes are constructed such that they do not diminish the overall accuracy of the method for interior schemes of orders 4, 6, and 8 using both explicit (central) and compact finite differences. Previous attempts to develop stable numerical boundary schemes have resulted in schemes which significantly reduced the global accuracy or required numerical dissipation for stability when applied to the non-linear fluid equations. Thus, the schemes presented here are the first to not affect the global accuracy, while also ensuring discrete conservation. We discuss a general procedure for the construction of conservative boundary schemes of any order followed by a simple, yet novel, optimization strategy which focuses directly on the compressible Euler equations. The result of this non-linear optimization process is a set of high-order, stable, and conservative numerical boundary schemes which demonstrate excellent stability and convergence properties on an array of linear and non-linear hyperbolic problems.

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CP3

Mesh Requirements for Transmission Problems with Sign-Changing Coefficients

Transmission problems with sign-changing coefficients occur in electromagnetic theory in the presence of negative materials (metals at optical frequencies or metamaterials) surrounded by classical materials. For general geometries, establishing well-posedness of these transmission problems is well-understood thanks to the T-coercivity approach. At the discrete level, one simply imposes some meshing rules to guarantee an optimal convergence rate for the finite element approximation. However, in practice the current approach does not hold optimal convergence when the interface presents corners. We propose here a new treatment at the corners of the interface which allows to design meshing rules for an arbitrary polygonal interface and then recover standard error estimates.

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CP3

Well-Balanced Methods for Hyperbolic Systems of Balance Laws

We present a second-order well-balanced central-upwind scheme for hyperbolic systems of balance laws. Here we advocate a new paradigm based on a purely conservative reformulation of the equations using globally-based fluxes. The proposed scheme is capable of exactly preserving steady-state solutions expressed in terms of a nonlocal equilibrium variable. A crucial step in the construction of the second-order scheme is a well-balanced piecewise linear reconstruction of equilibrium variables which is combined with a well-balanced central-upwind evolution in time. We show the performance of the newly developed central-upwind scheme in a series of one- and two-dimensional examples.

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CP3

Solution of PDEs in Frequency Space for Photobleaching Kinetics Using Krylov Subspace Spectral

Methods

We solve the first order reaction-diffusion equations using the photobleaching scanning profile of confocal laser scanning microscopes. The initial conditions that come from prebleach steady states accompanying with a time-domain method known as a Krylov Subspace Spectral method (KSS method) is applied. KSS methods are explicit for solving time-dependent variable-coefficient partial differential equations (PDEs) that were developed by Lambers. We applied KSS methods because of their high-order accuracy and their scalability. In this talk we show how a KSS method can provide an approximate analytical solution which delivers insight into the behavior of the solution in frequency space.

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CP4

Pde Systems and Efficient Fire Suppression Allocation

Accumulation of burnable forest fuels is changing natural wildfire regimes. Decisions to quickly suppress fire discount the long-term risk of interrupting nature's course. Recent megafires are an unintended consequence. Our capability to suppress unwanted fires stems from a complex national sharing process in which specialized ground-based and aerial firefighting resources mobilize around the United States to respond to incidents of fire. This work elaborated a coupled system of advection, diffusion, reaction equations and applied them to an archive of risk and allocation data from 2011-2016 in order to forecast upcoming workloads. This presentation will explain how variation in fire risk impacts allocation. By implementing forward and inverse finite difference methods we balanced prediction and assimilation in time-stepping schemes on structured, regionally-connected meshes. We reduced underlying functional spaces to tractable subspaces by using regional risk data surfaces like ongoing fire activity, suppression resource use, fire weather, expenditures, accessibility, and population density. Time series results from pressure-fitting, spatial gradient estimation, and short-term prediction uncovered guidelines that will help managers better justify decisions to let excess fuel burn and restore fire's natural regime.

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CP4

On the Numerical Solution to the Far Field Refractor Problem

The far field refractor problem in geometric optics is an inverse problem which deals with constructing a refracting surface that is capable of reshaping a light beam from a one point source with a given illumination intensity into a prescribed intensity distribution. The aim of this talk is to discuss its numerical solution. In particular, we will describe a numerical algorithm which was first used in the work of Caffarelli, Kochengin and Oliker, in relation to synthesis of reflector surfaces and show that a simplified version of this algorithm can be extended to obtain an approximate solution for the refractor problem with arbitrary precision. We further exhibit the convergence in finite steps of the method when the distribution density functions are bounded and mass balance conditions are met.

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CP4

Combined Optimal Stopping and Control of Regime Switching Lévy Processes and Applications

In this paper, we study the combined optimal stopping and optimal control problem of regime switching Lévy processes. We fully characterize the value function is the unique viscosity of the corresponding Hamilton-Jacobi-Bellman variational inequalities. Furthermore, we prove the C^2 regularity of the value function when the running cost is semiconvex. We numerically solve the system of fully nonlinear integrodifferential variational inequalities and derive an approximation of the value function and the optimal control and stopping policies. As an application, we formulate the problem of finding optimal extraction policies for natural resources as a combined optimal stopping optimal control problem and derive optimal extraction rules. A numerical example is presented to illustrate these results.

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CP4

Nonlinear Magneto-Elasticity: Direct and Inverse Problems

There are studied some direct and inverse problems associated with the vibration of an elastic conductive body governed by the Lamé and Maxwell equations coupled through the nonlinear magneto-elastic effect. We prove the existence and uniqueness for both the direct and inverse problem, which consists in identifying the unknown scalar function $f(t)$ in the elastic force $f(t)\mathbf{g}(\mathbf{x}, t)$ acting on an elastic conductive body when some additional measurement is available.

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CP4

Multigrid Methods for Stochastic Optimal Control Problems

We consider an optimal control problem constrained by an elliptic SPDE, with a stochastic cost functional of tracking type. We use a sparse grid stochastic collocation approach to discretize in the probability space and finite elements to discretize in the physical space. To accelerate the solution process, we propose a deterministic multigrid preconditioner for the stochastic reduced KKT system. Numerical results show that the number of conjugate gradient iterations decreases as the resolution increases, a feature shared by similar multigrid preconditioners for deterministic optimal control problems.

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CP5

Virtual Element Methods for Time Dependent Convection Diffusion Reaction Equation with Supg Stabilization

In this talk, we would like to discuss virtual element method (VEM)for the approximation of time dependent convection diffusion reaction equation. The implementation procedure of the proposed method does not require explicit construction of basis functions and also suitable for any polyhedral meshes. In order to avoid non-physical oscillations–generally occurred for large mesh Peclet number, we have added a stabilizer which involve additional diffusion in streamline direction. An internal $\%L^2$ %-projection is used to discretize both stationary and non-stationary, and the discretized scheme design such that the bilinear forms involved in the formulation are coercive with respect to SUPG-norm. With the help of suitable projectors, optimal error estimates in SUPG-norm and L2-norm are established for semi-discrete and fully discrete schemes. Further, several numerical test are conducted on voronoi-mesh to validate the proposed method and verify the theoretical results.

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CP5

A Numerical Solution for a Class of Differential Initial-Boundary Value Problems Via Convex Optimization

A novel methodology to find approximate continuous solutions of differential boundary value problems (D-BVP) via polynomials (p_d) is formulated. This consist in minimizing the resulting residual functions δ_d from the equality conditions of the D-BVP, via recasting them as polynomial inequalities. The main idea of this approach is based on a notable result from Real Algebraic Geometry: the *Positivstellensatz*. Thus, for domain representations ($\Omega = \{g_j\}$) which are *compact basic semi-algebraic sets*, these inequalities are relaxed via their *Sum-of-Squares* (SOS: $\sum_s$) decomposition, so that the D-BVP can be formulated as:

$$\mathbf{P}_d \begin{cases} \gamma^* = & \inf_{\gamma, p_d} \ \gamma \\ \text{subj. to:} & (\rho_M - \delta_d(x) - \sum_{j=1}^m s_{1,j}(x) g_j(x)) \in \sum_s, \\ & (\delta_d(x) - \rho_m - \sum_{j=1}^m s_{2,j}(x) g_j(x)) \in \sum_s, \\ & \gamma \geq 0, \ s_{1,j}, s_{2,j} \in \sum_s, \\ & [\gamma, \rho_M; \rho_M, \gamma] \succeq 0, \ [\gamma, \rho_m; \rho_m, \gamma] \succeq 0, \\ & B_i[p_d(\cdot)](x)|_{x \in \partial\Omega_i} = u_i, \end{cases} \tag{1}$$

where ρ_m and ρ_M are the minimum and maximum of δ_d, respectively, to be minimized in Ω and B_i are boundary conditions. This approach leads to a *convex optimization problem*, implementable via semidefinite programming, capable of solving PDE-initial value problems with polynomial non-linearities.

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CP5

A Numerical Algorithm for Computational Modeling of Reaction-Diffusion Models Arising in Chemical Processes

In this article, the author developed a numerical algorithm for computational modeling to capture the patterns of some reaction-diffusion models arising in chemical processes with Neumann and Dirichlet boundary conditions. These models arise in the mathematical modeling of chemical systems such as in enzymatic reactions, and in plasma and laser physics in multiple coupling between modes. Accuracy and efficiency of the proposed algorithm successfully tested on some numerical examples such as Gray-Scott, Schnakenberg, Isothermal Chemical models.

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CP5

Invariant Subspace and Functionally Generalized Separable Solutions of n-Dimensional PDEs

This work provides a systematic approach to compute functionally generalized separable solutions of n-dimensional PDEs not only for linear but also for nonlinear ones. Using the notion of invariance of n-dimensional PDE with respect to Lie-Backlund vector field, a result shows that one can construct a sequence of differential equations each with one independent variable less than the previous one. An algorithm is devised that generates the sequence and find invariant subspace generated by the functional involved in each DE. Finally, we demonstrate the efficacy of the method using linear and nonlinear diffusion equations.

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CP5

Lie Symmetry Analysis and Dust-Acoustic Waves in Dusty Plasma Modeled by Burgers Type Equation

In this work, the Dust-acoustic waves in dusty plasma modeled by nonlinear Burgers type equation are studied through Lie symmetry approach. Using suitable similarity transformations, the given Burgers type equation is reduced to ordinary differential equations (ODEs). During the procedure of reduction, sometime we got some highly nonlinear ODEs which are not easily solvable for traveling wave solutions. Therefore, numerical methods are applied to the reduced ODEs for constructing Dust-acoustic waves.

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CP5

Numerical Study of Reaction Diffusion Fisher's Equation by Fourth Order Cubic B-Spline Collocation Method

Fourth order B-spline collocation method has been applied for study of numerical solutions and physical behaviour of Fisher's equation which represents several important phenomenon such as biological invasions, reaction diffusion in chemical processes and neutron multiplication in nuclear reactions. R.A. Fisher "[Fisher, Ronald Aylmer, Sir,(1890-1962) The Wave of Advance of Advantageous Genes, 7: 355-369 (1937).Issue Date: 1937]" introduced Fisher's equation to investigate the propagation of a virile gene in an infinite long habitat. It is observed that when time becomes sufficiently large, local initial disturbance propagates with constant limiting speed. There are a number of methods to solve Fisher's equation analytically and numerically. In the proposed method we have used fourth order B-spline collocation method to solve Fisher's equation. Earlier work on B-spline collocation method uses second order approximation for double derivative and fourth order approximation for single derivative. In this work, we have improved approximation for double derivative by taking one more term in Taylor series expansion. Results are found to be better than second order B spline method"[R.C. Mittal and Geeta Arora(2010), Efficient numerical solution of Fishers equation by using B-spline method, International Journal of Computer Mathematics,Vol. 87, No. 13, pp. 30393051]".Proposed method is satisfactorily efficient in terms of accuracy and stability.

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CP6

Cell-Centered Finite Volume Element Methods for Elliptic Equations

Two new finite volume element (FVE) schemes are proposed and analyzed for second order elliptic equations. These schemes are based on triangular partitions and provide numerical approximations for both the primary and flux variables. Specifically, the schemes place the primary unknowns on the vertices of the underlying mesh and the flux variable on element edges and discretize the PDE by retaining the flux conserving property on each element, and thus the name of cell-centered FVE methods. Unlike most existing FVE schemes, no Voronoi mesh is needed in our schemes. This Voronoi-free feature makes the method highly flexible and desirable in practical computation.Using the techniques proposed in C. Wang, J. Wang, A primal-dual weak Galerkin finite element method for second order elliptic equations in non-divergence form, the numerical solution is characterized as a minimization of a prescribed non-negative quadratic functional with constraints given by the discrete problem. It is shown that both the finite element solution and the numerical flux converge to the exact solutions with optimal orders. The theoretical results are verified by numerical experiments. A two-phase flow model in porous media has been simulated to illustrate the motivation and the efficiency of this work. The numerical results match the underlying physics and hence show that the conservative fluxes obtained by both CCFVE schemes perform well.

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CP6

A Multiscale Approximation of a Cahn-Larch System with Phase Separation on the Microscale

We consider the process of phase separation of a binary system under the influence of mechanical deformation and we derive a mathematical multiscale model, which describes the evolving microstructure taking into account the elastic properties of the involved materials. Motivated by phase-separation processes observed in lipid monolayers in film-balance experiments, the starting point of the model is the Cahn–Hilliard equation coupled with the equations of linear elasticity, the so-called Cahn–Larché system. Owing to the fact that the mechanical deformation takes place on a macrosopic scale whereas the phase separation happens on a microscopic level, a multiscale approach is imperative. We assume the pattern of the evolving microstructure to have an intrinsic length scale associated with it, which, after nondimensionalisation, leads to a scaled model involving a small parameter $\epsilon > 0$, which is suitable for periodic-homogenisation techniques. For the full nonlinear problem the so-called homogenised problem is then obtained by letting ϵ tend to zero using the method of asymptotic expansion. Furthermore, we present a linearised Cahn–Larché system and use the method of two-scale convergence to obtain the associated limit problem, which turns out to have the same structure as in the nonlinear case, in a mathematically rigorous way. Properties of the limit model will be discussed.

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CP6

Eigencurves for Linear Elliptic Equations

This talk will describe qualitative properties of eigencurves associated with self-adjoint linear elliptic boundary value problems. Weak forms of the problems are considered, so the analysis is based solely on results for bilinear forms instead of linear operators. First, variational characterizations of the eigencurves are given and various orthogonality results for eigenspaces are detailed. Then continuity, differentiability, and asymptotic results for the eigencurves are analyzed. Lastly, a geometrical description of the eigencurves is discussed. The theory is illustrated by treating the weak form of the Robin-Steklov two-parameter eigenvalue problem.

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CP6

Liouville Type Theorem for Some Nonlocal Elliptic Equations

In this talk, we introduce some Liouville theorem for nonlinear elliptic equations involving nonlocal nonlinearity and nonlocal boundary value condition. We extend the Liouville theorems from local problems to nonlocal problem. We use the moving plane method to prove our result.

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CP7

A Determination and Comparison of Analytical and Numerical Soliton Solutions of the Coupled Nonlinear Klein-Gordon Equations As Used in Condensed Matter Physics

This research investigates and compares analytical and numerical soliton solutions of the coupled nonlinear Klein-Gordon Equations. Both the cubic and higher power law nonlinearity have been considered. Numerical calculations have been implemented using finite element methods, and results have been compared with analytical outcomes. Variational iteration methods were used to perform the integrations. As the Klein-Gordon equation is the relativistic limiting equation in zero spin quantum systems, its importance and the nonlinear extensions are considered paramount for subsequent density functional calculations.

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CP7

Fractional Real and Distributed Order Models of Wave Propagation in Viscoelastic Media

Differential and integral operators of noninteger order have become an indispensable tool for modeling certain phenomena in physics, mechanics, engineering, economics, medicine, etc. Over the past years there has been an extensive study of wave propagation in viscoelastic materials within the fractional framework. In this talk we discuss various possibilities for generalizations of the classical wave equation by the use of fractional derivatives of constant real order. As a novel approach, we propose distributed order fractional model to describe wave propagation in viscoelastic infinite media, and study existence and uniqueness of fundamental solutions for the corresponding generalized Cauchy problem. Some particular cases of distributed order fractional constitutive stress-strain relations are examined in details, and numerical experiments are presented to illustrate theoretical results. The talk is based on collaborations with Lj. Oparnica and D. Zorica.

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CP7

Soliton-Like Behavior in Fast Two-Pulse Collisions in Weakly Perturbed Linear Systems of Coupled-Pdes

In this talk, we present the soliton-like behavior in fast two-pulse collisions in weakly perturbed linear systems of coupled-PDEs. The behavior is demonstrated for linear waveguides with weak cubic loss and for systems described by linear diffusion-advection models with weak quadratic loss. We show that in both systems, the expressions for the collision-induced amplitude shifts due to the nonlinear loss have the same form as the expression for the amplitude shift in a fast collision between two solitons of the nonlinear Schrödinger equation in the presence of weak cubic loss. Our work shows that conclusions drawn from analysis of fast two-soliton collisions in the presence of dissipation can be applied for understanding the dynamics of fast two-pulse collisions in a large class of weakly perturbed linear systems of coupled-PDEs, even though the pulses in the linear systems are not shape preserving.

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CP7

Haar Wavelets Based Algorithms for Simulation of

Hyperbolic Type Wave Equations

In this article, the authors developed two algorithms based on Haar wavelets operational matrix for simulation of nonlinear hyperbolic type wave equations. These types of equations describe a variety of physical model in the nonlinear optics, relativistic quantum mechanics, solitons and condensed matter physics, interaction of solitons in collisionless plasma and solid state physics etc. The algorithms reduced the equations into a system of algebraic equations and then the system is solved by Gauss-elimination procedure. Some well-known hyperbolic type wave problems are considered as numerical problems to check the accuracy and efficiency of the proposed algorithm. The numerical results are shown in figures and errors form.

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CP7

Small Amplitude Wave Propagation in Heterogeneous Media with Cracks: High and Low Frequency Approximations.

In this work, we study small amplitude wave propagation in pre-loaded heterogeneous media with periodic structure of heterogeneities weakened by cracks. We suppose the existence of several length scales: the smallest microscale defining the characteristic size of cracks, the mesoscale defining the characteristic size of periodic distribution of heterogeneities, and the macroscale which can be defined as a global characteristic size. The low-frequency approximation assumes the situation where the wavelength exceeds the mesoscale characteristic size. The high frequency approximation implies the same order of magnitude for these two characteristic lengths. We assume cracks to be isolated, randomly oriented and either open or closed penny shaped. In the case of closed penny shaped cracks, we take into account the Coulomb friction between crack faces. For low-frequency and high-frequency cases we propose multiscale approaches which allow us to replace real heterogeneous materials with effective media. As a result, we derive expressions for displacements and velocities of waves in effective media, and study how these quantities can be influenced by external stress, wave's frequency and the direction of propagation.

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CP7

Periodic Traveling Interfacial Hydroelastic Waves with or Without Mass

We study the motion of an interface between two irrotational, incompressible fluids, with elastic bending forces present; this is the hydroelastic wave problem. We prove a global bifurcation theorem for the existence of families of spatially periodic traveling waves on infinite depth. Our traveling wave formulation uses a parameterized curve, in which the waves are able to have multi-valued height. This formulation and the presence of the elastic bending terms allows for the application of an abstract global bifurcation theorem of "identity plus compact' type. We furthermore perform numerical computations of these families of traveling waves, finding that, depending on the choice of parameters, the curves of traveling waves can either be unbounded, reconnect to trivial solutions, or end with a wave which has a self-intersection. Our analytical and computational methods are able to treat in a unified way the cases of positive or zero mass density along the sheet, the cases of single-valued or multi-valued height, and the cases of single-fluid or interfacial waves.

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CP8

A Class of Linear PDEs Describing Asymptotically Algebraically Unstable Waves

The Fourier-Laplace integral solution for linear constant coefficient PDEs is used to demonstrate the possibility of long-time algebraic growth. Such growth is possible when the dispersion relation extracted from classical stability analysis indicates neutral stability. Interestingly, growth can occur (asymptotically, for long-time) like t^s, where s can be non-integer. Unlike linear constant coefficient ODEs that exhibit such growth only for non-normal systems (i.e. with insufficient eigenvectors) for which s is an integer, the growth mentioned above arises through a different mechanism in normal operators - namely singularity cancellation in Fresnel (and Fresnel-like) integrals that arise from the Fourier-Laplace integral solution of the PDE. The practical relevance of this work is that linear PDEs describing the propagation of disturbances in both space and time may in fact lead to growing responses, even when the linear stability analysis predicts non-growing solutions at the neutral stability threshold.

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CP8

Morphological Evolution of Crystal Surfaces below the Roughening Temperature:from Mesoscopic and Macroscopic View

During the heteroepitaxial growth on vicinal surface, step flow is one of various structures created on crystal sur-

faces. Understanding and mastering the thin film growth is a major challenge of materials science. We first introduce the step flow dynamics for mesoscopic models and their continuum limit to 4th order degenerate parabolic equations. Especially, various long range elastic interactions are considered, which leads to the instability of step growth. Then we use the regularized method to deal with one of those degenerate parabolic equations in attachment-detachment-limit regime and obtain a global weak solution, which is sign-preserved almost everywhere.

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CP8

Instability and Dynamics of a Generalized Volatile Thin Film Model

We study the evolution of a mathematical generalized thin film model that characterizes the dynamics of thin films of volatile viscous fluids on a dewetting solid substrate. The governing lubrication model is a fourth-order nonlinear parabolic partial differential equation with a loss term due to evaporation or condensation. Interesting dynamics like pattern formation, finite time singularities, droplet dynamics are investigated. In particular, unlike similar models without evaporation where positivity of solutions is guaranteed, in our model instabilities enhanced by evaporation can cause finite-time rupture. Self-similar dynamics lead to the singularities, produced by balances between evaporation and surface tension or intermolecular forces. The self-similar rupture solutions are analyzed and validated against high resolution PDE simulations.

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CP8

On the Explosive Instability in a Three-Species Food Chain Model with Modified Holling Type IV Functional Response

In earlier literature, a version of a classical three-species food chain model, with modified Holling type IV functional response, is proposed. Results on the global boundedness of solutions to the model system under certain parametric restrictions are derived, and chaotic dynamics is shown. We prove that in fact the model possesses explosive instability, and solutions can explode/blow up in finite time, for certain initial conditions, even under the parametric restrictions of the literature. Furthermore, we derive the Hopf bifurcation criterion, route to chaos, and Turing bifurcation in case of the spatially explicit model. Lastly, we propose, analyze, and simulate a version of the model, incorporating gestation effect, via an appropriate time delay. The delayed model is shown to possess globally bounded solutions, for any initial condition.

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CP8

A Three-Field Formulation for Poroelasticity Equations and Its Solvability Via Fredholm Alternative

In this talk we present a stable and convergent conforming finite element method for the discretisation of the linear poroelasticity equations in a new formulation, where the volumetric contributions to the total stress are merged into an additional unknown. The resulting saddle point formulation can be analysed by means of a Fredholm alternative, after realizing that the problem is a compact perturbation of a Stokes-like invertible system. A generic Galerkin scheme is constructed, whose solvability properties follow closely those from the continuous variational form, and more importantly, given that specific finite dimensional spaces are chosen adequately, it is stable even in the incompressible limit.

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CP9

Controllability of Nonlinear Reaction-Diffusion Equations

We discuss some results concerning the global approximate controllability of semilinear reaction-diffusion equations governed via the coefficient of the reaction term (multiplicative or bilinear control). We study both uniformly parabolic and degenerate equations. We start to consider a one-dimensional uniformly parabolic problem and we extend in [1] some nonnegative controllability results by bilinear controls assuming that both the initial and target states admit no more than finitely many changes of sign. Our method uses a technique, introduced in [1], employing the shifting of the points of sign change by making use of a finite sequence of initial-value pure diffusion problems. The results obtained in [1] have allowed us to approach the multidimensional case with radial symmetry. Indeed, assuming that the initial and final data are radial on a ball about the origin, we reduce the problem to a one-dimensional setting. In this way, we obtain an approximate controllability result for data which admit finitely many hyperspheres of sign change. The method, introduced in [1] for uniformly parabolic equations, can be also extended to degenerate reaction-diffusion equations. [1] P. Cannarsa, G. Floridia, A.Y. Khapalov, Multiplicative controllability for semilinear reaction-diffusion equations with finitely many changes of sign, preprint (2016), to appear on *Journal de Mathématiques Pures et Appliquées.*

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CP9

Homogenization and Concentrated Capacity for the Heat Equation with Two Kinds of Microstructures

We investigate how geometric microstructures of a domain can affect the diffusion on the macroscopic level. More precisely, we look at a domain with additional microstructures of two kinds, the first one are periodically arranged 'horizontal barriers' and the second one are 'vertical barriers' which are not periodically arranged, but uniform on certain intervals. Both structures are parametrized in size by a small parameter ε. Starting from such a geometry combined with a diffusion(-reaction) model, we derive the homogenized limit and discuss the differences of the resulting limit problems for various particular arrangements of the microstructures. Moreover, we discuss the motivation of the above mentioned problem by structures observed in strongly folded membranes and conclude by a short outlook.

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CP9

The Kirkpatrick-Barton Reaction-Diffusion System in Spatial Evolutionary Ecology

In a paper celebrated by biologists, Kirkpatrick and Barton [American Naturalist 1997] introduced the system $N_t = N_{xx} + N\left(1 - N - \frac{1}{2}Z^2\right)$, $Z_t = Z_{xx} + 2\frac{N_x}{N}\left(Z_x + B\right) - AZ$ as a model for the joint evolution of a population density N and the mean Z of a quantitative trait—that is, a continuous random variable such as body size in animals—in a nonhomogeneous selective environment. We present a local existence proof for solutions of this system that may exhibit linear growth of Z as $x \to \pm\infty$, as numerical experiments suggest is true for some traveling wave and stationary (pinned) solutions. We also prove existence of some traveling waves and pinned solutions. These appear to be the first rigorous results of any kind concerning this system.

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CP9

Global Existence and Uniform Estimates for Volume Surface Reaction Diffusion Systems

We consider coupled reaction-diffusion models where some components react and diffuse on the boundary of a region, while other components diffuse in the interior and react with those on the boundary through mass transport, dynamic or Wentzell boundary conditions. We derive Sobolev estimates for linear dynamic initial boundary value problems and combine these with classical potential theory and classical estimates for linear initial boundary value problems to prove local well-posedness. Conservation of mass and other reasonable assumptions afford a priori estimate, and allow us to employ duality arguments to bootstrap sufficiently to obtain global existence, and uniform sup-norm bounds. Systems of this form arise in a number of physical scenarios.

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CP9

Numerical Simulation to Capture the Pattern Formation

This work deals to capture the different types of patterns of nonlinear time dependent coupled reaction-diffusion models. To accomplish this work, a new differential quadrature (DQ) algorithm is developed with the help of modified trigonometric cubic B-spline functions. The stability part of the developed algorithm is studied by matrix stability analysis method. In the experimental part, different types of patterns of Gray-Scott, Schnakenberg, Isothermal Chemical and Brusselator Models are captured which are similar to the existing patterns of the models.

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CP9

Modelling Pattern Formation on the Surface of a Ferrofluid

Consider an infinite slab Ω separated into two simply connected subdomains: Ω_F is occupied by a ferrofluid and Ω_A is occupied by air, both subjected to an upwards pointing vertical magnetic field of strength $H > 0$. Let $\mathbf{B} : \Omega \to R^3$ denote the magnetic induction and $\mathbf{H} : \Omega \to R^3$ the (irrotational) magnetic field strength. Since the field is irrotational there exist two magnetic potentials ϕ, χ such that $\mathbf{H} = -\nabla\phi$ in Ω_F and $\mathbf{H} = -\nabla\chi$ in Ω_A. Assuming a steady state, Maxwell's equations of magnetostatics imply that χ is harmonic in Ω_A and ϕ is μ-harmonic in Ω_F; here the function μ describes the magnetization law of the ferrofluid. For an arbitrary μ, we extract a free boundary problem involving the magnetic potentials in the ferrofluid and the air together with compatibility and dynamic conditions on the free interface. First, we stay in the planar case and assume that the surface of the ferrofluid can be described by the graph of a function. Using spatial dynamic techniques and an appropriate center manifold reduction we show existence of static solitons on the surface. Next, going back to 3d and dropping the "graph' assumption, we solve the free boundary problem by applying techniques developed for the study of convex-concave functionals.

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CP10

How Robin Meets Dirichlet

This talk will describe the approximation of the solution of Dirichlet boundary value problems for second order elliptic equations by Robin boundary value problems. The case of Laplace's equation on bounded regions in R^N will be described. It is well known that the Dirichlet boundary value problem with $u = g$ on the boundary has a unique solution in $H^1(\Omega)$ if and only if g is in $H^{1/2}(\partial\Omega)$. The Robin problem with $\epsilon D_\nu u + u = g$ has a unique solution $H^1(\Omega)$ if and only if g is in $H^{-1/2}(\partial\Omega)$. This talk will describe the convergence of the solutions of the Robin problem as $\epsilon \to 0^+$ to those of the Dirichlet problem. When g is in $H^{-1/2}(\partial\Omega)$, there is a unique L^2- solution of the Dirichlet problem and the Robin solutions converge to this Dirichlet solution in the L^2-norm.. Rate of convergence results will be given for $g \in H^s(\partial\Omega)$ and $s > -1/2$.

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CP10

Recent Development in the Boltzmann Equation in Bounded Domains

The Boltzmann equation in smooth convex bounded domain with specular boundary condition was long-standing open problem since the announcement of Shizuta and Asano (1977). After several decades, novel $L^2 - L^\infty$ bootstarp was introduced in [Y.Guo, Decay and Continuity of the Boltzmann equation, ARMA, 2010] for partial result. This problem was completely solved in [Kim and Lee, The Boltzmann equation with specular boundary condition in convex domains, CPAM, 2017] by considering geometric decomposition of particle trajectory and introducing novel triple iteration techniques. We introduce key ideas of the paper. Moreover, we also introduce some recent development for non-convex domains: Asymptotic behavior and Local Holer regularity. We also mention about constructive coercivity which gives higher integrability.

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CP10

Asymptotic Investigation of a Nonlinear Initial-Boundary-Value Problem for a Light Multi-Tethered Sphere in Uniform and Modulated Flows

We derive a nonlinear initial-boundary-value problem (IBVP) for a lighter-than-air multi-tethered sphere using the extended Hamilton's principle augmented by Lagrange multipliers that describe the configuration geometric constraints. The tethers are modeled as continuum cables that move in longitudinal, normal, and bi-normal directions. The six-degrees-of-freedom rigid-body motion of the buoyant sphere define the boundary conditions of the IBVP. The entire structure is immersed in modulated aerodynamic flow and incorporates both internal viscoelastic structural damping for the cables and external drag-induced viscous damping of the sphere. Motivated by numerical analysis of the IBVP that exhibits a variety of periodic, quasiperiodic and chaotic solutions in a limiting planar configuration [Mi & Gottlieb 2016], we apply the asymptotic multiple-scales method to investigate the existence of internal resonances that govern energy transfer between the sphere degrees-of-freedom and the cables. Formulation of the IBVP solvability conditions enables construction of the system frequency response which allows comparison of the asymptotic dynamics with their numerical counterparts. A comprehensive bifurcation structure is anticipated to shed light on the orbital stability of multi-tethered sphere in uniform and modulated flows.

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CP10

A Generalization of the Lions-Aubin-Simon Compactness Lemma to Problems on Moving Domains

We are interested in studying compactness of sequences that approximate functions $\mathbf{u}(t, x)$ in Bochner spaces $L^2(0, T; X(t))$, where $X(t)$ is a Hilbert space, which depends on time. Problems of this type arise, for example, in studying evolution problems modeled by partial differential equations defined on domains that depend on time. Examples include general moving-boundary problems, or more particularly, fluid flows in time-dependent fluid domains that may either be given *a priori*, or in fluid domains that are not known *a priori* but depend on the solution of a fluid-structure interaction problem. In the latter case the elastodynamics of a compliant (elastic, or viscoelastic) structure determines the fluid domain. Thus, the spatial domain depends on time through the unknowns of the problem, giving rise to a strong geometric nonlinearity. This is joint work with S. Canic, University of Houston.

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CP10

L^p Estimates and Higher Regularity for Semilinear Spdes with Monotone Semilinearity

L^p- estimates for semilinear stochastic partial differential equations (on a bounded domain) with monotone semilinear term are obtained. These estimates are then used to

obtain higher interior regularity of solutions to such equations. These L^p-estimates together with known results for linear SPDEs can also be used to obtain the regularity of solution up to boundary in some weighted Sobolev space.

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CP10

Lower Bounds of the Blow-Up Time under the Local Nonlinear Neumann Boundary Condtions

In this talk, we will focus on the lower bound estimate of the blow-up time T^* for the heat equation $u_t = \Delta u$ in a bounded domain Ω in $\mathbb{R}^n (n \geq 2)$ with positive initial data u_0 and a local nonlinear Neumann boundary condition: The normal derivative $\partial u/\partial n = u^q$ on partial boundary $\Gamma_1 \subseteq \partial\Omega$ for some $q > 1$ and $\partial u/\partial n = 0$ on the rest of the boundary. In particular, we will discuss the asymptotic behavior of T^* as $q \to 1$, $|\Gamma_1| \to 0$ or $M_0 \to 0$, where $|\Gamma_1|$ denotes the surface area of Γ_1 and M_0 denotes the maximum of u_0. This is a joint work with Zhengfang Zhou.

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CP11

On the Wellposedness of Generalized Darcy-Forchheimer Equation

We consider the Generalized Darcy-Forchheimer model,

$$\begin{aligned} \frac{\mu}{\rho}\boldsymbol{K}^{-1}\boldsymbol{u} + \frac{\beta}{\rho}|\boldsymbol{u}|^{m-1}\boldsymbol{u} + \bigtriangledown p = \boldsymbol{f} \qquad &\text{in} \qquad \Omega, m \in (1\ 2] \\ div\boldsymbol{u} = b \qquad &\text{in} \qquad \Omega, \\ \boldsymbol{u}\cdot\boldsymbol{n} = g \qquad &\text{on} \qquad \partial\Omega. \end{aligned}$$

modelling a steady single phase fluid flow in two or three dimensional porous medium, where $\boldsymbol{u}$ and p denote the unknown velocity vector and pressure field respectively. $\boldsymbol{K}$ is the permeability tensor. The parameter ρ,μ,β positive constants represent the density, viscosity and dynamic viscosity of the fluid respectively. f, b and g are given functions satisfying some compatibility conditions.
The problem is nonlinear of monotone type. For $m = 2$, the existence and uniqueness theory is presented in [Girault and Wheeler, Numerical discretization of Darcy-Forchheimer Equation] . For strong inertia flows in simple media,with $m \in (1, 2]$ and under some mild regularity assumptions on the interior and boundary data, we established the existence, uniqueness and stability of the solution $(\boldsymbol{u}, p)$ of (**??**) $-$ (**??**) in $\Big(L^m(\Omega)^d \times (W^{1,\frac{m+1}{m}}(\Omega) \bigcap L_0^2(\Omega))\Big)$.

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CP11

Multilayered Flows in the Shallow-Water Limit: Dynamics and Loss of Hyperbolicity

In this talk, we will formulate and discuss the problem of density stratified interfacial flows in the shallow-water limit. This type of flow occurs in nature with the atmosphere and ocean as prime examples. Mathematical studies of these are particularly important, since wave motion tends not to be resolved by most numerical climate models due to their fast scales, and thus need to be understood and parameterized. For example waves may break and dissipate energy or mix the underlying fluids and affect the medium in which they are propagating. Consequently this research will both increase the understanding of internal waves, and have an impact on future climate models. We will focus our attention on the two and three-layer flows, without the so-called Boussinesq approximation which requires small density differences. This is a simplified model for geophysical situations, but it is not too simplified: the model has both barotropic (fast waves affecting the whole fluid uniformly) and baroclinic modes (slower waves with more internal structure). The governing equations will be derived and the dynamics of their solutions will be studied from both analytical and numerical points of view, particularly the issue of whether the solutions maintain hyperbolicity (i.e. wave-like behaviour).

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CP11

Continuous Data Assimilation for the Magnetohydrodynamic Equations in 2D

We propose several continuous data assimilation algorithms based on feedback control for the 2D magnetohydrodynamic (MHD) equations. We show that for sufficiently large choices of the control parameter and resolution and assuming that the observed data is error-free, the solution of the controlled system converges exponentially (in L^2 and H^1 norms) to the reference solution independently of the initial data chosen for the controlled system. We also obtain results when controls are placed only on the horizontal (or vertical) variables, or on a *single* Elsässer variable, under more restrictive conditions on the control parameter and resolution. Finally, using the data assimilation system, we show the existence of *abridged* determining modes, nodes and volume elements.

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CP11

Flows of Immiscible Fluids Through the Channels with Porous Media in the Presence of Magnetic Field

This paper concerns with the flow of viscous, steady, incompressible and immiscible fluids with different viscosities in the channels of two infinite parallel plates. The flow is driven by the constant pressure gradient in the presence of transverse magnetic field of uniform strength. Both the channels are filled with the highly porous media and having different permeability. The flows through the channels are governed by the Brinkman equation with the inclusion of inertia term. No-slip conditions at the end of plates, continuity of velocity and continuity of shearing stress at the interface have been used as the boundary conditions to get the solution of the considered problem. The effect of various fluid parameters like permeability of porous region, magnetic number etc on the flow velocity profile, flow rate and shearing stress has been discussed graphically.

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CP11

Mathematical and Numerical Analysis of Some Viscoelastic Flows

We present our recent theoretical and numerical results for the Peterlin viscoelastic fluids. This constitutive model is motivated by the Peterlin dumbbell theory with a nonlinear spring law for an infinitely extensible spring. A diffusion term is included in the constitutive model. We prove global existence of weak solutions for large data. For more regular data and a special choice of nonlinear constitutive functions the regularity and uniqueness of the solution can be shown. The Peterlin viscoelastic model has been investigated also from the numerical point of view and approximated by the LagrangeGalerkin scheme. We prove error estimates with the optimal convergence order without any relation between the time increment and the mesh size. The result is valid for both the diffusive and non-diffusive models. If time permits we report on our recent existence results for the multiscale model combining the macroscopic flow equations with the kinetic equation for viscoelastic effects. Here the elastic stress tensor is defined by the Kramers expression through the probability density function that satisfies the corresponding Fokker-Planck equation. The present research has been realized in the cooperation with H. Mizerova (Mainz), S. Necasova (Prag), M. Renardy (Virginia Tech), M. Tabata (Tokyo), H. Notsu (Kanazawa), A. Swierczewska-Gwiazda (Warsaw) and P. Gwiazda (Warsaw). It has been supported by the German Science Foundation DFG under the grant TRR 146.

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CP11

Fracture Modeling and Optimization for Nonlinear Flows in Coupled Fracture Porous Media

In this study, we analyze the flow filtration process of slightly compressible fluids in porous media containing fractures with complex geometries. We model the coupled fracture-porous media system where the linear Darcy flow is considered in porous media and the nonlinear Forchheimer equation is used inside the fracture. We develop a model to examine the flow inside fractures with complex geometries and variable thickness on a Riemannian manifold. The fracture is represented as the normal variation of a surface immersed in $\mathbb{R}^{\not\models}$ and using Laplace Beltrami operator, an equation that describes the flow is formulated. Using the model, pressure profile of a nonlinear flow is analyzed and compared with the actual pressure profile obtained numerically in order to validate the model. Also, we couple the fracture model with the reservoir system. The diffusive capacity, a functional that measures the performance of the reservoir, is analyzed and compared with the actual diffusive capacity.

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MS1

Weak Solutions of Conservation Laws and Energy/Entropy Conservation

A common feature of systems of conservation laws of continuum physics is that they are endowed with natural companion laws which are in such case most often related with the second law of thermodynamics. This observation easily generalizes to any symmetrizable system of conservation laws. They are endowed with nontrivial companion conservation laws, which are immediately satisfied by classical solutions. Not surprisingly, weak solutions may fail to satisfy companion laws, which are then often relaxed from equality to inequality and overtake a role of a physical admissibility condition for weak solutions. We want to answer the question what is a critical regularity of weak solutions to a general system of conservation laws to satisfy an associated companion law as an equality. An archetypal example of such result was derived for the incompressible Euler system by Constantin et al. in a context of the seminal Onsager's conjecture. This general result can serve as an easy criterion to numerous systems of mathematical physics to prescribe the regularity of solutions needed for an appropriate companion law to be satisfied.

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MS1

On the Energy Flux of Homogeneous Solutions to the Euler Equation

In this talk we will discuss mechanisms for energy balance restoration in 2D and 3D Onsager-critical homogeneous solutions to the incompressible Euler system. We also discuss classification of such solutions.

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MS1

Nonuniqueness of Weak Solutions to the SQG Equation

We prove that weak solutions of the inviscid and the dissipative SQG equations are not unique. In view of the well-known global existence of weak solutions for the dissipative SQG equation with datum at the level of the Hamiltonian, our work is the first to show that weak solutions constructed via convex integration can exist in a regularity class in which the nonlinearity is weakly continuous. This is joint work with T. Buckmaster and S. Shkoller.

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MS1

Statistical Solutions and Onsager's Conjecture

Recently, Fjordholm et al. introduced a statistical notion of solution for conservation laws. We adapt their framework to the incompressible Euler equations and prove a suitable version of the "conservative" part of Onsager's Conjecture. As a byproduct, we obtain an alternative proof of the classical statement for weak solutions.

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MS2

Multi-Species Kinetic and Fluid Models and Applications

A kinetic description for evolving gases is given the so called BGK model, or ES-BGK models, or BGK models for a polyatomic gas. To overcome the restriction of this type of model to a single specific gas in applications, where gas mixtures are important, one is lead to multi-species kinetic models. All these models are devised so that they relax towards fluid models, such that correct features of the macroscopic partial differential equations (like viscosity coefficients) are recovered. These two fluid models allow one to present a hierarchy of fluid models. We shall illustrate this by beginning with ions and electrons, arriving at two fluid plasma equations. We shall illustrate the improved physical understanding of multi-species fluid models, and give examples of their numerical simulation. This is joint work with Marlies Pirner, Gabriella Puppo und Anas Crestetto.

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MS2

A Bgk Model for Polyatomic Gas Flows at High Temperature

For atmospheric reentry problems, it is necessary to make numerical simulation of complex hypersonic flows, in which the temperature can be very large. For flows in continuous (dense) regime, simulation codes use models that take into account high temperature effects, like the excitation of the rotational and vibrational energy of the molecules. This is done by using a special equation of state (EOS), which is even not not known analytically, and is rather given by a numerical table. For such flows in high altitude, the air is rarefied, and a kinetic model must be used, like the Boltzmann equation. At the computational level, taking into rotational and vibrational non equilibrium in the Boltzmann equation induces a model with a very large dimension (more than 7 degrees of freedom). Its numerical solving is almost impossible, at least for transitional flows, in which DSMC solvers are known to be inefficient. In this talk, I will show that it is possible to design a simpler BGK model that is consistent with any arbitrary EOS. This model can take into account rotational and vibrational non equilibrium with the same level of accuracy as a CFD solver in a dense regime, with a complexity which is close to that of a simple monoatomic gas. This work is in collaboration with C. Baranger, G. Marois, J. Mathe, and J. Mathiaud, (French atomic energy agency).

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MS2

Well-Balanced and Asymptotic Preserving Schemes for Kinetic Models

We propose a general framework for designing numerical schemes that have both well-balanced (WB) and asymptotic preserving (AP) properties, for various kinds of kinetic models. We are interested in two different parameter regimes, 1) When the ratio between the mean free path and the characteristic macroscopic length ε tends to zero, the density can be described by (advection) diffusion type (linear or nonlinear) macroscopic models; 2) When $\varepsilon = O(1)$, the models behave like hyperbolic equations with source terms and we are interested in their steady states. We apply the framework to three different kinetic models: neutron transport equation and its diffusion limit, the transport equation for chemotaxis and its Keller-Segel limit. Numerical examples are given to demonstrate the properties of the schemes.

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MS2

Self-organized Pattern Formation in a Kinetic Transport Equation for Chemotactic Bacteria

Collective motion of chemotactic bacteria as E. Coli relies, at the individual level, on a continuous reorientation by runs and tumbles. It has been established that the length of run is decided by a stiff response to temporal sensing of chemical cues along the pathway. We analyze consequences on self-organized pattern formation resulting from modulation of tumbling frequency with stiff response. Thanks to both analytical arguments and numerical simulations, we show that the stationary homogeneous state of population density is destabilized in realistic ranges of parameters. A remarkable property is that the unstable frequencies remain bounded, as it is the case in Turing instability.

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MS3

Application of Herglotz Functions to the Study of Viscodynamics of Porous Media

One important quantity in the study of porous media is the dynamic tortuosity, which characterizes the effective ebergy dissipation and the inertia coupling between the viscous fluid phase and the solid phase in a porous media. It plays the role of the the memory kernel in the generalized Biot equations, which are the governing equations of wave propagation in poroelastic media when the wave length is much longer than the length scale of the microstructure. In this talk, we will illustrate how the Herglotz function arises in the study of dynamic permeability, following the 1991 paper by Avellaneda and Torquato , and show how this result can be applied to the study of dynamic tortuosity and its Prony type approximation. Both the isotropic and anisotropic cases will be considered. We will show how the close tie between the Herglotz function and the Multipoint Pade (or rational) approximation is explored in this line of research.

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MS3

Constraint Energy Minimizing Generalized Multiscale Finite Element Method

In this talk, we present Constraint Energy Minimizing Generalized Multiscale Finite Element Method (CEM-GMsFEM). The key part of the method is the design of multiscale basis functions within GMsFEM framework such that the convergence of method is independent of the contrast and linearly decreases with respect to mesh size if oversampling size is appropriately chosen. Our construction starts with an auxiliary multiscale space by solving local spectral problems. In auxiliary multiscale space, we select the basis functions that correspond to small (contrast-dependent) eigenvalues. These basis functions represent the channels (high-contrast features that connect the boundaries of the coarse block). Using the auxiliary space, we propose a constraint energy minimization to construct multiscale spaces. The minimization is performed in the oversampling domain, which is larger than the target coarse block. The constraints allow handling non-decaying components of the local minimizers. If the auxiliary space is correctly chosen, we show that the convergence rate is independent of the contrast and is proportional to the coarse-mesh size. We will also present some numerical results to verify the theoretical estimates. (The research is supported by Hong Kong RGC General Research Fund (Project 14317516).)

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MS3

Navier Slip Condition for Viscous Fluids on a Rough Boundary

In this talk, using homogenization methods and boundary layer techniques, I will derive asymptotically the effective Navier slip boundary condition, as a first-order corrector, to the no-slip condition on the interface between a fluid and a rough surface. The method used provides a formula to calculate the slip length for various geometries. I will also show some computations done, using FreeFem++, which agree with experimental data.

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MS3

Criteria for Opening Band Gaps in Periodic Media

Explicit conditions on geometry and material contrast are identified for creating band gaps in 2-d photonic and 3-d acoustic crystals. The approach applied here makes use of the electrostatic and quasi-periodic source free resonances of the crystal, which deliver a spectral representation for solution operators associated with the propagation of waves inside the periodic high contrast medium. This, together with the Dirichlet spectrum and an auxiliary spectrum associated with the inclusions, delivers conditions for opening band gaps at finite contrast for a given inclusion geometry. This is joint work with Robert Viator Jr.

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MS4

Low Reynolds Number Fluid-Structure Interactions: Modeling the Response of Soft Microfluidic

Devices

In this talk, we will summarize some recent results on the mathematical and computational modeling of microfluidic devices. Rectangular channels with deformable walls are used as one of the simplest models for the main component of lab-on-a-chip devices. Experimentally, these devices are found to deform into a non-rectangular cross-section due to fluid–structure interactions, leading to a non-linear relationship between the volumetric flow rate and the pressure drop. We predict this relation via perturbative calculations involving a coupled system of Stokes ($Re = 0$) flow in a 3D rectangular channel with a top wall that is a linearly elastic Kirchhoff–Love plate. We have benchmarked and verified the theoretical predictions by 3D numerical simulations, calibrated with experimental pressure drop–flow rate data, using the commercial software suite ANSYS. We will also discuss recent extensions of this work to solid geometries that are not well approximated as plates, and also cylindrical domains. The transient problem of inflation/deflation of a microchannel will also be touched upon.

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MS4

The Einstein-Navier-Stokes System

We consider Einstein's equations coupled to equations modeling relativistic fluids with viscosity. We establish existence, geometric uniqueness, and causality of the corresponding initial-value problem. If time allows, we shall discuss applications to quark-gluon plasmas that form in collisions of heavy ions.

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MS4

Plasticity by a Phase Field Model

In plastic metal theory, the mechanical behavior is related with the underlying micro-scale structure, such as dislocations and disclinations, which are considered as defects in the crystal structure of metals. It is well known that the plastic behavior is due to the increasing disorder of the crystal lattice caused by the strains. So, the dislocation migration is described by a differential system, from which by numerical simulation, we obtain the classical hysteresis loop for cyclic hardening under strain control.

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MS4

Fluid Flow Through Deformable Porous Media: Analysis, Simulations and Applications

Fluid flow through porous deformable media is relevant for many applications in biology, medicine and bioengineering. In this talk, we discuss the problem of existence of weak solutions in bounded domains, accounting for non-zero volumetric and boundary forcing terms, with particular focus on the role of structural viscoelasticity. The theoretical analysis shows that different time regularity is required for the volumetric source of linear momentum and the boundary source of traction depending on whether or not viscoelasticity is present. The theoretical results are further investigated via numerical simulations based on a novel dual mixed hybridized finite element discretization. Simulations show that, in the purely elastic case, the solutions might become unbounded if the data do not enjoy the time regularity required by the theory. Furthermore, solution blow-up is proved by exhibiting an explicit solution in the one-dimensional case. Applications will be presented in the case of blood flow through ocular tissues. In this context, the theoretical findings led us to formulate a novel hypothesis concerning the causes of hemorrhages in the optic disc, namely that abrupt time variations in stress conditions, due to changes in intraocular or cerebrospinal fluid pressure, combined with lack of structural viscoelasticity, due to aging or disease, could lead to microstructural damage and rupture of blood vessels due to local fluid-dynamical alterations.

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MS5

Longtime Existence of Models of Water Waves on the Torus

We shall discuss a new method for the longtime existence of models of water waves.

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MS5

Two Dimensional Water Waves

We consider the question of describing the long time dynamics for several one dimensional water wave models. Our primary focus will be the Benjamin-Ono equation, but if time permits the discussion will also involve the cubic NLS equation and the KdV equation.

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MS5

On Local-in-Time Existence of Solutions to the Free Moving Boundary Incompressible Euler Equations Without Surface Tension

We establish a priori estimates for local-in-time existence of solutions to the water wave model consisting of the 3D incompressible Euler equations on a domain with a free surface, without surface tension, under minimal regularity assumptions on the initial data and the Rayleigh-Taylor sign condition. The initial data is allowed to be rotational and it is assumed to belong to Sobolev space $H^{2.5+\delta}$, where $\delta > 0$ is arbitrary. This is joint work with Igor Kukavica from the University of Southern California.

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MS5

Challenges in the Modeling and Analysis of Axial Flow Flutter

Flutter is a (bounded response, self-excitation) instability brought about by the interaction of an elastic structure in a surrounding fluid flow. Here, we describe the difficult problem of modeling the flutter phenomenon for plates (or beams), when a significant portion of the structures boundary is free and the flow is along the principal length axis. Much can be said at the qualitative level about flag, flap, and wing flutter; these phenomena are of great interest in engineering. Mathematically, there is a lack of rigorous analysis. Beyond the obvious applications in aeroscience, the flutter phenomenon also arises in the biomedical realm and in sustainable energies. We will discuss some recent results for mathematical models of panel flutter, a simpler situation involving a fully clamped structure. We then discuss the ways in which this analysis breaks down when a portion of the structures boundary is free. We review two classes of pertinent beam models (including the recent inextensible models proposed by Dowell et al), and emphasize the effect of rotational inertia in the structure. The challenges in the analysis can be viewed as reflections of the difficulty in modeling the physics of the problem. Recent results will be discussed that address well-posedness and global attractors of various cantilevered dynamics, along with recent numerical simulations.

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MS6

Anomaly Detection and Classification for Streaming Data Using Partial Differential Equations

Non-dominated sorting, also called Pareto Depth Analysis (PDA), is widely used in multi-objective optimization and has recently found important applications in multi-criteria anomaly detection. Recently, a PDE continuum limit was discovered for non-dominated sorting, which provides a fast and convenient method for approximate PDA. A second PDE continuum limit was discovered which sorts points within their Pareto fronts, based on the extent to which they violate a criterion. In this talk we present an algorithm based on the discretization of these PDEs which provides a real-time streaming version of the PDA algorithm that exploits the computational advantages of the PDE and has the added benefit of being able to classify anomalies. Numerical experiments conducted on both synthetic and real data validate the efficacy of the algorithm are presented.

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MS6

Deep Relaxations: Partial Differential Equations for Optimizing Deep Neural Networks

This paper establishes a connection between non-convex optimization and nonlinear partial differential equations (PDEs). We interpret empirically successful relaxation techniques motivated from statistical physics for training deep neural networks as solutions of a viscous Hamilton-Jacobi (HJ) PDE. The underlying stochastic control interpretation allows us to prove that these techniques perform better than stochastic gradient descent (SGD). Moreover, we derive this PDE from a stochastic homogenization problem which proves connections to algorithms for distributed training of deep networks like Elastic-SGD. Our analysis provides insight into the geometry of the energy landscape and suggests new algorithms based on the non-viscous Hamilton-Jacobi PDE that can effectively tackle the high dimensionality of modern neural networks.

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MS6

A PDE Approach to Prediction with Mixed Strategies

This work investigates a classical problem from online machine learning using methods from optimal control theory. The problem is a discrete time iterative process involving decision making at every step; the goal for mathematical analysis is to understand the optimal strategy and its consequences over a long period of time. The solution is analyzed through its continuous limit - an appropriately defined value function, which solves a PDE in the viscosity sense. The PDE is then used to determine the optimal strategies.

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MS6

Elliptic PDE Tackled by Primal-Dual Optimization

Elliptic PDE are the Euler-Lagrange equations of a *convex* optimization problem. Here we propose to make use of the recent efficient primal-dual hybrid gradients method to solve the PDE through a convex optimization lens. The proposed scheme avoids inversion of the operator and uses adjoints instead. Elimination of the dual variable eventually yields an explicit scheme with faster convergence than traditional stiffness-condition limited explicit scheme. The speed-up is due to an apparent boosting term, reminiscent of the momentum method. We present preliminary numerical results on standard problems (Poisson problem, obstacle problem), applied problems (H1-regularized least squares, MBO motion by mean curvature), random walks, and diffuse interfaces on graphs. Off-label use extends the proposed method to non-convex problems such as Schroedinger eigenfunctions and pagerank.

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MS7

Slow Motion for the 1D Swift–Hohenberg Equation

We study the behavior of certain solutions to the Swift–Hohenberg equation on a one-dimensional torus. Combining results from Γ-convergence and ODE theory, we show that solutions corresponding to initial data that is L^1-close to a jump function v, remain close to v for large time. This can be achieved by regarding the equation as the L^2-gradient flow of a second order energy functional, and obtaining asymptotic lower bounds on this energy in terms of the number of jumps of v.

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MS7

A Generalized Swift-Hohenberg Model for Active Liquid Crystal Suspensions

Recent laboratory experiments have demonstrated that biological rod-protein assemblies exhibit a 2D active liquid crystal phase characterized by a rich topological defect dynamics. This remarkable discovery has sparked considerable theoretical and experimental interest. I will present and validate a tensor Swift-Hohenberg PDE model for this system by merging universality ideas with the classical Landau-de Gennes theory. The resulting model agrees quantitatively with recently published data and, in particular, predicts a previously unexplained regime characterized by antipolar order of topological defects. Our results suggest that complex nonequilibrium pattern-formation phenomena might be predictable from a few fundamental symmetry-breaking and scale-selection principles.

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MS7

Moduli Spaces of Growth Patterns

Interfaces or boundaries affect the formation of crystalline phases in sometimes quite dramatic ways. Examples range from the alignment of convection roles in Benard convection perpendicular to the boundary, to the robust patterning through presomites in limb formation. Mathematically, the object of interest is a moduli space of solutions to elliptic equations in unbounded domains. This moduli space contains the relation between rate of growth and crystallographic parameters such as the width and orientation of convection rolls or presomites. I will explain the role of this moduli space and give results and conjectures on its shape in examples, starting with simple convection-diffusion and phase separation problems, and concluding with Turing patterns.

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MS7

The Effect of Impurities on Stripes

We study the effect of algebraically localized impurities on striped phases in one and higher space-dimension. We therefore develop a functional-analytic framework which allows us to cast the perturbation problem as a regular Fredholm problem despite the presence of essential spectrum, caused by the soft translational mode. Our results establish the selection of jumps in wavenumber and phase, depending on the location of the impurity and the average wavenumber in the system. We also show that, for select locations, the jump in the wavenumber vanishes.

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MS8

The Lagrangian and Eulerian Analyticity for the Euler Equations

We revisit preservation of analyticity and Gevrey regularity for the Euler equation. We provide a result on preservation of Gevrey norm and analyticity in Lagrangian formulation and discuss the validity of the result in the Eulerian variables.

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MS8

Inertial Manifolds for the Hyperviscous Navier-Stokes Equations

We prove the existence of an inertial manifold, i.e., a globally invariant, exponentially attracting, finite-dimensional smooth manifold, for the incompressible hyperviscous Navier-Stokes equations on the two or three-dimensional torus:

$$u_t + \nu(-\Delta)^\beta u + (u \cdot \nabla)u + \nabla p = f, \quad (t, x) \in \mathbb{R}_+ \times \mathbb{T}^d,$$

with $\nabla \cdot u = 0$, where $d = 2$ or 3 and $\beta \geq 3/2$. Since the spectral gap condition is not available for the aforementioned problem in three dimensions, we employ the spatial averaging method introduced by Mallet-Paret and Sell.

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MS8

On a Subclass of Solutions of the 2D Navier-Stokes Equations with Constant Energy and Enstrophy

It is not yet known if the global attractor of the space periodic 2D Navier-Stokes equations contains nonstationary solutions u(x; t) such that their energy and enstrophy per unit mass are constant for every t. Due to the hypothetical existence of such solutions, they were called ghost solutions. In this work, we introduce and study geometric structures shared by all ghost solutions.This study led us to consider a subclass of ghost solutions for which those geometric structures have a supplementary stability property. In particular, we show that the wave vectors of the active modes of this subclass of ghost solutions must satisfy certain supplementary constraints. We also find a computational way to check for the existence of these ghost solutions.

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MS8

Efficient Numerical Algorithms for Approximating Long Time Statistical Behavior of Certain Fluid Models

The long-time dynamics of many infinite-dimensional dynamical systems, especially those generated by various fluid models, are very complex with abundant chaotic/turbulent behaviors which calls for statistical descriptions. The long-time statistics, characterized by the invariant measures, which describes the "climate" of the system is of particular significance in many applications. The design of algorithms that are able to capture the "climate" is intrinsically a challenge since small errors might accumulate over an extended time interval. We present a set of Lax type conditions that consists of an appropriate consistent condition and a suitable stability condition. The Lax type conditions guarantee the convergence of the long-time statistical properties of the discrete schemes to those of the underlying PDEs both in the semi-discrete in time case and the fully discretized case. Applications to the two-dimensional Navier-Stokes equations and the barotropic quasi-geostrophic equation, the infinite Prandtl number model for convection, a double diffusive convection model, and the complex Ginzburg-Landau equation will be discussed.

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MS9

Optimal Shape of Isolated Ferromagnetic Domains

We investigate the optimal shape and the scaling of the minimal energy of isolated magnetic domains in hard magnetic materials. The underlying energy is given by the interfacial energy of the domain and a competing nonlocal term due to magnetostatic energy. This energy appears in the nucleation theory for magnetization reversal in uniaxial materials. We show existence of minimizers for all volumes and derive a scaling law for the minimal energy. Moreover, we show further properties on regularity and topology for local minimizers and the potential.

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MS9

A Variational Model for Charged Drops

Equilibrium shapes of charged, conducting liquid drops are governed by a geometric variational problem that involves a perimeter term modeling surface tension and a capacitary term modeling Coulombic repulsion. I will discuss the well-posedness of such model in two and three dimensions, and show the global stability of the ball when the total charge is sufficiently small.

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MS9

Analysis and Numerics for Induced-charge Electrokinetic Flow with Interfaces

Abstract Not Available At Time Of Publication.

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MS9

Energy-based Phase Field Model for Two Phase Ferrodroplet Deformation and Breakup under Magnetic Field

Abstract Not Available At Time Of Publication.

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MS10

Inviscid Limit of Viscous Flows in Domains with Rough Boundaries

We will present a joint work with Lacave, NGuyen and Rousset about the inviscid limit of the Navier-Stokes equation endowed with a slip condition at a rough boundary. In the case of smooth boundaries, the inviscid limit can be shown easily either by direct energy estimates or by compactness properties of the vorticity. These methods fail in the rough case due to an "inviscid" boundary layer generated by the roughness. We will show how to handle this issue under suitable conditions on the viscosity and roughness parameters.

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MS10

A Proof of Onsager's Conjecture

In an effort to explain how anomalous dissipation of energy occurs in hydrodynamic turbulence, Onsager conjectured in 1949 that weak solutions to the incompressible Euler equations may fail to exhibit conservation of energy if their spatial regularity is below 1/3-Hölder. I will discuss a proof of this conjecture that shows that there are nonzero, $(1/3-\epsilon)$-Hölder Euler flows in 3D that have compact support in time. The construction is based on a method known as "convex integration," which has its origins in the work of Nash on isometric embeddings with low codimension and low regularity. A version of this method was first developed for the incompressible Euler equations by De Lellis and Székelyhidi to build Hölder-continuous Euler flows that fail to conserve energy, and was later improved by Isett and by Buckmaster-De Lellis-Székelyhidi to obtain further partial results towards Onsager's conjecture. The proof of the full conjecture combines convex integration using the Mikado flows introduced by Daneri-Székelyhidi with a new gluing approximation technique. The latter technique exploits a special structure in the linearization of the incompressible Euler equations.

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MS10

On the Riemann Problem for the MultiD Isentropic Euler System

We consider the Riemann problem for the two-dimensional compressible isentropic Euler system, i.e. we solve the equations on the whole 2D space and the initial data consists of two pairs of constants, each on one of the half-planes. This classical problem possesses a one-dimensional self-similar admissible solution which is unique in the class of self-similar 1D solutions. We study uniqueness of this solution in the broader class of essentially bounded 2D functions. We summarize the up-to-date results concerning uniqueness and nonuniqueness of admissible weak solutions in certain cases of initial data. The nonuniqueness results are based on the theory of De Lellis and Székelyhidi for incompressible Euler equations and in particular the results show that the entropy inequality is not good enough to single out a unique solution. The uniqueness results are based on the relative entropy method.

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MS10

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MS11

Bgk Models for Mixtures of Polyatomic Gases with Discrete Or Continuous Internal Energy

In kinetic theory, non–translational degrees of freedom of polyatomic molecules are modelled allowing the distribution function to depend also on a discrete or continuous internal energy variable. Besides classical elastic collisions, particles are subject to inelastic encounters changing their internal energy state (transforming part of kinetic energy into internal energy or vice versa) and/or to chemical reactions implying also transfer of mass. We propose consistent BGK approximations of the cumbersome Boltzmann equations for polyatomic gas mixtures, where parameters of the Maxwellian attractors are uniquely determined as functions of the main macroscopic fields (densities, velocities, and temperatures) by imposing preservation of exact equilibria and collision invariants of the original kinetic approach. This BGK approximation is well suited both for gases with a set of discrete internal energy levels (where a single gas is described as a mixture of monatomic components, each one with a fixed internal energy), and for gases with continuous internal energy. Even simple reactive flows are investigated, managing additional difficulties due to the mass action law, a transcendental equation relating equilibrium temperature with number densities of the constituents. An asymptotic Chapman–Enskog analysis is then performed in the continuum limit in order to achieve consistent fluid–dynamic Navier–Stokes equations for the macroscopic fields.

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MS11

Construction of BGK Models from Entropy Minimization Principles

In this talk we will present a derivation principle of BGK models using the resolution of an entropy minimization problem. The construction is based as on the introduction of relaxation coefficients and a principle of entropy minimization under constraints for moments. These free parameters are next adjusted to transport coefficients when performing a Chapman-Engskog expansion up to Navier-Stokes. Firstly, the methodology will be explained and illustrated for a monoatomic and polyatomic single gas. -Next the case of gas mixtures is considered. In this part, after clarifying the Chapman-Engskog, a BGK model is derived. This BGK model is proved to satisfy Fick and Newton laws. In a last part, we will explain how to extend our model to reacting gas mixtures.

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MS11

A Consistent Kinetic Model for a Two-component Mixture of Polyatomic Molecules

We consider a multi-component gas mixture with translational and internal energy degrees of freedom assuming that the number of particles of each species remains constant. We derive a two species kinetic model which can easily be generalized to more species. The two species are allowed to have different degrees of freedom in internal energy. We prove consistency of our kinetic model: conservation properties, positivity of the temperature, H-theorem, convergence to a global equilibrium in the form of a global Maxwell distribution, existence, uniqueness and positivity of solutions. Then, we derive the corresponding macroscopic conservation laws. For numerical efficiency we apply the Chu reduction to our kinetic model for polyatomic gases and give an application for a gas consisting of a mono atomic and a diatomic species. This is joint work with Christian Klingenberg (Würzburg University) and Gabriella Puppo (Università Insubria).

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MS11

A Dichotomy in the Dissipation Estimates for the Polatomic BGK Model

In this talk, we consider a dichotomy observed in the dissipation estimates for the polyatomic BGK model. By dissipation estimate, we mean either the entropy-entropy production estimate of the nonlinear polyatomic BGK model, or the coercive estimate of the linearized polyatomic relaxation operator. In the former case, we observe a jump in the coefficient and the target equilibrium state as a relaxation parameter tends to zero. In the latter case, we show that the coefficient and the degeneracy of the coercive estimate see a sudden jump as the same relaxation parameter reaches zero. We also discuss how these two results are related.

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MS12

Homogenization of the Poincaré-Neumann Operator

We study the spectrum of the Neumann-Poincaré operator K^*_ε of a periodic collection of smooth inhomogeneities, as the period $\varepsilon \to 0$. Under the assumption that the pattern of inhomogeneity is strictly included in the periodicity cell,we show that the limit set $\lim_{\varepsilon\to 0} \sigma(K^*_\varepsilon)$ is the union of a Bloch spectrum and of a boundary spectrum, associated with eigenfunctions which are not too small (as functions in H^1) near the boundary.

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MS12

Low-Frequency, Low-Wavenumber Approximation of the Willis Effective Model for Periodic Media

Willis (1981,2009) proposed the effective constitutive relations (coupling stress, momentum density, strain, and particle velocity) describing the mean wave motion in elastic composites with either random or periodic microstructure. The focus of this work is to establish a uniform representation of the Willis effective constitutive relations for periodic media and to explore their connection to the previously established framework of multiple-scales homogenization. We first show via an eigenfunction approach that the Willis effective constitutive relations are well defined in the non-degenerate case, and that they may have singularities in the exceptional case. The Willis framework of homogenization can be deemed *exact* in the sense that the germane dispersion relationship, when computed in terms of the averaged quantities, recovers that written in terms of the original (non-averaged) fields. We next compare the low frequency low wavenumber (LF-LW) expansion of the Willis effective impedance with that computed by the two-scale homogenization approach. We show for the first time that in the Fourier domain, the two approximations *differ by a factor* which is a polynomial in wave vector and frequency. This modulation factor is found to arise from homogenization of the *source term* in the governing field equation, that is often ignored by multiple-scales homogenization analyses.

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MS12

Data-to-Born Transform for Inversion and Imaging with Waves

We consider an inverse problem for the acoustic wave equation, where an array of sensors probes an unknown medium with pulses and measures the scattered waves. The goal is to determine from these measurements the structure of the scattering medium, modeled by a spatially varying acoustic impedance function. Many conventional inversion algorithms assume that the dependency of the scattered waves on the unknown impedance is approximately linear. The linearization, known as the Born approximation, is not accurate in strongly scattering media, where the waves undergo multiple reflections before reaching the sensors. This results in artifacts in the impedance reconstructions. We show that it is possible to remove the multiple scattering effects from the data, using a reduced order model (ROM). The ROM is an orthogonal projection of the wave equation propagator on the subspace spanned by the time domain snapshots of the wavefields. While the snapshots are only known at sensor locations, this information is enough to construct the ROM. Once the ROM in constructed, we use its perturbations to generate a new data set that the same impedance would generate if the waves in the medium propagated according to Born approximation. We refer to such procedure as the Data-to-Born transform. Once the multiple scattering effects are removed from the data by the transform, it can be fed to conventional linearized inversion workflows.

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MS12

Effect of Asymmetries on Bulk Resonance in Multi-Scale Periodic Structures

I will discuss the relationships between several aspects of periodic structures: symmetries, embedded eigenvalues, factorability of the dispersion relation, and resonance. By controlling the amount of asymmetry at the meso-scale of a periodically micro-structured material, one can control the sharpness of the resonances that define the bulk wave-propagation properties. Bilayer graphene with periodically dispersed defects provides an illustrative example.

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MS13

Stabilization of Maxwell's Equations

We will discuss the stabilizability of the dynamic Maxwell equations by means of a conductivity term. Various results will be given, depending on the set in which the conductivity is known to be strictly positive. The initial configuration of the magnetic field will be assumed to be divergence free which is in agreement with most physical models.

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MS13

Global Existence for Fluid-Structure Models

We address a fluid-structure system coupling the incompressible Navier-Stokes equations and a linear wave equation with interior damping. The interaction take place at a common interface and it is described by the transmission boundary conditions matching the velocities and the stress forces at the interface. We prove the global existence and exponential decay of solutions for small initial data in a suitable Sobolev space. This is a joint work with Igor Kukavica, Irena Lasiecka, and Amjad Tuffaha.

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MS13
On the Muskat Flow

Of concern is the motion of two uids separated by a free interface in a porous medium, where the velocities are given by Darcy's law. We consider the case with and without phase transition. It is shown that the resulting models can be understood as purely geometric evolution laws, where the motion of the separating interface depends in a nonlocal way on the mean curvature. It turns out that the models are volume preserving and surface area reducing, the latter property giving rise to a Lyapunov function. We show well-posedness of the models, characterize all equilibria, and study the dynamic stability of the equilibria. Lastly, we show that solutions which do not develop singularities exist globally and converge exponentially fast to an equilibrium.

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MS14
Fluid-Structure and Structure-Structure Interaction with Slip

In fluid mechanics the widely accepted boundary condition for viscous flows is the no-slip condition. When applied to fluid-structure interaction problems this condition states that the fluid velocity at the moving structure boundary is equal to the velocity of the structure boundary itself. Recent advances in mathematical analysis and experimental measurements have shown, however, that the no-slip condition is not adequate to capture certain important physical phenomena. Examples include flows over hydrophobic surfaces (e.g. spray fabricated liquid repellant surfaces), flows over rough boundaries such as elastic tissue scaffolds, and contact between elastic bodies in a viscous, incompressible fluid. Despite a relatively rich literature on FSI problems with no-slip boundary condition, there are no analytical results or partitioned numerical schemes that deal with the Navier slip condition. In this talk we present an existence result and a partitioned numerical scheme for this class of problems. The existence proof is constructive, based on the time-discretization via operator splitting. In addition to the theoretical results, we will show numerical simulations with laminated structures, where different layers are connected with a slip boundary condition. Our results show that laminated structures with slip damp high frequency oscillations in FSI problems, which has practical importance in the design of, e.g., oceanic platforms, and vascular constructs.

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MS14
Energy Estimates for A Relativistic Liquid

We prove new energy estimates for the free boundary problem for a compact relativistic liquid. These energies control the fluid velocity as well as the regularity of the free boundary. This is joint work with Hans Lindblad.

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MS14
A Flow Map Approach to the Water Wave Equations

This work is concerned with the infinite depth water wave equations in two space dimensions. We revisit the local well posedness and cubic existence of solutions for small data. Neither of these results are new; they have been recently obtained by Alazard-Burq-Zuily, Wu, Hunter-Ifrim-Tataru using different coordinates, and methods. Instead our goal will be to improve the understanding of this problem by providing a "flow map' approach that will uncover the special structure of the water waves system. This presentation will be self contained.

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MS14
Long-time Behavior and Stability of Rigid Bodies with a Fluid-filled Gap

We consider the fluid-solid interactions occurring when a viscous incompressible fluid is confined to move in a bounded domain between two rotating rigid bodies. We study the long-time dynamics and stability of steady-states of the whole system S of rigid bodies with the fluid-filled gap. We show that the fluid has a stabilizing effect on the motions of both the rigid bodies. More precisely, the fluid velocities relative to the solids tend, respectively, to zero as time approaches to infinity. Moreover, the long-time dynamics of the whole system is completely characterized by permanent rotations with S moving as a whole rigid body. The stability of such permanent rotations will be also discussed.

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MS15
The Weighted p-Laplacian and Semi-Supervised Learning

Semi-supervised learning refers to machine learning algorithms that make use of both labeled data and unlabeled data for learning tasks. Examples include large scale nonparametric regression and classification problems, such as predicting voting preferences of social media users, or classifying medical images. In this talk, we will present some new results on continuum limits for graph-based semi-supervised learning in the limit of infinite unlabeled data and finite labeled data. We show that the continuum limits correspond to solving a weighted p-Laplace equation in the viscosity sense and are non-degenerate only when $p > d$.

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MS15

Gromov-Hausdorff Limit of Wasserstein Spaces on Point Clouds

Inferring geometric properties of a ground-truth measure based on the observation of finitely many samples is an important task with applications to machine learning and statistics. Given that many analytical and geometrical notions at the continuum level can be analyzed by interpreting them in Wasserstein space, it is then natural to do the same at the sample level by considering the right notion of discrete Wasserstein space and ask: when and how are these notions stable as the sample size grows to infinity? The main result that I will present in the talk can be used to establish a variety of consistency results for evolutions of gradient flow type that are relevant to tasks like manifold learning and clustering.

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MS15

Auction Dynamics: A Volume Constrained Mbo Scheme

We show how auction algorithms, originally developed for the assignment problem, can be utilized in Merriman, Bence, and Osher's threshold dynamics scheme to simulate multi-phase motion by mean curvature in the presence of equality and inequality volume constraints on the individual phases. The resulting algorithms are highly efficient and robust, and can be used in simulations ranging from minimal partition problems in Euclidean space to semi-supervised machine learning via clustering on graphs. Numerous numerical experiments, particularly exhaustive in the case of the latter application, are presented that demonstrate on various benchmark datasets results exceeding the state-of-the-art in accuracy while requiring a fraction of the computational time.

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MS15

A Generalized MBO Diffusion Generated Motion for Orthogonal Matrix Valued Fields

MBO diffusion generated motion is a method introduced by Merriman, Bence, and Osher for evolving the boundary of a set by mean curvature flow. The method consists of two simple steps, which are iterated until convergence. The first is the time evolution of an indicator function of the set by the diffusion equation for a short time. The second is the point-wise thresholding of this function to obtain a new indicator function. Over the last 25 years, this method has been further analyzed, developed, and employed in a variety of interesting applications. In this talk, I'll discuss a generalization of this method to orthogonal matrix valued fields. In particular, following the Ginzburg-Landau approach, we consider a relaxation of the Dirichlet energy for orthogonal matrix valued fields that includes a term that penalizes the matrix not being orthogonal. We introduce a generalization of the MBO diffusion generated motion that effectively finds local minimizers of this relaxed energy. We extend the Lyapunov function of Esedoglu and Otto to show that the method is non-increasing on iterates and hence, unconditionally stable. We also give a proof of convergence for the algorithm. The algorithm is efficiently implemented using the closest point method and non-uniform FFT. I'll conclude by presenting several numerical experiments to demonstrate the range of behavior for local minimizers of this generalized energy.

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MS16

Vortices in Rapidly Rotating Boussinesq Convection

We study long time asymptotics in the Boussinesq approximation for rapidly rotating stably-stratified fluids in a three dimensional infinite layer with either stress-free or periodic boundary conditions. For initial data satisfying certain smallness criteria, we use self-similar variables to show that the baroclinic vorticity converges to an Oseen Vortex with algebraic rate while the baroclinic component decays to zero faster than any algebraic rate. In the case of periodic boundary conditions, we also find that the barotropic vertical velocity and thermal fluctuations converge to decaying Gaussians whose amplitudes oscillate with opposite phase of each other. We also use dispersive estimates and Lyapunov functional techniques to determine asymptotics in the rapid rotation limit for a broader class of initial data where we only require smallness in the quasi-geostrophic part of the baroclinic dynamics.

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MS16

Travelling Waves for the Stochastic Nagumo Equation

In this talk we study stochastic traveling waves in the Nagumo equation using methods from deterministic nonlinear stability analysis. Combining classical methods with stochastic calculus enables us to compute the changes in the expected speed and shape of the stochastic wave compared with the deterministic wave. Furthermore, we can prove stability of the stochastic travelling wave when we extend the estimates from the well known deterministic case.

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MS16

Bifurcation to Locked Fronts in Two Component Reaction Diffusion Equations

We study invasion fronts and spreading speeds in two component reaction-diffusion systems. Using Lin's method, we construct traveling front solutions and show the existence of a bifurcation to locked fronts where both components invade at the same speed. Expansions of the wave speed as a function of the diffusion constant of one species are obtained. The bifurcation can be sub or super-critical depending on whether the locked fronts exist for parameter values above or below the bifurcation value. Interestingly, in the sub-critical case the spreading speed of the system does not depend continuously on the coefficient of diffusion.

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MS16

Competing Interactions, Patterns, and Traveling Waves in Discrete Systems

We consider bistable lattice differential equations with competing first and second nearest neighbor interactions. We construct heteroclinic orbits connecting the stable zero equilibrium state with stable spatially periodic orbits of period p=2,3,4 using transform techniques and a bilinear bistable nonlinearity. We investigate the existence, global structure, and multiplicity of such traveling wave solutions. For smooth nonlinearities an abstract result on the persistence of traveling wave solutions is presented and applied to lattice differential equations with repelling first and/or second neighbor interactions and to some problems with infinite range interactions.

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MS17

Gaining Two Derivatives on a Singular Force in the 2D Navier-Stokes Equations

It has long been known, for the autonomous 2D Navier-Stokes equations with singular forcing in H^{-1}, that there exist unique solutions which are globally in L^2, a gain of one derivative. These classical techniques also show us that the solution is almost everywhere in H^1. On the other hand, if the forcing term is in L^2, it is known that the solution remains in H^2 globally, a gain of two derivatives. In this paper, we explore classical techniques to show that if the force is in H^α for $\alpha \in (-1, 0)$, then the solution gains two derivatives globally. These methods break down for forces in H^{-1}. In this scenario, we use a Littlewood-Paley decomposition in Fourier space to show that a solution which exists in H^1 at some time t must then remain in H^1 for a small interval of time. This is a joint work with Landon Kavlie.

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MS17

Geometry of 3D Turbulent Flows and the Navier Stokes Regularity Problem

We show that the scaling gap in the 3D Navier-Stokes equation regularity problem can be reduced by an algebraic factor. All preexisting improvements have been logarithmic in nature, regardless of the functional set up utilized. This result is inspired by the geometry of the regions of intense vorticity observed in computational simulations of 3D turbulent flows.

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MS17

Asymptotic Enslavement in Hydrodynamic Equations and Applications to Dynamics and Data Assimilation

In their 1967 seminal paper, Foias and Prodi captured precisely a notion of finitely many degrees of freedom in the context of the two-dimensional (2D) incompressible Navier-Stokes equations (NSE). In particular, they proved that if a sufficiently large low-pass filter of the difference of two solutions converge to 0 asymptotically in time, then the corresponding high-pass filter of their difference must also converge to 0 in the long-time limit. In other words, the high modes are eventually enslaved by the low modes. One could thus define the number of degrees of freedom to be the smallest number of modes needed to guarantee this

convergence for a given flow, insofar as it is represents as a solution to the NSE. This property has since led to several developments in the longtime behavior of solutions to the NSE, such as, for instance, uniqueness of invariant measures for stochastically forced NSE, and to data assimilation as well. In this talk, we will discuss applications of this asymptotic enslavement property in the context of hydrodynamic and related equations, which are stochastically forced.

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MS17

Numerical Approximations of a Feedback-Control Data Assimilation Algorithm: Uniform in Time Error Estimates

We consider a feedback-control (nudging) approach for data assimilation that works for a general class of dissipative dynamical systems and observables. The algorithm is defined by modifying the original forecast system through the addition of an extra term which relaxes only the coarse scales of the solution towards the spatially coarse observations. Our goal is to obtain an analytical estimate of the error committed when numerically solving this modified system by using a post-processing technique for the spectral Galerkin method, inspired by the theory of approximate inertial manifolds. This numerical approximation yields a dimensionally reduced version of the modified system. Most importantly, our error estimate is uniform in time, which reflects its global stability. This is a joint work with E. S. Titi.

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MS18

Stability of the Gaussian Isoperimetric Problem

Abstract Not Available At Time Of Publication.

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MS18

Nonlinear Stability Results for the Nonlocal Mullins-Sekerka Flow

Abstract Not Available At Time Of Publication.

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MS18

A Universal Thin Film Model for Ginzburg-Landau Energy with Dipolar Interaction

We present an analytical treatment of a three-dimensional variational model of a system that exhibits a second-order phase transition in the presence of dipolar interac- tions. Within the framework of Ginzburg-Landau theory, we concentrate on the case in which the domain occupied by the sample has the shape of a flat thin film and obtain a reduced two-dimensional, non-local variational model that describes the ener- getics of the system in terms of the order parameter averages across the film thickness. Namely, we show that the reduced two-dimensional model is in a certain sense asymp- totically equivalent to the original three-dimensional model for small film thicknesses. Using this asymptotic equivalence, we analyze two different thin film limits for the full three-dimensional model via the methods of G-convergence applied to the reduced two- dimensional model. In the first regime, in which the film thickness vanishes while all other parameters remain fixed, we recover the local two-dimensional Ginzburg-Landau model. On the other hand, when the film thickness vanishes while the sample's lateral dimensions diverge at the right rate, we show that the system exhibits a transition from homogeneous to spatially modulated global energy minimizers. We identify a sharp threshold for this transition.

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MS18

Droplet Breakup in the Liquid Drop Model

The liquid drop model, proposed by George Gamow and described by a nonlocal geometric variational problem, is a successful model which predicts the shape of atomic nuclei of small masses and nuclear fission at large masses. In this talk I will present on a recent project in which we consider a variant of this model with a long-range attractive background potential with weight Z. In the regime of small Z we characterize the structure of minimizers by means of a sharp asymptotic expansion of the energy. This asymptotic limit leads to a discrete attractive-repulsive nonlocal functional. In the process of studying this limit we also characterize all minimizing sequences for the Gamows model in terms of generalized minimizers

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MS19

On Stochastic Anisotropic 3D Navier-Stokes Equations

Three dimensional Navier-Stokes equations in the whole space subject to an anisotropic viscosity and a random perturbation of multiplicative type is described. By adding a term of Brinkman-Forchheimer type to the model, existence and uniqueness of global weak solutions in the PDE sense are proved. These are strong solutions in the probability sense. The convective term given in terms of the Brinkman-Forchheirmer provides some extra regularity in space. As a consequence, the nonlinear term has better properties which allows to prove uniqueness. The proof of existence is performed through a control method. A Large Deviations Principle is shown.

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MS19

Explosion in the Multiplicative Stochastic Process Associated with the 3D Navier-Stokes Equations

We will consider a stochastic branching process that can be naturally associated with the Navier-Stokes equations, showing that it develops infinite number of branches in finite time – a phenomenon called explosion. Possible connections of this explosion to the problem of uniqueness of the solutions will also be discussed.

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MS19

On Measure-Valued Solutions and Their Applications in Numerical Analysis

We introduce a concept of dissipative measure valued solution to problems arising in fluid dynamics, notably the Euler and Navier-Stokes systems of equations. These are, roughly speaking, the most general objects that comply with the so-called weak-strong uniqueness principle. Applications to convergence of numerical schemes will be discussed.

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MS19

Adaptive RBF-WENO Methods for Hyperbolic Conservation Laws

We present adaptive ENO/WENO methods by adopting infinitely smooth radial basis functions (RBFs) for solving nonlinear hyperbolic conservation laws. The RBF-ENO/WENO finite difference and finite volume method slightly perturb the reconstruction coefficients with RBFs as the reconstruction basis and enhance accuracy in the smooth region by locally optimizing the shape parameters. The optimization is obtained by considering the local flow conditions. Consequently the RBF-ENO/WENO methods provide more accurate reconstruction than the regular ENO/WENO reconstruction and provide sharper solution profiles near the jump discontinuity. We present several numerical examples including weak shock reflections.

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MS20

On the Convergence of Statistical Solutions of Evolution Equations

In this talk we will present an abstract framework for the theory of statistical solutions for general evolution equations. This theory extends the notion of statistical solutions initially developed for the 3D incompressible Navier-Stokes equations to other evolution equations that have global solutions which are not known to be unique. We will prove the convergence of statistical solutions of regularized evolution equations to statistical solutions of the original one. The applicability of the theory will be illustrated with the 2D inviscid limit, that is, the convergence of statistical solutions of the 2D Navier-Stokes to the statistical solutions of the 2D Euler equations. This is a joint work with Cecilia Mondaini (Texas A&M) and Ricardo Rosa (UFRJ).

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MS20

Non-Decaying Solutions to the 2D Euler Equations

We establish the existence of weak solutions to the 2D Euler equations in the whole plane for which the vorticity is bounded and the velocity is allowed to grow at a prescribed rate at infinity, showing how the rate of growth affects the existence time. We also establish higher regularity of solutions for more regular initial data.

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MS20

The Lighthill Principle and Vorticity Estimates for Flows with Symmetry

Abstract Not Available At Time Of Publication.

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MS20

Finite Time Singularity of a Vortex Patch Model in the Half Plane

The question of global regularity v.s. finite time blow-up remains open for many fluid equations. In this talk, I will discuss a family of equations which interpolate between the 2D Euler equation and the surface quasi-geostrophic (SQG) equation. We focus on the patch dynamics for this family of equation in the half-plane, and obtain the following results: For the 2D Euler patch model, the patches remain globally regular even if they initially touch the boundary of the half-plane; whereas for the family of equations that are slightly more singular than the 2D Euler equation, the patches can develop a finite-time singularity. This talk is based on a joint work with A. Kiselev, L. Ryzhik and A. Zlatos.

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MS21

Two-Grid Discretization for Interior Penalty and Mixed Finite Elements Methods for the Monge-Ampere Equation

Abstract Not Available At Time Of Publication.

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MS21

A Trefftz Discontinuous Galerkin Method for Time Harmonic Waves with Generalized Impedance Boundary Conditions

We show how a Trefftz Discontinuous Galerkin (TDG) method for the displacement form of the Helmholtz equation can be used to approximate problems having a generalized impedance boundary condition (GIBC) involving surface derivatives of the solution. Such boundary conditions arise naturally when modeling scattering from a scatterer with a thin coating. The thin coating can then be approximated by the GIBC. A second place GIBCs arise is as higher order absorbing boundary conditions. Since the TDG scheme has discontinuous elements, we propose to couple it to a surface discretization of the GIBC using continuous finite elements. We prove convergence of the resulting scheme and demonstrate it with two numerical examples.

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MS21

Multivariate Splines for Numerical Solution of Maxwell Equations in Potential Function Formulation

Abstract Not Available At Time Of Publication.

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MS21

Discrete Theories for Elliptic Problems in Non-divergence Form

In this talk, two discrete theories for elliptic problems in non-divergence form are presented. The first, which is applicable to problems with continuous coefficients and is motivated by the strong solution concept, is based on discrete Calderon-Zygmund-type estimates. The second theory relies on discrete Miranda-Talenti estimates for elliptic problems with discontinuous coefficients satisfying the Cordes condition. Both theories lead to simple, efficient, and convergent finite element methods. We provide numerical experiments which confirm the theoretical results, and we discuss possible extensions to fully nonlinear second order PDEs.

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MS22

Recent Advances on Optimal Control of Parabolic Free Boundary Problems

This talk presents recent advances on optimal control of Stefan type free boundary problems for the second order parabolic PDEs arising in control of phase transition processes, laser ablation of biomedical tissues and other applications. We analyze well-posedness of the optimal control problems, energy estimates and convergence of the sequence of discrete optimal control problems to the original problem both with respect to cost functional and control, Frechet differentiability in Besov spaces, necessary conditions for optimality, Pontryagin's maximum principle under the minimal regularity assumptions on the data.

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MS22

A Two-Fluid Mixture Model of Platelet Aggregation

We present a two-phase model of platelet aggregation in coronary-artery-sized blood vessels. The model tracks the number densities of three platelet populations as well as the concentration of a platelet activating chemical. Through the formation of elastic bonds, activated platelets can cohere with one another to form a platelet thrombus. Bound platelets in a thrombus move in a velocity field different from that of the bulk fluid. Stresses produced by the elastic bonds act on the bound platelet material. The relative motion between bound platelets and the background fluid permits intraclot transport of individual platelets and activating chemical, allows the bound platelet density to reach levels much higher than the platelet density in the bulk blood, and allows thrombus formation to occur on a physiological timescale, all of which were precluded by our earlier single phase model. Computational results from the two-phase model indicate that through complicated fluid-structure interactions, the platelet thrombus can develop significant spatial inhomogeneities and that the amount of

intraclot flow may greatly affect the growth, density, and stability of a thrombus.

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MS22

Stabilization and Control of a 3 D Fluid Structure Interaction

We consider interface problem consisting of a 3 D- fluid equation interacting with a 3 -D dynamic elasticity. The interface is moving according to the speed of the fluid. Boundary control problem corresponding to a minimization of hydrodynamic resistance on the interface. The problem is motivated by applications arising in biomechanics, aeroelasticity and industrial processes. The fluid is governed by Navier-Stokes equation while the structure is represented by the system of dynamic elasticity. The interface between the two environments undergoes oscillations which leads to moving frame configuration giving rise to quasilinear system. The boundary control is exerted on a part of the surface of the fluid and the functional cost represents hydrodynamic pressure on the wall of the body. This leads to nonconvex and non-smooth optimization problem. It is shown that under small disturbance hypothesis, control-to-state map is well posed, within a suitable topological framework, and the optimal control problem admits a solution. Both finite and infinite horizon optimal control problem will be considered which correspond, respectively, to local and global solvability of the underlying quasilinear system. The latter depends on recent results established in *Small data global existence for a fluid-structure model model* by M. Ignatova, I. Kukavica. I. Lasiecka and A. Tuffaha- *Nonlinearity*, 2017

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MS22

Phaseless Scattering and Global Convergence for Coefficient Inverse Problems

The Phaseless Coefficient Inverse Scattering Problem amounts to the determination of an unknown coefficient of the Helmholtz equation from measurements of the absolute value of the complex valued wave field outside of the scatterers. Phase is not measured. Since 2014 a significant progress has been made in works of M.V. Klibanov and V.G. Romanov in addressing this problem. More precisely, uniqueness theorems were proved, reconstruction procedures were established and numerical results were obtained. These works constitute the first solution of a long standing problem posed by. K. Chadan and P.C. Sabatier in 1977. The second topic of my talk is globally convergent numerical method for Coefficient Inverse Problems (CIPs). CIPs are both highly nonlinear and ill-posed. These two factors cause very substantial challenges in the development of numerical methods for them. This is especially true for the most difficult case of CIPs with single measurement data. A natural idea to solve CIPs is the least squares minimization. However, this approach inevitably suffers from the phenomenon of multiple local minima and ravines. The latter makes computational results unreliable. Our research group has proposed two globally convergent numerical methods for CIPs with single measurement data. The main advantage of these numerical techniques over all other available ones is that a small neighborhood of the solution is reached without any a priori knowledge of that neighborhood.

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MS23

Global Existence and Finite Time Singularity for Solutions to Solid Film Model and Tear Film Model

The governing equations for tear film dynamics on human eyes and solid film dynamics on vicinal surface are 4th order degenerate parabolic equations. When the mobility exponents vary in several different ranges, the behaviors of the solution are dramatically different. We analytically prove the global existence of solutions to tear film model with specific ranges of exponents and present some numerical simulation. Characterizing the finite time singularity is more challenging so we formulate the problem as the gradient flow of a suitably-defined convex functional in a non-reflexive Banach space. Then we introduce two methods to study the global solution with hidden singularity: gradient flow in metric space; maximal monotone operators in non-reflexive space.

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MS23

Backward Behavior of Some Dissipative Evolution Equations

In this talk, I will discuss the backward-in-time behaviors of several dissipative evolution equations. This line of study was motivated by investigating the Bardos-Tartar conjecture on the 2D Navier-Stokes equations.

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MS23

Title Not Available At Time Of Publication

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MS24

Aggregation in Mean Field Games

In this talk we consider time-dependent viscous Mean-Field Games systems in the case of local, decreasing and unbounded coupling. These systems arise in mean field game theory, and describe Nash equilibria of games with a large number of agents aiming at aggregation, i.e. at converging to a common state. From the PDE viewpoint, several issues are intrinsic in this framework, mainly caused by the lack of regularizing effects induced by increasing monotonicity of the coupling. Non-existence, non-uniqueness of solutions, non-smoothness, and concentration are likely to arise. Even more than in the competitive case, the assumptions on the Hamiltonian, the growth of the coupling and the dimension of the state space affect the qualitative behavior of the system. We prove the existence of weak solutions that are minimisers of an associated non-convex functional, by rephrasing the problem in a convex framework. Under additional assumptions involving the growth at infinity of the coupling, the Hamiltonian, and the space dimension, we show that such minimisers are indeed classical solutions by a blow-up argument and additional Sobolev regularity for the Fokker-Planck equation.

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MS24

Stationary Mean-Field Games with Congestion

Mean-field games (MFGs) are models for large populations of competing rational agents that seek to optimize a suitable functional. In the case of congestion, this functional takes into account the difficulty of moving in high-density areas. Here, we study stationary MFGs with congestion with quadratic or power-like Hamiltonians. First, using explicit examples, we illustrate two main difficulties: the lack of classical solutions and the existence of areas with vanishing density. Our main contribution is a new variational formulation for MFGs with congestion. This result was not previously known, and, thanks to it, we prove the existence and uniqueness of solutions. Finally, we consider some applications to numerical methods.

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MS24

On the Variational Formulation of Some Stationary Second Order Mean Field Game Systems

We consider the variational approach to prove the existence of solutions of second order stationary mean field games on a bounded domain $\Omega \subset \mathbb{R}^d$, with Neumann boundary conditions, and with and without density constraints. We consider Hamiltonians which growth as $|\cdot|^{q'}$, where $q' = q/(q-1)$ and $q > d$. Despite this restriction, our approach allows us to prove the existence of solutions in the case of rather general coupling terms. When density constraints are taken into account, our results improve those in [A.R. Mészáros and F.J. Silva, A variational approach to second order mean field games with density constraints: the stationary case, *J. Math. Pures Appl.*, Vol. 104 (2015), 6, 1135-1159]. Furthermore, our approach can be used to obtain solutions of systems with multiple populations. The talk is based on a joint work with F. J. Silva (University of Limoges, France).

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MS24

Singular Mean Field Games

We prove the existence of smooth solutions for mean-field games with a singular mean-field coupling; that is, a coupling in the Hamilton-Jacobi equation of the form $g(m) = -1/m^a$. We consider stationary and time-dependent settings. The function g is monotone, but it is not bounded from below. With the exception of the logarithmic coupling, this is the first time that MFGs whose coupling is not bounded from below is examined in the literature. This coupling arises in models where agents have a strong preference for low-density regions. To prove the existence of solutions, we consider an approximate problem for which the existence of smooth solutions is known. Then, we prove new a priori bounds for the solutions that show that $1/m$ is bounded. Finally, using a limiting argument, we obtain the existence of solutions. The proof in the stationary case relies on a blow-up argument and in the time-dependent case on new bounds for $1/m$.

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MS25

Bubbly Media: From Super-resolution to Metamaterials

The aim of this talk is to review recent results on the propagation of acoustic waves in bubbly media. Our main focus is on developing a mathematical and computational framework for the analysis of Minnaert bubbles. By characterizing and exploiting the Minnaert resonance frequencies of bubbles in a variety of situations, we construct a unified theory of super-focusing of acoustic waves, acoustic metamaterials, and controlling acoustic wave propagation at the subwavelength scale. Super-resolution and metamaterials are usually studied within the context of different approaches. Remarkably, as shown in this talk, they owe their origin to the same underlying physical mechanism, namely, wave interaction with a subwavelength resonator.

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MS25

Title Not Available At Time Of Publication

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MS25

Fractional White-Noise Limit and Paraxial Approximation for Waves in Random Media

Abstract Not Available At Time Of Publication.

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MS25

Beam-Wave Scattering and Imaging

Abstract Not Available At Time Of Publication.

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MS26

Lojasiewicz Inequalities for Yang-Mills and Harmonic Map Energy Functions

The Lojasiewicz-Simon gradient inequality is a generalization, due to Leon Simon (1983), to analytic or Morse-Bott functionals on Banach manifolds of the finite-dimensional gradient inequality, due to Stanislaw Lojasiewicz (1963), for analytic functions on Euclidean space. We shall discuss several recent generalizations of the Lojasiewicz-Simon gradient inequality and a selection of their applications, such as global existence and convergence of Yang-Mills gradient flow over four-dimensional manifolds and discreteness of the energy spectrum for harmonic maps from Riemann surfaces into analytic Riemannian manifolds.

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MS26

Lavrentiev Gap Phenomena for Harmonic Maps

Minimizing harmonic maps (i.e. minimizers of the Dirichlet integral) with prescribed boundary conditions from the ball to the sphere may have singularities. For some boundary data it is known that all minimizers of the energy have singularities and the energy is strictly smaller than the infimum of the energy among the continuous extensions (the so called Lavrentiev gap phenomenon occurs). We prove that the Lavrentiev gap phenomenon for harmonic maps into spheres holds on a dense set of zero degree boundary data. This is joint work with P. Strzelecki.

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MS26

On Free Boundary Problems for Conformally Invariant Variational Functionals

I will present a regularity result at the free boundary for critical points of a large class of conformally invariant variational functionals. The main argument is that the Euler-Lagrange equation can be interpreted as a coupled system, one of local nature and one of nonlocal nature, and that both systems (and their coupling) exhibit an antisymmetric structure which leads to regularity estimates.

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MS26

A Minimizing Problem Involving Nematic Liquid Crystal Droplets

In this talk, we will describe an energy minimizing problem arising from seeking the optimal configurations of a class of nematic liquid crystal droplets. More precisely, the general problem seeks a pair (Ω, u) that minimizes the energy functional:

$$E(u, \Omega) = \int_\Omega \frac{1}{2}|\nabla u|^2 + \mu \int_{\partial\Omega} f(x, u(x)) d\sigma,$$

among all open set Ω within the unit ball of $\mathbb{R}^3$, with a fixed volume, and $u \in H^1(\Omega, \mathbb{S}^2)$. Here $f : \mathbb{R}^3 \times \mathbb{R} \to \mathbb{R}$ is a suitable nonnegative function, which is given. While the existence of minimizers remains open in the full generality, there has been some partial progress when Ω is assumed to be convex. In this talk, I will discuss some results for Ω that are not necessarily convex. This is a joint work with Qinfeng Li.

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MS27

No Equations, No Variables, No Parameters, No Space, No Time: Data and the Computational Modeling of Complex/multiscale Systems

Obtaining predictive dynamical equations from data lies at the heart of science and engineering modeling, and is the linchpin of our technology. In mathematical modeling one typically progresses from observations of the world (and some serious thinking!) first to equations for a model, and then to the analysis of the model to make predictions. Good mathematical models give good predictions (and inaccurate ones do not) - but the computational tools for analyzing them are the same: algorithms that are typically based on closed form equations. While the skeleton of the process remains the same, today we witness the development of mathematical techniques that operate directly on observations -data-, and appear to circumvent the serious thinking that goes into selecting variables and parameters and deriving accurate equations. The process then may appear to the user a little like making predictions by "looking in a crystal ball". Yet the "serious thinking" is still there and uses the same -and some new- mathematics: it goes into building algorithms that "jump directly" from data to the analysis of the model (which is now not available in closed form) so as to make predictions. Our work here presents a couple of efforts that illustrate this "new path from data to predictions. It really is the same old path, but it is travelled by new means.

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MS27

Common Variable Learning Using Alternating Diffusion and Deep Siamese Networks

One of the challenges in signal processing is to distinguish between different sources of variability. In this work, we consider the manifold learning perspective and deep networks perspective on using diversity for separating sources of variability. From the manifold learning standpoint, we introduce a method based on alternating products of diffusion operators, which extracts the common source of variability from multimodal recordings. From the deep networks perspective, we discuss an approach based on Siamese Networks.

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MS27

How Can We Order and Organize Laplacian Eigenfunctions Naturally?

For the development and theory of discrete wavelets on regular lattices in $\mathbf{R}^d$, the Fourier series and transforms have played a significant role. Hence, when attempting to develop wavelet theory for graphs and networks, some researchers have used graph Laplacian eigenvalues and eigenvectors in place of the frequencies and complex exponentials, respectively. While tempting to do so, there are several fundamental problems in this viewpoint. One of them is the intricate relationship between the frequencies and the Laplacian eigenvalues. For undirected and unweighted paths (or cycles), the Laplacian eigenvectors are the discrete cosine (or Fourier) basis vectors and the corresponding eigenvalues are square of their frequencies. Consequently on those simple graphs, one can precisely develop the classical wavelets using the Littlewood-Paley theory. However, as soon as a graph becomes even slightly more complicated (e.g., a discretized thin rectangle in 2D), the situation completely changes: we cannot view the eigenvalues as a simple monotonic function of frequency anymore. Hence, a fundamental question is how to order Laplacian eigenfunctions without using the eigenvalues and to create a *dual* domain graph. In this talk, we discuss this important problem further and explain our effort using Earth Mover's Distance to measure natural distances between eigenfunctions followed by embedding the resulting distance matrix into an appropriate Euclidean domain.

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MS27

Interactions Between Graph Laplacians and Elliptic Pdes

I plan to discuss several recent results that apply equally to classical elliptic partial differential equations and such equations on graph – the unifying ingredient is that tools from the discrete world can be used profitably in the continuous world and either simplify existing proofs or motivate totally new statements. I will also discuss a new phenomenon that arose in this context and has yet to be explained. Partially joint with Manas Rachh, Xiuyuan Cheng, Gal Mishne and Janna Lierl.

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MS28

On the Local Well-posedness and a Prodi-Serrin Type Regularity Criterion of the Three-dimensional MHD-Boussinesq System without Thermal Diffusion

Abstract Not Available At Time Of Publication.

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MS28

A Hamiltonian Preserving Discontinuous Galerkin Method for the Generalized Korteweg-De Vries Equation

Abstract Not Available At Time Of Publication.

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MS28

New Unilateral Problems Related to the Humid Atmosphere

In this lecture we will present new unilateral problems related to the humid atmosphere. The formulation involves variational or quasi-variational inequalities. We will discuss issues related to the modeling, the theory and the approximation of these problems.

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MS28

Global Solutions for Active Hydrodynamics

The hydrodynamics of active liquid crystals in the Beris-Edwards framework with the Landau-de Gennes Q-tensor order parameter arises in wide applications including many biophysical systems. Global existence of weak solutions, regularity, and uniqueness will be discussed.

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MS29

Non-decaying Solutions to the Euler Equations Part II: Uniqueness and Stability

As in Part I, we consider weak solutions to the 2D Euler equations in the whole plane for which the vorticity is bounded and the velocity is allowed to grow at a prescribed rate at infinity. For this class of solutions, we establish uniqueness and continuous dependence on the initial data. We also bound the effect that distant changes to the initial data have on a solution over time.

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MS29

On the Hall-Magneto-Hydrodynamics System

We will discuss some properties of solutions to the 3D incompressible Hall-magneto-hydrodynamics (Hall-MHD) system. The Kolmogorov 41 phenomenological theory of turbulence predicts that there exists a critical wavenumber above which the high frequency part is dominated by the dissipation term in the fluid equation. Inspired by this idea, we apply an approach of splitting the wavenumber to obtain a new regularity criterion which is weaker than conditions in the existing criteria (Prodi-Serrin type criteria) for the 3D Hall-MHD system. We also study the asymptotic behavior of strong solutions to the generalized Hall-magneto-hydrodynamics system with one single diffusion. In light of the Fourier splitting technique, we establish that one single diffusion, can be weak as $(-\Delta)^{\alpha}b$ or $(-\Delta)^{\beta}u$ with small enough α, β, is sufficient to prevent asymptotic energy oscillations for certain strong solutions to the system.

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MS29

2D Incompressible Euler with Singular Vorticity

Abstract Not Available At Time Of Publication.

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MS29

The Surface Quasi-geostrophic Equation in Domains with Boundaries

The surface quasi-geostrophic equation (SQG) of geophysical significance is an active scalar in which the incompressible velocity is determined through Riesz transforms of the scalar. This equation has been extensively studied in the whole plane and on the 2D torus. In bounded domains with boundaries, well-posedness issues are more delicate due to the lack of translation invariance of fractional Dirichlet Laplacian which induces among other difficulties the lack of good commutator estimates. We will report recent results in joint work with P. Constantin on local well-posedness of strong solutions and global existence of weak solutions.

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MS30

Bernstein Bezier Basis for High Order Finite Elements on Tetrahedra and Hexahedra

Abstract Not Available At Time Of Publication.

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MS30

A New Regularity of the Solution to Dirichlet Problem of Poisson Equations and Its Applications

We study the regularity of the solution of Dirichlet problem of Poisson equations over a bounded domain. A new condition, uniformly positive reach is introduced. Under the assumption that the closure of the underlying domain of interest has a uniformly positive reach, the H^2 regularity of the solution of the Poisson equation is established. In particular, this includes all star-shaped domains whose closures is of positive reach, regardless if they are Lipschitz domains or non-Lipschitz domains. An application to the second order elliptic PDE in non-divergence form is presented to demonstrate the usefulness of the new regularity condition.

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MS30

Construction of Smooth Gbc over Quadrilateral Partitions

Abstract Not Available At Time Of Publication.

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MS30

A Primal-Dual Weak Galerkin Finite Element Method for Fokker-Planck Type Equations

The speaker will present a primal-dual weak Galerkin (PD-WG) finite element method for a class of second order elliptic equations of Fokker-Planck type. The method is based on a variational form where all the derivatives are applied to the test functions so that no regularity is necessary for the exact solution of the model equation. The numerical scheme is designed by using locally constructed weak second order partial derivatives and the weak gradient commonly used in the weak Galerkin context. Optimal order of convergence is derived for the resulting numerical solutions. The speaker will demonstrate the numerical results to show the performance of the numerical scheme.

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MS31

The Bayesian Formulation of EIT

We provide a rigorous Bayesian formulation of the Electrical Impedance Tomography (EIT) problem in an infinite dimensional setting, leading to well-posedness in the Hellinger metric with respect to the data. We focus particularly on the reconstruction of binary fields where the interface between different media is the primary unknown. We consider three different prior models - log-Gaussian, star-shaped and level set. Numerical simulations based on the implementation of MCMC are performed, illustrating the advantages and disadvantages of each type of prior in the reconstruction, in the case where the true conductivity is a binary field, and exhibiting the properties of the resulting posterior distribution. We then consider a hierarchical Bayesian approach wherein interface properties, such as regularity, are not assumed to be known a priori, and are instead learned from the data. We illustrate numerically the improvement in reconstruction quality that this can lead to.

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MS31

Frechet Differentiability in Besov Spaces in the Optimal Control of Parabolic Free Boundary Problems

We consider the inverse Stefan type free boundary problem, where information on the boundary heat flux and density of the sources are missing and must be found along with the temperature and the free boundary. We pursue optimal control framework analyzed in *Inverse Problems and Imaging, 7, 2(2013), 307-340; 10, 4(2016), 869–898*, where boundary heat flux, density of sources, and free boundary are components of the control vector. We prove the Frechet differentiability in Besov spaces, and derive the formula for the Frechet differential under minimal regularity assumptions on the data. The result implies a necessary condition for optimal control and opens the way to the application of projective gradient methods in Besov spaces for the numerical solution of the inverse Stefan problem.

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MS31

Evolution of Interfaces for the Nonlinear Double Degenerate Parabolic Equation of Turbulent Filtration with Absorption

We prove the short-time asymptotic formula for the interfaces and local solutions near the interfaces for the nonlinear double degenerate reaction-diffusion equation of turbulent filtration with strong absorption

$$u_t = \Big(|(u^m)_x|^{p-1}(u^m)_x\Big)_x - bu^\beta,\ mp > 1,\ \beta > 0.$$

Full classification is pursued in terms of the nonlinearity parameters m, p, β and asymptotics of the initial function near its support. Numerical analysis using a weighted essentially nonoscillatory (WENO) scheme with interface capturing is implemented, and comparison of numerical and analytical results is presented.

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MS31

Breast Cancer Detection through Electrical

Impedance Tomography and Optimal Control Theory: Theoretical and Computational Analysis

We analyze the inverse problem of breast cancer detection through Electrical Impedance Tomography. EIT is a non-invasive medical imaging method to recover electrical conductivity of the body from electrical measurements on its surface and potentials which are applied to the electrodes such that $\sum U_i = 0$. Mathematical formulation of the problem is referred to as Calderon's inverse problem on the identification of the conductivity coefficient of the second order elliptic PDE from additional boundary measurements. We pursue variational formulation and consider the optimal control problem on the minimization of the L_2-norm declination of the flux on certain subset of the boundary for the uniformly elliptic PDE

$$(a_{ij}(x)u_{x_j})_{x_i} = 0$$

with unknown matrix a_{ij} and Potentials $U_1, U_2, ..., U_m$ such that $\sum U_i = 0$, and subject to the mixed Neumann-Robin type boundary conditions. We prove Frechet differentiability in the Banach space of bounded measurable matrix functions, and derive first order optimality condition. We pursue numerical analysis in a simplified two-dimensional case by implementing projective gradient method in Banach spaces, re-parametrization and space reduction based on principal component analysis, Tikhonov regularization and sensitivity analysis with respect to relative size and locations of cancerous tumors.

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MS32

Title Not Available At Time Of Publication

Abstract Not Available At Time Of Publication.

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MS32

Barotropic Instability of Shear Flows

We consider linear instability of shear flows for incompressible fluids with Coriolis effects. For a class of shear flows including the one with sinus profile, we proved sharp stability conditions for the whole parameter space, which corrected previous results in the fluid literature. Our results are confirmed by more precise numerical computations. The addition of the Coriolis force is found to bring fundamental changes to the stability of shear flows. Moreover, we study the bifurcation of nontrivial steady solutions and the linear inviscid damping near the shear flows. The first ingredient of our proof is a careful analysis of the neutral limiting modes. Second, we use the Hamiltonian structure of the linearized fluid equation and an instability index theory recently developed by Lin and Zeng for Hamiltonian PDEs. This is a joint work with Jinchang Yang and Hao Zhu.

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MS32

On the Muskat Problem with Viscosity Jump: Global in Time Results

This talk is about the Muskat problem, modeling the filtration of two incompressible immiscible fluids in porous media. We consider the case in which the fluids have different constant densities together with different constant viscosities. In this situation the equations are non-local, not only in the evolution system, but also in the implicit relation between the amplitude of the vorticity and the free interface. Among other extra difficulties, no maximum principles are available for the amplitude and the slopes of the interface in L^∞. We prove global in time existence results for medium size initial stable data in critical spaces. We also improved previous methods showing smoothing (instant analyticity) together with sharp decay rates of analytic norms for a more general class of initial data. The found technique is twofold, giving ill-posedness in unstable situations for lower regularity solutions. This is a joint work with Francisco Gancedo, Eduardo Garcia Juarez, and Neel Patel.

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MS32

Critical Thresholds, Spectral Gap and Singular Kernels in Flocking Hydrodynamics

We discuss the question of global regularity for a general class of Eulerian dynamics driven by a forcing with a commutator structure. The study of such systems is motivated by the hydrodynamic description of agent-based models for flocking driven by alignment. When the commutators involve bounded kernels, global regularity follows for subcritical initial data such that the initial divergence is not too negative and, in the 2D case, the initial spectral gap of the velocity gradient is not too large. In contrast, at least in the 1D case, singular kernels lead to global smooth solutions approaching a flocking wave behavior. The global existence is not restricted by the initial configuration.

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MS33

Existence Theory for Mean Field Games with Non-Separable Hamiltonians

Many existence results for the mean-field games system assume that the Hamiltonian is additively separable; in the separable case, there are two further subcases, in which the coupling may either be local or nonlocal. However, in practice, non-separable Hamiltonians are frequently of interest. We discuss existence proofs for strong solutions in the case of non-separable Hamiltonians. The functional settings considered include spaces based on the Wiener algebra, and also standard Sobolev spaces. Our various results all require a smallness constraint, and this can be on the size of the data, on the size of the time interval, or on the Hamiltonian itself.

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MS33

Singular Mean Field Games

In this talk, we discuss the well-posedness for mean field games with a singular mean field coupling of the form $g(m) = -m^{-\alpha}$. We consider stationary and time-dependent settings. The function g is monotone, but it is not bounded from below. This coupling arises in models where agents have a strong preference for low-density regions. Paradoxically, this causes the agents to spread and prevents the creation of solutions with a very-low density. The existence of solutions follows from new a priori bounds for the solutions, combined with an approximate problem and a limiting argument. The proof in the stationary case relies on a blow-up argument whereas in the time-dependent setting, we use new bounds for m^{-1}.

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MS33

Energy Production and Mean Field Game Models

The dramatic decline in oil prices, from around $110 per barrel in June 2014 to around $30 in January 2016 highlights the importance of competition between different energy producers. Indeed, the price drop has been primarily attributed to OPEC's strategic decision (until very recently) not to curb its oil production in the face of increased supply of shale gas and oil in the US, which was spurred by the development of fracking technology. Most dynamic Cournot models focus on supply-side factors, such as increased shale oil, and random discoveries. However declining and uncertain demand from China is a major factor driving oil price volatility. We study mean field Cournot games in a stochastic demand environment, and present asymptotic and numerical results, as well as a modified Hotelling's rule for games with stochastic demand.

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MS33

Balanced Growth Path Solutions of a Boltzmann Mean Field Game for Knowledge Growth

In this paper we study balanced growth path solutions of a Boltzmann mean field game model, which models knowledge growth in an economy. Agents can either increase their knowledge level by exchanging ideas in learning events or by producing goods with the knowledge they already have. The existence of balanced growth path solutions implies exponential growth of the overall production in time. We proof existence of balanced growth path solutions if the initial distribution of individuals with respect to their knowledge level satisfies a Pareto-tail condition. Furthermore we give first insights into the existence of such solutions if in addition to production and knowledge exchange the knowledge level evolves by geometric Brownian motion.

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MS34

Intensity Correlation Imaging in Random Media

Wave propagation in random media can be studied by multi-scale and stochastic analysis. We first show that, in a physically relevant regime of separation of scales, wave propagation is governed by a Schrodinger-type equation driven by a Brownian field. We analyze the associated moment equations. In particular we solve the fourth-moment equation and we study recent imaging modalities based on speckle intensity correlations that allow for imaging through scattering media.

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MS34

Inverse Boundary Problems for Magnetic Schrodinger Operators in Transversally Anisotropic Geometries

Abstract Not Available At Time Of Publication.

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MS34

A One-step Reconstruction Method for Photoacoustics with Multispectral Data

We present a one-step approach for numerical reconstructions in photoacoustics where we intend to reconstruct partial information on both the ultrasound speed and the optical absorption/scattering. We assume that data from multiple optical wavelength are available in this setup. We will also discuss briefly some related theoretical issues. This talk involves joint work with Sarah Vallelian (NCSU) and Yimin Zhong (UT Austin).

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MS34

Inverse Boundary Value Problem for the Anisotropic Elastic Wave Equation

Abstract Not Available At Time Of Publication.

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MS35

Almgren-Pitts Min-Max and the Space of Minimal Hypersurfaces

We use Lusternik-Schnirelmann Theory to study the topology of the space of closed embedded minimal hypersurfaces on a manifold of dimension between 3 and 7 and positive Ricci curvature. Combined with the recent work of Marques-Neves we can also obtain more information on the geometry of the minimal hypersurfaces they found. When the metric is bumpy we can further show that there exist minimal hypersurfaces with arbitrarily large index+area.

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MS35

Harmonic Maps into Metric Spaces with Upper Curvature Bounds

We consider harmonic maps from Riemannian manifolds to metric spaces with upper curvature bounds in the sense of Alexandrov. We will present a Sacks-Uhlenbeck type result for such maps, which we prove by demonstrating that the tools harmonic replacement can be extended to this setting. This work is joint with Fraser, Huang, Mese, Sargent, Zhang.

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MS35

Rigidity in Npc Metric Spaces

The goal of this talk is to describe different approaches of using harmonic maps into general metric spaces of nonpositive curvature in the sense of Alexandrov (NPC spaces) and describe how one can obtain enough regularity to extend the classical Bochner formulas in this setting.

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MS35

A Fully Nonlinear Sobolev Trace Inequality

The k-Hessian operator σ_k is the k-th elementary symmetric function of the eigenvalues of the Hessian. It is known that the k-Hessian equation $\sigma_k(D^2u) = f$ with Dirichlet boundary condition $u = 0$ is variational; indeed, this problem can be studied by means of the k-Hessian energy $\int -u\sigma_k(D^2u)$. We construct a natural boundary functional which, when added to the k-Hessian energy, yields as its critical points solutions of k-Hessian equations with general non-vanishing boundary data. As a consequence, we prove a sharp Sobolev trace inequality for k-admissible functions u which estimates the k-Hessian energy in terms of the boundary values of u. This is joint work with Jeffrey Case.

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MS36

Laplacian Regularization for Localized Function Models

Regression problems typically assume the training data are independent samples, but in many modern applications samples come from individuals connected by a network or some other form of baseline information. In the case that the population is divided into discrete and disjoint classes with no notion of inter-class connection, hierarchical linear modelling can address such issues. We propose a series of optimization schemes that create generalized linear models, which incorporate both the local neighborhoods and global structure of the population network Laplacian to define localized regressions that smoothly vary with respect to the network. Depending on the context of the data and function, this method can be used to learn local function gradients on a manifold, model and denoise time varying processes with drift terms determined by some initial condition on a network, and perform co-clustering of a matrix or tensor. We also discuss incorporating the local regression coefficient estimates to redefine the network geometry and build a function adapted diffusion process.

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MS36

An Overview of Numerical Acceleration Techniques for Nonlinear Dimension Reduction

Since we live in an increasingly data-dependent world, it is necessary for researchers to offer methods that allow processing of complex, large, high-dimensional data sets. Techniques from machine learning, such as e.g., non-linear dimension reduction, seek to organize this wealth of data by extracting fewer descriptive features. These techniques, though powerful in their ability to find compact representations, are hampered by their high computational costs. This prevents us from processing large modern data collections in a reasonable time or with modest computational means. In this talk we shall present some of the important numerical techniques which significantly improve the computational efficiency of the aforementioned methods, while preserving much of their representational power. Specifically, we address Random Projections, Approximate k-Nearest Neighborhoods, Approximate Kernel methods, and Approximate Matrix Decomposition methods.

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MS36

Jigsaw Puzzle and Graph Connection Laplacian

In this work we introduce a new non greedy algorithm to solve large jigsaw puzzles, which is known to be an NP-hard problem. We consider square puzzle pieces with unknown orientations and shuffled locations. We introduce a new method to construct the affinity graph, corresponding to the puzzle, where the vertices are the puzzle pieces and the edges connect between them. Then, we use this graph's Graph Connection Laplacian to complete the puzzle. Our proposed algorithm has state-of-the-art performance for the puzzles, where the orientation of the pieces are unknown.

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MS36

Hierarchical Geometric Organization of Tensors

We develop a nonlinear, data-driven and model-free approach for the analysis of a spatio-temporal dynamical system, represented as a rank-3 tensor. Our approach gives rise to the joint data-driven organization of the spatial regions and dynamic patterns in hierarchical data structures. These provide a local to global representation of the data: from a local partitioning via flexible trees, we derive new multiscale transforms and metrics, which are then integrated in a global manifold embedding. The application of our technique to in-vivo video recordings of neuronal activity in an awake animal demonstrates the capability of extracting neuronal activity patterns and identifying temporal trends. By jointly organizing neurons along time segments and across repetitive experiments, our methodology reveals co-dependencies and patterns of activation related to external short-term triggers (e.g., a tone), long-term manipulations introduced in the experiments and behavioral events (e.g., the sequence of motor actions). A by-product of the dynamic organization is an automateddetailed in-depth morphology of the imaged brain.

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MS37

Eventual Regularity of Infinite Energy Solutions to the Navier-Stokes Equations

The finite energy solutions constructed by J. Leray in 1934 eventually regularize in the sense that there exists a finite time after which a solution is smooth. This is, in general, unknown for the local Leray solutions introduced by Lemarie-Rieusset, which are local analogues of Leray's solutions in that they evolve from uniformly locally square integrable, preserve energy locally, and satisfy the local energy inequality. In this talk we discuss sufficient conditions for eventual regularity of local Leray solutions and mention some applications.

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MS37

An Onsager Singularity Theorem for the Compressible Euler Equations

Abstract Not Available At Time Of Publication.

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MS37

Geometric Function Theory and Navier-Stokes Equations

The goal of this lecture is to review some recent results in which a suitably defined scale of sparseness of the super-level sets of the positive and negative parts of the vorticity components in the 3D NSE plays a major role in the study of turbulent dissipation and possible singularity formation in the model. In particular, this approach led to an algebraic reduction of the ever-resisting 'scaling gap' in the 3D NS regulartiy problem (a joint work with Z. Bradshaw and A. Farhat). A key mathematical component is utilization of the diffusion–manifested by the local-in-time spatial analyticity quantified in the L^∞-type spaces–via the harmonic measure maximum priciple. Certain rigidity is necessary; however, the analytic structure may prove to be 'too rigid', and some comments will be made about a possble role the theory of quasi-conformal mappings might play in this enterprise.

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MS37

The Energy Measure for the Euler and Navier-Stokes Equations

The potential failure of energy equality for a solution u of the Euler or Navier-Stokes equations can be quantified using a so-called 'energy measure': the weak-$*$ limit of the measures $|u(t)|^2\,\mathrm{d}x$ as t approaches the first possible blowup time. We show that membership of u in certain (weak or strong) L^qL^p classes implies uniform boundedness of a certain upper s-density of $\mathcal{E}$, giving a uniform lower bound on the lower local dimension of $\mathcal{E}$. We also define and give lower bounds on the 'concentration dimension' associated to $\mathcal{E}$, which is the Hausdorff dimension of the smallest set on which energy can concentrate. Both the lower local dimension and the concentration dimension of $\mathcal{E}$ measure the departure from energy equality. As an application of our results, we prove that any solution to the 3-dimensional Navier-Stokes Equations which is Type-I in time must satisfy the energy equality at the first blowup time. Furthermore, we give new criteria for energy conservation (equality) in terms of the dimension of the singularity set and classical $L^q L^p$ conditions.

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MS38

Optimal Bounds and Extremal Trajectories for Time Averages in Dynamical Systems

For any quantity of interest in a system governed by ordinary differential equations, it is natural to seek the largest (or smallest) long-time average among solution trajectories. Upper bounds can be proved a priori using auxiliary functions, the optimal choice of which is a convex optimization. We show that the problems of finding maximal trajectories and minimal auxiliary functions are strongly dual. Thus, auxiliary functions provide arbitrarily sharp upper bounds on maximal time averages. They also provide volumes in phase space where maximal trajectories must lie. For polynomial equations, auxiliary functions can be constructed by semidefinite programming, which we illustrate using the Lorenz system. This is joint work with David Goluskin and Ian Tobasco.

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MS38

The Vanishing Viscosity Limit for a Forced Active Scalar Equation

Abstract Not Available At Time Of Publication.

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MS38

Data Assimilation in Ocean and Atmosphere Dynamics

In the presentation, we discuss some recent results of the data assimilation algorithm proposed by Titi, etc, applied to the ocean and atmosphere dynamics. Namely, we prove the data assimilation scheme for the three dimensional primitive equations.

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MS38

Improved Algebraic Splitting Methods for NSE and MHD

We develop efficient and accurate solvers for saddle point linear systems that arise at each time step of an incompressible flow simulation. The solvers are based on high order algebraic splitting (discretize then split) and incremental variables formulation, and create SPD Schur complements that are the same at each time step. We analyze the solver by recasting the split system back into discrete PDEs, and prove it is fourth order accurate with respect to the time step size. Numerical tests show the solver approximation error is significantly lower than the discretization error, and several numerical tests are given that show its effectiveness. Extension to MHD is also discussed, and we show here that the method reduces the MHD block Schur complements into to 2 decoupled SPD Stokes Schur complements.

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MS39

Some Error Estimates on Virtual Element Methods

Abstract Not Available At Time Of Publication.

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MS39

Saddle Point Least Squares Methods for Mixed Variational Formulations

We introduce a Saddle Point Least Squares method for discretizing first and second order boundary value problems written as primal mixed variational formulations. For the mixed formulation we assume a stability LBB condition and a data compatibility condition at the continuous level. For the proposed discretization method a discrete $\inf - \sup$ condition is automatically satisfied by the natural choices of test spaces (first) and the corresponding trial spaces (second). The discretization and the iterative approach does not require nodal bases for the trial space and a SPD preconditioner acting on the discrete test space can be adopted to speed up the approximation process. A stopping criterion based on matching the order of the the iteration error with the the order of the expected discretization error can be considered. Applications of the method include discretizations of second order PDEs with oscillatory or rough coefficients and first order systems of PDEs, such as $div - curl$ systems and time-hamonic Maxwell equations. This is joint work with Jacob Jacavage.

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MS39

Macro Element Analysis for Axisymmetric Stokes Equations

Abstract Not Available At Time Of Publication.

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MS39

Weak Galerkin Finite Element Methods

Abstract Not Available At Time Of Publication.

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MS40

On the Relative Entropy Method for Thermoviscoelasticity

The idea of relative entropy, introduced by Dafermos and DiPerna, is quite powerful in comparing solutions of conservation laws or balance laws and it has been applied to problems that are classified under the domain of hyperbolic-parabolic systems. In this talk, we extend the class of computations that go under the general term "relative entropy" to the broader class of hyperbolic and hyperbolic-parabolic systems by systematizing the derivation of relative entropy identities. The resulting identity is useful to provide measure valued weak versus strong uniqueness theorems for the hyperbolic problem. Also, it yields a convergence result in the zero-viscosity limit to smooth solutions in an L^p framework. The relative entropy identity is also developed for the system of thermoviscoelasticity with viscosity and heat-conduction and for the system of thermoviscoelasticity with polyconvex Helmholtz free energy, for which we construct a symmetrizable extension. The corresponding identities are used to prove convergence of strong solutions in the adiabatic limit and a weak-strong uniqueness theorem for dissipative measure-valued solutions. Existing differences between the examples and the general hyperbolic-parabolic theory are underlined. The work presented is joint work with Athanasios E. Tzavaras and M. Galanopoulou.

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MS40

Transonic Solutions to Multidimensional Riemann Problems

We present the recent result on the existence of the transonic self-similar solution to the nonlinear wave system. The nonlinear wave system is a reduced model from the compressible Euler system of multi-dimensional conservation laws. We discuss transonic solutions to the Riemann problems.

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MS40

Radial Solutions to the Cauchy Problem for the Wave Equation as Limits of Exterior Solutions

We consider the strategy of realizing the solution of a Cauchy problem (CP) with radial data as a limit of radial solutions to initial-boundary value problems posed on the exterior of vanishing balls centered at the origin. The goal is to gauge the effectiveness of this approach in a simple, concrete setting: the three-dimensional (3d), linear wave equation with radial Cauchy data. We are primarily interested in this as a model situation for other, possibly nonlinear, equations where neither formulae nor abstract existence results are available for the radial symmetric CP. In treating the 3d wave equation we therefore insist on robust arguments based on energy methods and strong convergence. Our findings show that while one can obtain existence of radial Cauchy solutions via exterior solutions, one should not expect such results to be optimal. We also show that external Neumann solutions yield better regularity than external Dirichlet solutions. This is joint work with Helge Kristian Jenssen (PSU).

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MS40

Challenges to the Theory of Conservation Laws Posed by the Problem of Fracture

Many problems of material response lead to fracture. The objective of this talk is to review some works that indicate some challenges posed to analysis by the modeling and analysis of fracture. We will outline works in two directions: (i) The problem of dynamic cavitation in nonlinear isotropic elastic material, which offers a playground to study very singular solutions (with delta-shocks) for systems of conservation laws. (ii) The problem of localization into shear bands in high strain-rate plasticity, which offers a test case for studying the compound effect of Hadamard instability and viscosity.

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MS41

Incompressible MHD Without Resistivity on Periodic Boxes

We study the global existence of classical solutions to the 3D incompressible viscous MHD system without magnetic diffusion on periodic boxes. In Eulerian coordinate, we employ a specially designed time-weighted energy estimates to show that if the initial data is close enough to a nontrivial magnetic equilibrium along with some symmetries over the periodic boxes, then the initial value problem admits a unique global classical solution. This is a joint work with Yi Zhou and Yi Zhu.

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MS41

Global Strong Solution to Compressible Navier-Stokes Equations with Heat Conduction in Three Dimensions

In this talk, we will introduce our recent work on the global existence and uniqueness of compressible Navier-Stokes equations with heat conduction in three dimensions with vacuum. The initial mass is small in some sense. The initial density vanishes when the spatial variables go to infinity. Therefore the case that the initial density has a compact support is covered. This work is joint with Professor Changjiang Zhu.

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MS41

Second Proof of the Global Regularity of the Two-Dimensional Mhd System with Full Diffusion and Arbitrary Weak Dissipation

In regards to the mathematical issue of whether a system of equations admits a unique solution for all time or not, given an arbitrary initial data sufficiently smooth, the case of the magnetohydrodynamics (MHD) system may be arguably more difficult than that of the Navier-Stokes equations (NSE). In this talk, some recent developments will be reviewed, in particular the global regularity issue of the 2D MHD system with full magnetic diffusion but not necessarily full dissipation, as well as other topics such as logarithmically supercritical MHD system, Hall-MHD system, micropolar and magneto-micropolar fluid systems, in both deterministic and stochastic perspectives.

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MS41

Energy Conservation for the Compressible Navier-Stokes Equations

In this talk, we will talk on the energy conservation for the weak solutions of the compressible Navier-Stokes equations globally in time, under some certain conditions. Our argument can handle the vacuum issue.

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MS42

Inhomogeneous Boltzmann-Type Equations Modelling Opinion Leadership and Political Segregation

We discuss different kinetic models for opinion formation, when the opinion formation process depends on an additional independent variable, e.g. a leadership or a spatial variable. More specifically, we consider: (i) opinion dynamics under the effect of opinion leadership, where each individual is characterised not only by its opinion, but also by another independent variable which quantifies leadership qualities; (ii) opinion dynamics modelling political segregation in 'The Big Sort', a phenomenon that US citizens increasingly prefer to live in neighbourhoods with politically like-minded individuals. Based on microscopic opinion consensus dynamics such models lead to inhomogeneous Boltzmann-type equations for the opinion distribution. We derive macroscopic Fokker-Planck-type equations in a quasi-invariant opinion limit and present results of numerical experiments.

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MS42

On a Boltzmann Mean Field Model for Knowledge Growth

We analyze a Boltzmann type mean field game model for knowledge growth, which was proposed by Lucas and Moll. It describes a population of agents structured by their knowledge level. Each agent optimizes their future earnings by choosing between producing with their current knowledge level or learning to increase their knowledge. We discuss the underlying mathematical model, which consists of a coupled system of a Boltzmann type equation for the agent density and a Hamilton-Jacobi-Bellman equation for the optimal strategy. We study the analytic features of the fully coupled system. Furthermore we focus on the existence of special solutions, which are related to exponential growth in time - so called balanced growth path solutions.

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MS42

Traveling Waves in Myxobacteria - An Age-Structured Model

Myxobacteria are social bacteria, that can glide in 2D and form counter-propagating, interacting waves. In this talk I will present a novel age-structured, continuous macroscopic model for the movement of myxobacteria. The derivation is based on microscopic interaction rules that can be formulated as a particle-based model and set within the SOH (Self-Organized Hydrodynamics) framework. The strength of this combined approach is that microscopic knowledge or data can be incorporated easily into the particle model, whilst the continuous model allows for easy numerical analysis of the different effects. This allows to analyze the influence of a refractory (insensitivity) period following a reversal of movement. Our analysis reveals that the refractory period is not necessary for wave formation, but essential to wave synchronization, indicating separate molecular mechanisms. I will present analytical as well as numerical results.

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MS42

Opinion Dynamics over Kinetic Networks

In recent years the importance of large scale social networks has grown enormously due to the rapid proliferation of novel communication platforms. The need to handle with millions, and often billions, of vertices implies a considerable shift of interest to large-scale statistical properties of networks which may be described through the methods of the kinetic theory. In this talk we propose a kinetic description of the agents' distribution over the evolving network which combines an opinion update based on binary interactions between agents with a dynamic creation and removal process of new connections *G.Albi, L. Pareschi, M. Zanella, KRM (2017).* The number of connections of each agent influences the spreading of opinions in the network, further the way connections are created is influenced by the agents' opinion. We will study the evolution of the network of connections by showing that its asymptotic behavior is consistent both with Poisson distributions and truncated power-laws. In order to study the large time behavior of the opinion dynamics we derive a mean-field description which allows to compute exact stationary solutions in some simplified situations. Structure preserving numerical methods are hence employed to describe correctly the large time behavior of the system, see *L. Pareschi, M. Zanella, 2017.*

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MS43

Coupling Between Internal and Surface Waves

Based on a Hamiltonian formulation of a two-layer ocean, we consider the situation in which internal waves are treated in the long-wave regime while surface waves are described in the modulation regime. We derive an asymptotic model for surface-internal wave interactions, in which the nonlinear internal waves evolve according to a KdV equation while the smaller-amplitude surface waves propagate at a resonant group velocity and their envelope is described by a linear Schrodinger equation. In the case of an internal soliton of depression, for small depth and density ratios of the two layers, the Schrodinger equation is shown to be in the semi-classical regime in analogy with quantum mechanics, and thus admits localized bound states. This leads to the phenomenon of trapped surface modes, which propagate as the signature of the internal wave, and thus it is proposed as a possible explanation for bands of surface roughness above internal waves in the ocean. Some numerical simulations taking oceanic parameters into account are also performed to illustrate this phenomenon. This is joint work with Walter Craig and Catherine Sulem.

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MS43

Wave Turbulence: A Story Far from Over

We discuss the premises under which closure can be achieved for weakly nonlinear resonantly interacting waves, the successes that the theory has had and some of the open challenges.

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MS43

Coupled Nonlinear Schrödinger Equations, Lotka-Volterra Models, and Nonlinear Dynamics of Optical Soliton Amplitudes

We study the propagation of N sequences of colliding solitons in nonlinear optical waveguides in the presence of dissipative perturbations. The propagation is described by a system of N perturbed coupled nonlinear Schrödinger (NLS) equations. We show that the collision-induced dynamics of soliton amplitudes in N-sequence systems is described by generalized N-dimensional Lotka-Volterra (LV) models. To derive the LV models, we first analyze the effects of a single two-soliton collision, using a perturbative expansion in the eigenmodes of the linear operator describing small perturbations about the fundamental NLS soliton. We then use stability and bifurcation analysis for the equilibrium points of the LV models to develop ways for achieving robust transmission stabilization and switching of the soliton sequences. Further enhancement of transmission stability is enabled by suppression of resonant emission of radiation in nonlinear waveguide couplers with frequency dependent linear gain-loss. Furthermore, we show that supercritical Hopf bifurcations of the equilibrium points of the LV models can be used to induce large stable oscillations of soliton amplitudes along ultra-long distances. The latter finding is an important step towards realizing spatio-temporal chaos with multiple sequences of colliding NLS solitons.

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MS43

Orbital Stability of Domain Walls in Coupled Gross-Pitaevskii Systems

Domain walls are minimizers of energy for coupled one-dimensional GrossPitaevskii systems with nontrivial boundary conditions at infinity. In my talk, I will show that these solutions are orbitally stable in the space of complex H^1 functions with the same limits at infinity. Also, adopting a new weighted H^1 space, I will show how to control perturbations of the domain walls and improve the orbital stability result. A major difficulty arises from the degeneracy of linearized operators at the domain walls and the lack of coercivity.

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MS44

Vortex Filament Clustering in 3D Ginzburg-

Landau

Abstract Not Available At Time Of Publication.

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MS44

External Field Response of Smectic A Liquid Crystals in Three Dimensions

Abstract Not Available At Time Of Publication.

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MS44

High Dimensional Ginzburg-Landau Equations under Weak Anchoring Boundary Conditions

Abstract Not Available At Time Of Publication.

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MS44

(-1)-Homogeneous Solutions of Stationary Incompressible Navier-Stokes Equations with Singular Rays

In 1944, L.D. Landau first discovered explicit (-1)-homogeneous solutions of 3-d stationary incompressible Navier-Stokes equations (NSE) with precisely one singularity at the origin, which are axisymmetric with no swirl. These solutions are now called Landau solutions. In 1998 G. Tian and Z. Xin proved that all solutions which are (-1) homogeneous, axisymmetric with one singularity are Landau solutions. In 2006 V. Sverak proved that with just the (-1)-homogeneous assumption Landau solutions are the only solutions with one singularity. He also proved that there are no such solutions in dimension greater than 3. Our work focuses on the (-1)-homogeneous solutions of 3-d incompressible stationary NSE with finitely many singularities on the unit sphere.

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MS45

The Data Assimilation Map and Its Applications to the Foias-Prodi Statistical Solutions of the Navier-Stokes Equations

Motivated by feed-back control, Azouni, Olson and Titi introduced a data assimilation algorithm for dissipative systems by incorporating a nudging term on the coarse scales. Based on this algorithm, we construct a data assimilation map for the Navier-Stokes equations and investigate its properties. This map is then used to develop a data assimilation scheme for statistical solutions of the two-dimensional Navier-Stokes equations, where the coarse scale statistics of the system is obtained from measurements. As a corollary, we deduce that the statistical solutions of the Navier-Stokes equations are determined by their coarse scale distributions. This establishes the existence of determining parameters for statistical solutions.

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MS45

Porous Media Flow: Analysis and Applications in Biomechanics

Modeling of fluid flows through porous deformable media is relevant for many applications in biology, medicine and bioengineering, like tissue perfusion and fluid flow inside cartilages and bones. These fluid-structure mixtures are described mathematically by nonlinear poro-elastic or poro-visco-elastic systems on bounded domains, with nonhomogeneous, mixed boundary conditions for both the elastic displacement and the fluid pressure. In most of the applications, the boundary conditions are the primary drivers of the dynamics of these systems. Their influence over and ability to control the solution is an important open question, with beneficial implications in the development of novel strategies to improve experimental and clinical approaches in bio-engineering and medicine. In this talk we present some recent results on (i) well-posedness results for these models, (ii) the influence of structural viscoelasticity on the solution and on the regularity requirements for the forces present in the system, and (iii) sensitivity analysis of solutions with respect to the boundary data. Lastly, we discuss applications of our results in the case of blood flow through the optic nerve head, and the connections to the development of glaucoma.

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MS45

Exponential Stability Analysis for a Compressible Flow-Structure Pde Model

In this talk, we present recently derived results of uniform stability for a coupled partial differential equation (PDE) system which models a compressible fluid-structure interaction of current interest within the mathematical literature. The coupled PDE model under discussion will involve a linearized compressible, viscous fluid flow evolving within a 3-D cavity, and a linear elastic plate–in the absence of rotational inertiawhich evolves on a portion of the fluid cavity wall. Since the fluid equation component is the result of a careful linearization of the compressible Navier-Stokes equations about an arbitrary state, this interactive PDE component will include a nontrivial ambient flow profile, which tends to complicate the analysis. Moreover, there is an additional coupling PDE which determines the associated pressure variable of the fluid-structure system. Under a suitable assumption on the ambient vector field, and by

obtaining an appropriate estimate for the associated fluid-structure generator on the imaginary axis, we provide a result of exponential stability for finite energy solutions of the fluid-structure PDE system.

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MS45

H^2 Solutions and z-Weak Solutions for 3D Viscous Primitive Equations

Recent results on global in time uniform boundedness for H^2 solutions and wellposedness for z-weak solutions for viscous 3D Primitive Equations for large scale ocean will be presented. Related results may also be discussed.

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MS46

Numerical Analysis of the Stochastic Navier-Stokes Equation

We consider the statistical inverse problem of estimating a background fluid flow from the partial and noisy observation of a passive scalar (e.g., the concentration of a pollutant). Here our unknown is a divergence free vector field that is fully specified by an infinite number of degrees of freedom. Our work expands on frameworks developed in recent years for infinite-dimensional Bayesian inference. We approach the problem both analytically and computationally developing Metropolis-Hastings type algorithms to generate unbiased samples from the posterior distribution. This is joint work with Jeff Borggaard and Justin Krometis

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MS46

Dispersion of Vorticity in Solutions of the Euler-Alpha Equations

Abstract Not Available At Time Of Publication.

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MS46

Global Regularity for Burgers Equation with Density Dependent Fractional Dissipation

Fractional Burgers equations are a family of equations which connect inviscid and viscous Burgers equations. It is well-known that if the dissipation is strong, the solution is globally regular. On the other hand, it the dissipation is weak (called supercritical case), the solution can lose regularity at a finite time. In this talk, I will introduce a model where the dissipation depends on density. The model is motivated by self-organized dynamics in math biology. Despite that the equation shares a lot of similarities to fractional Burgers equation, the solution is globally regular, even in the supercritical case. I will explain the regularization mechanism that is due to the nonlocal nonlinear modulation of dissipation. This is a joint work with T. Do, A. Kiselev, and L. Ryzhik.

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MS46

Global Stability of Solutions to a Beta-Plane Equation

We study the motion of an incompressible, inviscid two-dimensional fluid in a rotating frame of reference. There the fluid experiences a Coriolis force, which we assume to be linearly dependent on one of the coordinates. This is a common approximation in geophysical fluid dynamics and is referred to as beta-plane. In vorticity formulation the model we consider is then given by the Euler equation with the addition of a linear anisotropic, non-degenerate, dispersive term. This allows us to treat the problem as a quasilinear dispersive equation whose linear solutions exhibit decay in time at a critical rate. Our main result is the global stability and decay to equilibrium of sufficiently small and localized solutions. Key aspects of the proof are the exploitation of a double null form that annihilates interactions between waves with parallel frequencies and a Lemma for Fourier integral operators, which allows us to control a strong weighted norm and is based on a non-degeneracy property of the nonlinear phase function associated with the problem. Joint work with Fabio Pusateri; prior work with Tarek Elgindi.

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MS47

Data Assimilition for Geophysical Flows Employing Only Surface Measurements

We prove that data assimilation by feedback control can be achieved for the three-dimensional quasi-geostrophic equation using only large spatial scale observables on the dynamical boundary. On this boundary a scalar unknown (buoyancy or temperature of a fluid) satisfies the surface quasi-geostrophic equation. The feedback nudging is done on this 2D model, yet ultimately synchronizes the streamfunction of the three-dimensional flow. The main analytical difficulties involved in ensuring the synchronization property arise from the presence of a nonlocal dissipative operator in the surface quasi-geostrophic equation. This necessitates the derivation of various boundedness and approximation properties for the observation operators used in the feedback nudging.

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MS47

The Stampacchia Maximum Principle for Stochastic Partial Differential Equations and Applications

Stochastic partial differential equations are considered, linear and nonlinear, for which we establish comparison theorems for the solutions, or positivity results a.e., and a.s., for suitable data. Comparison theorems for SPDEs are available in the literature and comparisons are made with our results. The originality of our approach is that it is based on the use of truncations, following the Stampacchia approach to maximum principle. We believe that our method, which does not rely too much on probability considerations, is simpler than the existing approaches and more general. As an application we also show how one can prove the existence of positive solutions for SPDEs with a quadratic nonlinearity (and possibly other nonlinearities).

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MS47

A Model for Hyporheic Zone

We propose a model for fluid flows in hyporheic zone. The hyporheic zone is a region beneath and alongside a stream bed, where there is mixing of shallow groundwater and surface water. The flow dynamics and behavior in this zone is of great importance to the health of rivers and streams and the associated ecological systems. In the first part of the talk, we discuss the small Darcy number regime and demonstrate the equivalence of two seemingly disparate interface boundary conditions: the balance of the normal component of normal stress, and the balance of the normal component of the normal stress that takes into account the dynamic pressure as suggested by J.L. Lions. Connections to popular simplified models in groundwater community will be discussed as well. In the second part, we present a novel numerical method that has a discrete energy law and decouples the computation of the free flow from the Darcy flow.

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MS47

Far Field Regularity for the Supercritical Quasi-Geostrophic Equations

We address the far field regularity for solutions of the surface quasi-geostrophic equation

$$\theta_t + u \cdot \nabla\theta + \Lambda^{2\alpha}\theta = 0 \qquad u = \mathbb{R}^{\perp}\theta = (-\mathbb{R}_2\theta, \mathbb{R}_1\theta),$$

in the supercritical range $0 < \alpha < 1/2$ with α sufficiently close to $1/2$. We prove that if the datum is sufficiently regular, then the set of space-time singularities is compact in $\mathbb{R}^2 \times \mathbb{R}$. The proof depends on a new spatial decay result on solutions in the supercritical range.

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MS48

Fully Discrete Models in Viscoelastic Wave Propagation

Using Zeners classical model, we analyze the propagation of waves through viscoelastic materials. In addition to the continuous problem, we study the semidiscretization in space in the framework of using Finite Elements. For the time discretization, we use Convolution Quadrature in the Laplace domain. It is in the Laplace domain that we study the stability and convergence of the discrete problem. A direct in time analysis using semigroup theory is also achieved for the semidiscrete (in space) model, where we assume our solution is continuous in time. To complete this analysis, we must reformulate the model into a first order form involving displacement, strain, and diffusive stress. We also apply this analysis to the fractional Zener model which uses fractional order derivatives to relate the stress and strain.

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MS48

New Anisotropic Fems on Polyhedral Domains

Abstract Not Available At Time Of Publication.

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MS48

Weak Galerkin for H(div) Approximation on Quadrilaterals

Abstract Not Available At Time Of Publication.

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MS48

High Order Scheme with Exponential Fitting for

Convection Diffusion Equations

Abstract Not Available At Time Of Publication.

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MS49

Recent Progress for Large Solutions of the p-system

The existence of large BV solution for the p-system is a long-standing open problem. We will discuss some recent progress on this topic.

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MS49

Invariant Measures for the Stochastic One-dimensional Compressible Navier-Stokes Equations

We discuss the existence of invariant measures for the one-dimensional compressible Navier-Stokes system, in the case of perfect gas pressure law. We prove existence of an invariant measure for the Markov process generated by strong solutions. We overcome the difficulties of working with non-Feller Markov semigroups on non-complete metric spaces by generalizing the classical Krylov-Bogoliubov method, and by providing suitable polynomial and exponential moment bounds on the solution.

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MS49

Eulerian and Lagrangian Solutions to the Continuity and Euler Equations with L^1 Vorticity

In my talk I will describe some recent results obtained in collaboration with C. Nobili (Basel), C. Seis (Bonn), and S. Spirito (L'Aquila). First of all we establish a uniqueness result for continuity equations with velocity field whose derivative can be represented by a singular integral operator of an L^1 function, extending the Lagrangian theory in [Bouchut-Crippa, JHDE 2013]. The proof is based on a combination of a stability estimate via optimal transport techniques developed in [Seis, Ann IHP 2017] and some tools from harmonic analysis introduced in [Bouchut-Crippa, JHDE 2013]. In addition, we address a question that arose in [Mazzucato-Lopes-Lopes, ARMA 2006], namely whether 2D Euler solutions obtained via vanishing viscosity are renormalized (in the sense of DiPerna and Lions) when the initial data has low integrability. We show that this is the case even when the initial vorticity is only in L^1, extending the proof for the L^p case in [Crippa-Spirito, CMP 2015].

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MS49

Convergence Rates of Finite Difference Schemes for the Linear Advection and Wave Equation with Rough Coefficient

We prove convergence rates of explicit finite difference schemes for the linear transport and wave equation in one space dimension with Hölder continuous coefficient. The obtained convergence rates explicitly depend on the Hölder regularity of the coefficient and the modulus of continuity of the initial data. We compare the theoretically established rates with the experimental rates of a couple of numerical examples.

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MS51

Continuum Descriptions of the Vicsek Model

Flocking models abound in the recent mathematical literature. Applications areas include bacteria, insects, birds, and even humans, while mathematical investigations can be found at the particle, kinetic, and hydrodynamic levels. The Vicsek model is the basis for many of these investigations and applications, although the interpretation of the model varies quite a bit. Here, we will explore several variations of the Vicsek model, deriving continuum limits and analyzing the differing behaviors that these models exhibit.

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MS51

Kinetic Games and Insurance Plans

There are many methods for deriving continuous models for populations of rational agents interacting in a game theoretical framework. Examples range from replicator equations to hydrodynamic closures to mean-field games. In this talk, we introduce a new framework for deriving kinetic equations governing asymmetric games where two populations play a game against each other. We specifically separate the dynamics of the state and strategy of each population. This allows each population to "learn" based on the results of previous games. We will investigate the resulting dynamics and present an application involving shopping for insurance plans.

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MS51

Variational Mean Field Games for Market Competition with Renewable Resources

In this paper, we explore a variant of Chan and Sircar's Mean Field Games model for market competition. We consider a situation with reflecting boundary conditions, which expresses the fact that producers can renew their stock as soon as it depletes. We prove existence, uniqueness and regularity of solutions to the corresponding system of equations, and show that this system can be written as an optimality condition of a convex minimization problem. Finally, we prove existence of weak solutions to the corresponding first order system at the deterministic limit.

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MS51

Agent-based Model of the Effect of Globalization on Inequality and Class Mobility

We consider a variant of the Bouchaud-Mezard model for wealth distribution in a society which incorporates the interaction radius between the agents, to model the extent of globalization in a society. The wealth distribution depends critically on the extent of this interaction. When interaction is relatively local, a small cluster of individuals emerges which accumulate most of the societys wealth. In this regime, the society is highly stratified with little or no class mobility. As the interaction is increased, the number of wealthy agents decreases, but the overall inequality rises as the freed-up wealth is transferred to the remaining wealthy agents. However when the interaction exceeds a certain critical threshold, the society becomes highly mobile resulting in a much lower economic inequality (low Gini index). This is consistent with the Kuznets upside-down U shaped inequality curve hypothesis.

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MS52

Stabilizing the Propagation of Colliding Soliton Sequences of Nonlinear Schrödinger Models with Frequency Dependent Linear Gain-Loss

We study transmission of multiple sequences of optical solitons in Kerr nonlinear optical waveguide loops. The transmission is described by a system of coupled nonlinear Schrödinger (NLS) equations. Our numerical simulations with the coupled-NLS system shows that transmission destabilization in a single lossless waveguide is caused by resonant formation of radiative sidebands, i.e., peaks in the graph of the Fourier transform of the optical field as a function of the frequency ω. Additionally, we investigate the possibility to increase transmission stability by optimization with respect to the Kerr nonlinearity coefficient γ. Moreover, we develop a general method for transmission stabilization, based on frequency dependent linear gain-loss in Kerr nonlinear waveguide couplers, and implement the method in two-sequence and three-sequence transmission. We show that the introduction of frequency dependent loss leads to significant enhancement of transmission stability even for non-optimal γ values via decay of radiative sidebands, which takes place as a dynamic phase transition. For waveguide couplers with frequency dependent linear gain-loss, we observe stable oscillations of soliton amplitudes due to decay and regeneration of the radiative sidebands. Transmission stabilization is achieved without dispersion-management or filtering.

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MS52

Multi-Component Nonlinear Waves in Optics and Atomic Condensates: Theory, Computations and Experiments

Motivated by work in nonlinear optics, as well as more recently in Bose-Einstein condensate mixtures, we will explore a series of nonlinear states that arise in such systems. We will start from a single structure, the so-called dark-bright solitary wave, and then expand our considerations to multiple such waves, their spectral properties, nonlinear interactions and experimental observations. A twist will be to consider the dark solitons of the one component as effective potentials that will trap the bright waves of the second component, an approach that will also prove useful in characterizing the bifurcations and instabilities of the system. Beating so-called dark-dark soliton variants of such states will also be touched upon. Generalizations of all these notions in higher dimensions and, so-called, vortex-bright solitons will also be offered and challenges for future work will be discussed.

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MS52

Nonlinear Optics Models in Some Nonperturbative Regimes

I will discuss the derivation of some multiscale nonperturbative models for the propagation of short and intense optical pulses in a gas. Some mathematical and computational aspects will be presented, as well as some applications in laser physics.

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MS52

Rogue Waves and Large Deviations in Nonlinear Schroedinger Models

The appearance of rogue waves in deep sea is investigated using the modified nonlinear Schroedinger (MNLS) equation with random initial conditions that are assumed to be Gaussian distributed, with a spectrum approximating the JONSWAP spectrum obtained from observations of the North Sea. It is shown that by supplementing the incomplete information contained in the JONSWAP spectrum with the MNLS dynamics one can reliably estimate the probability distribution of the sea surface elevation far in the tail at later times. Our results indicate that rogue waves occur when the system hit small pockets of wave configurations hidden in the core of their distribution that trigger large disturbances of the surface height via modulational instability. The rogue wave precursors in these pockets are wave patterns of regular height but with a very specific shape that is identified explicitly, thereby allowing for early detection. The method proposed here builds on tools from large deviation theory that reduce the calculation of the most likely rogue wave precursors to an optimization problem that can be solved efficiently.

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MS53

Liquid Crystal Electrokinetics

Abstract Not Available At Time Of Publication.

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MS53

Analysis of a One-Dimensional Landau-De Gennes Model for Bent-Core Liquid Crystals

Abstract Not Available At Time Of Publication.

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MS53

Least Action Principles for Incompressible Flows and Optimal Transport Between Shapes

Abstract Not Available At Time Of Publication.

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MS53

Global Well-Posedness for Dynamical Models of Nematic Liquid Crystals

Abstract Not Available At Time Of Publication.

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MS54

Distributed Controllability of Elastic Systems Enclosing a Linear Potential Fluid

A variable coefficient string or beam equation is used to model the flexible portion of the boundary of the domain of a two dimensional linear potential fluid. Exact controllability is proved when control is applied over an open interval of positive length. The method of proof is based on application of Ingham's inequality together with mini-max estimates of eigenvalues.

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MS54

Uniform Stability to Non-Trivial Equilibrium of a Fluid-Structure Interaction Via Interior Feedback Control

Uniform stability to a non-trivial equilibrium of a nonlinear fluid structure interaction model is studied. We propose control action depending on the equilibrium and applied to the interior of the fluid and solid domain to achieve this goal. The stabilization result obtained is global and no assumptions on the smallness of the initial data or the size of equilibrium point are needed. The damping placed on the solid domain is the Kelvin-Voigt type of viscoelastic damping. Due to viscoelasticity, the boundary transmission conditions are highly unbounded, which requires perturbation independent argument. To overcome this difficulty, we seek to construct special multipliers based on the Stokes solver and a special projection operator on L_2 space.

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MS54

Spectral Analysis and Control Problems for Mathematical Model of Energy Harvester

A set of our recent results on a model of a piezoelectric energy harvester is presented. The model is well known from engineering literature. It is governed by a system of two equations. The first of them is the Euler/Bernoulli model for the transverse vibrations of a damped beam subject to action of an external force. The second equation represents the Kirchhoffs law for the electric circuit. Both equations are coupled by means of the direct and converse piezoelectric effects. The boundary conditions for the beam equations are of clamped free type with an additional term that is proportional to the voltage on the resistive load and is produced by the converse piezoelectric effect. The circuit equation contains an extra term that depends on the transverse displacement of the beam and is produced by the direct piezoelectric effect. The system is written as a single operator evolution equation in a Hilbert space, whose dynamics generator is a nonselfadjoint operator with compact resolvent. The following results will be presented. 1) Asymptotic formulas for the eigenvalues of the dynamics generator. 2) Completeness, minimality, and Riesz basis property of the generalized eigenvectors. 3) Solutions by the spectral decomposition method of three control problems: zero controllability problem and two versions of output tracking problem. The Interpolation theory in the Hardy space of analytic functions is used to solve the tracking problems.

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MS54

Analyticity, Spectral Analysis, and Uniform Stability of a Heat-viscoelastic Plate Interaction Model

We consider a heat equation defined on an interior bounded domain coupled with visco-elastic plate defined on surrounding external domain. Coupling occurs at the interface between the two domains, through high order coupling conditions between the two dynamics. We establish that the coupled system generates a strongly continuous contraction semi-group on the natural space of finite energy, which moreover is analytic and uniformly stable. A sharp spectral analysis is also provided. In particular, the generator fails to have compact resolvent operator.

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MS55

Force Convergence in Phase Field Models

The Cahn-Hilliard functional is a phase field version of free energy for many systems involving free interfaces. It is well known that the Cahn-Hilliard functional Gamma converges to the interface area. In this talk we will discuss the convergence of generalized forces, under minimal assumptions. As an application we will mention some results about a phase field model for molecule solvation.

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MS55

Evolution Equations from Epitaxial Growth

Abstract Not Available At Time Of Publication.

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MS55

Gradient Flow for a Relaxed Model for Bent-Core Liquid Crystals

Liquid crystals composed of bent-core molecules enjoy a characteristic shape within their molecules that allows for spontaneous polarization. We consider a columnar phase of these liquid crystals where the polarization can be reoriented by applying an electric field. To understand the switching mechanism, we consider a relaxed Landau-De Gennes-type free energy. We construct a discretized-in-time gradient flow through energy minimization and prove existence and uniqueness of the continuous gradient flow.

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MS55

An Elementary Proof to the Eigenvalue Preservation Property in the Beris-Edwards System

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MS56

Agent-Based and Continuous Models of Locust Hopper Bands: The Role of Intermittent Motion, Alignment and Attraction

Locust swarms pose a major threat to agriculture, notably in North Africa and the Middle East. In the early stages of aggregation, locusts form hopper bands. These are coordinated groups that march in columnar structures that are often kilometers long and may contain millions of individuals. We propose a model for the formation of locust hopper bands that incorporates intermittent motion, alignment with neighbors, and social attraction, all behaviors that have been validated in experiments. Using a particle-in-cell computational method, we simulate swarms of up to a million individuals, which is several orders of magnitude larger than what has previously appeared in the locust modeling literature. We observe hopper bands in this model forming as a fingering instability. Our model also allows homogenization to yield a system of partial integro-differential evolution equations. We identify a bifurcation from a uniform marching state to columnar structures, suggestive of the formation of hopper bands.

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MS56

Small Noise - Huge Pattern Changes: Predicting Large Fluctuations in High Dimensional Systems

Many dynamical processes in physics and biology are modeled discretely because either their continuum limits do not always exist at small spatial scales, or it is difficult to analyze the effects of long range interactions; e.g., crystal growth, swarming dynamics, collective cellular dynamics, social dynamics, to name a few. When taking continuum limits, it is typical to derive models in a deterministic setting. However, one important aspect missing in continuum limits is the lack of internal noise generation due to random interactions in finite dimensional systems. It is known that small noise in dynamical systems can induce large fluctuations in which noise causes pattern switching between different meta-stable states. Here I will present new results on high dimensional discrete networks that predict how such large fluctuations cause pattern switching. In addition, I will discuss how we might be able to control the rate of pattern switching using theory. Applications will be to physical spin systems (also used to model opinion formation), the creation of new swarming patterns, as well as large scale population dynamics.

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MS56

Macroscopic Models for Mixed Human-Autonomous Vehicle Traffic Flow

In vehicular traffic flow, the collective human driving behavior can produce macroscopic emergent stop-and-go traffic waves. This "phantom traffic jam" phenomenon can be explained as an instability in PDE-based traffic models. However, the reality of traffic flow is about to change in the near future, due to the insertion of autonomous vehicles (AVs) into the traffic stream. These will themselves drive differently (hopefully: more safely and efficiently) than humans. This, in turn, will affect the traffic flow at whole in ways that, ideally, should be understood, before AVs get deployed. We present mathematical models for mixed human-AV flow, focusing on the near-future situation of having only few AVs on the road. Via numerical simulations, as well as actual experiments, we demonstrate that even at low penetration rates, AVs can have substantial impact on the safety and efficiency of the overall traffic flow.

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MS56

Agent-Based and Continuum Models for Stripe Formation on the Fins of Zebrafish

Black and yellow pigment cells self-organize on the body and fins of the zebrafish to produce its namesake stripes. These patterns develop on the growing fish skin through a combination of short- and long-range interactions, including cell movement, differentiation, and competition, but mutations suggest different interactions are present on the body and tailfin. To help reconcile differences between these two regions, we study the development of zebrafish patterns using discrete (agent-based) and continuum (nonlocal conservation law) models on growing domains. Our models suggest that the presence of boney rays and altered types of skin growth can reconcile why different self-organization mechanisms are at work on the body and tailfin of zebrafish.

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MS57

Heterogeneous Fast Multipole Method for 2-D Wave Scattering in Layered Media

Numerical simulation for wave scattering in layered media plays a crucial role in designing and optimizing modern electronic devices. In this talk, a heterogeneous fast multipole method (H-FMM) for 2-D Helmholtz equation in layered will be presented. First, the layered media Greens function is represented with Sommerfeld integrals. Then, for many source points, source contribution is compressed with multipole expansion of the free-space Greens function and the far field contribution is also compressed with the same free-space multipole expansion. Then, the compressed information is translated over the tree-data structure using Grafs addition theorem. In particular, the spatially variant information of domain Greens function is collected in a newly developed multipole-to-local operator. Numerical experiments show linear complexity in low frequency regime. Moreover, due to equivalence between the method of image and Sommerfeld representation of the Greens function, H-FMM can be easily generalized to multi-layered media.

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MS57

Modeling and Computation of Nano-Optics

We present a multiscale modeling and computational scheme for optical- mechanical responses of nanostructures. The multi-physical nature of the problem is a result of the interaction between the electromagnetic (EM) field, the molecular motion, and the electronic excitation. To balance accuracy and complexity, we adopt the semi-classical approach that the EM field is described classically by the Maxwell equations, and the charged particles follow the Schr oidnger equations quantum mechanically. To overcome the numerical challenge of solving the high dimensional multi-component many- body Schr odinger equations, we further simplify the model with the Ehrenfest molecular dynamics to determine the motion of the nuclei, and use the Time- Dependent Current Density Functional Theory (TD-CDFT) to calculate the excitation of the electrons. This leads to a system of coupled equations that computes the electromagnetic field, the nuclear positions, and the electronic current and charge densities simultaneously. In the regime of linear responses, the resonant frequencies initiating the out-of-equilibrium optical-mechanical responses can be formulated as an eigenvalue problem. A self-consistent multiscale method is designed to deal with the well separated space scales. The isomerization of Azobenzene is presented as a numerical example.

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MS57

Stable, High-Order Computation of Impedance-Impedance Operators

The faithful modeling of the propagation of linear waves in a layered, periodic structure is of paramount importance in many branches of the applied sciences. In this talk we discuss a novel numerical algorithm for the simulation of such problems which is free of the artificial singularities present in related approaches. We advocate for a surface integral formulation which is phrased in terms of Impedance-Impedance Operators that are immune to the Dirichlet eigenvalues which plague the Dirchlet-Neumann Operators that appear in classical formulations. We demonstrate a High-Order Spectral algorithm to simulate these latter operators based upon a High-Order Perturbation of Surfaces methodology which is rapid, robust, and highly accurate. We demonstrate the validity and utility of our approach with a sequence of numerical simulations.

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MS57

Well-Conditioned Boundary Integral Equation Formulations and Nystrom Discretizations for the Solution of Helmholtz Problems with Impedance Boundary Conditions in Two-Dimensional Lipschitz Domains

Title Not Available At Time Of Publication

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MS58

Gelfand Type Problems for Reactive Turbulent Jets

Gelfand problem is one of the canonical problems in the theory of non-linear parabolic and elliptic partial differential equations (PDEs). This problem naturally arises in the Frank-Kamenetskii theory of thermal explosion (autoignition) and describes an initial stage of evolution of a temperature field in reactive materials and mixtures. In this talk I will present a generalization of Gelfand problem for analysis of autoignition of reactive turbulent jets. I will present both derivation of this new model and its analysis. The latter is performed using a combination of rigorous, formal asymptotic and numerical techniques. It will be shown that similar to the classical Gelfand problem an autoignition in jets occur exclusively owing to the absence of self-similar temperature distribution which, in mathematical terms, leads to loss of regularity (blow-up) of underlying PDE. The detailed analysis of self-similar temperature profiles will be presented and a sharp characterization of an autoignition event in terms of principal geometric and physical parameters of the problem will be given. This a joint work with U.G. Hegde and M.C. Hicks of NASA Glenn Research Center.

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MS58

Free Discontinuity Problems Associated to Singular Integral Operators

We shall introduce a set of free discontinuity problems that arise naturally when studying the geometry of measures for which an associated singular integral operator has various prescribed analytic properties. Joint work with Fedor Nazarov.

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MS58

Suppression of Chemotactic Explosion by Mixing

Chemotaxis plays a crucial role in a variety of processes in biology and ecology. In many instances, processes involving chemical attraction take place in fluids. One of the most studied PDE models of chemotaxis is given by the Keller-Segel equation, which describes a population density of bacteria or mold which attract chemically to substance they secrete. Solutions of the Keller-Segel equation can exhibit dramatic collapsing behavior, where density concentrates positive mass in a measure zero region. A natural question is whether presence of fluid flow can affect singularity formation by mixing the bacteria thus making concentration harder to achieve. I will discuss a result that shows that in two or three dimensions, there exist incompressible flows with that can suppress the finite time blow up. This ability of the flow is closely linked with its mixing properties. The talk is based on a joint work with Xiaoqian Xu.

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MS58

Density Functional Theory of Charge Screening in Graphene

We discuss a density functional theory of Thomas-Fermi-Dirac-von Weizsacker type to describe the response of a single layer of graphene resting on a dielectric substrate to a point charge or a collection of charges some distance away from the layer. We formulate a variational setting in which the proposed energy functional admits minimizers. We further provide conditions under which those minimizers are unique. The associated Euler-Lagrange equation for the charge density is also obtained, and uniqueness, regularity and decay of the minimizers are proved under general conditions.

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MS59

Mean Field Limit of Interacting Filaments and Vector Valued Non Linear PDEs

Families of N interacting curves are considered, with long range, mean field type, interaction. A family of curves defines a 1-current, concentrated on the curves, analog of the empirical measure of interacting point particles. This current is proved to converge, as N goes to infinity, to a mean field current, solution of a nonlinear, vector valued, partial differential equation. In the limit, each curve interacts with the mean field current and two different curves have an independence property if they are independent at time zero. This set-up is inspired from vortex filaments in turbulent fluids.

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MS59

Title Not Available At Time Of Publication

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MS59

Mathematical Aspects of Distributed Control for Compressible Fluids

The compressible Navier-Stokes equations comprise a system of PDE describing the evolution of a linearly viscous compressible fluid. We consider the general problem of driving the fluid to a given state over a fixed time T, under the influence of a distributed control in the form of a body force. An optimal control is sought such that a certain integral cost functional is minimized. We first obtain the existence of optimal controls for the nonlinear system. Our result relies on the weak-strong uniqueness property of the compressible Navier-Stokes equations to ensure the existence of unique states. Next we obtain the first order necessary conditions for a linearized version of the compressible system in the form of a Pontryagin maximum principle. We will remark on challenges with the full nonlinear system and how this result may be extended.

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MS59

Large Deviations for Landau-Lifschitz-Gilbert Equations with Pure Jump Noise

In this talk we consider a stochastic Landau-Lifshitz equation on a bounded interval and with pure jump noise in the Marcus canonical form. We first show that there exists a pathwise unique solution to this equation and that this solution has the maximal regularity property. Next, we prove the large deviations principle for small noise asymptotic of solutions using the weak convergence method. This is a joint work with Zdzislaw Brzezniak and Jianliang Zhai.

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MS60

Quantum and Kinetic Models in Spin-magnetization Coupling

The Schrdinger-Poisson-Landau-Lifshitz-Gilbert (SPLLG) system is an effective microscopic model that describes the coupling between conduction electron spins and the magnetization in ferromagnetic materials. This system has been used in connection to the study of spin transfer and magnetization reversal in ferromagnetic materials. In this work, we rigorously prove the existence of weak solutions to SPLLG and derive the Vlasov-Poisson-Landau-Lifshitz-Glibert system as the semiclassical limit.

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MS60

The Derivation of Heat Conduction Models with Fluctuations

During the past two decades, there has been rapidly grow-

ing interest in modeling heat transport at the microscopic scale. As the size of electrical and mechanical devices is decreased to the micron and sub-micron scales, they often exhibit heat conduction properties that are quite different from the observations familiar at macroscopic level, e.g., Fourier Law. At such scale, the observable quantities also carry substantial fluctuations. In this talk, heat conduction models are derived directly from the many-particle system as a coarse-grained description. By selecting the local energy as the coarse-grained variables, we apply a projection formalism to derive the reduced model. In sharp contrast to conventional energy transport models, this derivation yields a stochastic dynamics model for the spatially averaged energy. The model also exhibits non-locality in space and time. We discuss the approximation of the non-local term, along with the approximation of the random force using both additive and multiplicative noises, to ensure the correct statistics of the solution, especially the variance of the solution.

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MS60

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Abstract Not Available At Time Of Publication

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MS61

Spectral Stability of Solutions to the Vortex Filament Hierarchy

The Vortex Filament Equation (VFE) is part of an integrable hierarchy of filament equations. Several equations in this hierarchy have been derived to describe vortex filaments in various situations. Inspired by these results, we develop a general framework for studying the existence and the linear stability of closed solutions of the VFE hierarchy. The framework is based on the correspondence between the VFE and the nonlinear Schrödinger (NLS) hierarchies. Our results establish a connection between the AKNS Floquet spectrum and the stability properties of the solutions of the filament equations. We apply our machinery to solutions of the filament equation associated to the Hirota equation. We also discuss how our framework applies to soliton solutions.

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MS61

Center Manifolds for a Class of Degenerate Evolution Equations and Existence of Small Amplitude Kinetic Shocks

We construct center manifolds for a class of degenerate evolution equations including the steady Boltzmann equation and related kinetic models, establishing in the process existence and behavior of small-amplitude kinetic shock and boundary layers. Notably, for Boltzmann's equation, we show that elements of the center manifold decay in velocity at near-Maxwellian rate, in accord with the formal Chapman-Enskog picture of near-equilibrium ow as evolution along the manifold of Maxwellian states, or Grad moment approximation via Hermite polynomials in velocity. Our analysis is from a classical dynamical systems point of view, with a number of interesting modifications to accommodate ill-posedness of the underlying evolution equation.

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MS61

Nonlinear Stability of Bilayers under Geometric Flow

We present a fully nonlinear analysis of the stability of nearly circular bilayers in the Functionalized Cahn HIlliard equation under the H-1 gradient flow. We recover a linearized version of the Willmore flow associated to the geometric evolution. A key step is the control of interfaces proximal to the circular shape in terms of normal mode perturbations.

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MS61

Optimal Damping for Exponential Energy Decay in 1D Wave Equation

Abstract Not Available At Time Of Publication.

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MS62

Banach Spaces

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MS62

Iterative Solutions for Variational Inclusions Prob-

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Abstract Not Available At Time Of Publication.

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MS62

Iterative Solutions

Abstract Not Available At Time Of Publication.

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MS62

Accretive Operators

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MS63

Mathematical Models of Bi-layer Nanostructures

Abstract Not Available At Time Of Publication.

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MS63

Gamma-convergence of an Anisotropic Superconductivity Model with Magnetic Fields Near H_{c_1}

We analyze the Lawrence-Doniach model for layered superconductors occupying a bounded generalized cylinder, $\Omega \times (0, L)$, in R^3, where Ω is a bounded simply connected smooth domain in R^2. For an applied magnetic field $\vec{H}_{ex} = h_{ex}\vec{e}_3$ that is perpendicular to the layers with $h_{ex} \sim |\ln \epsilon|$ as $\epsilon \to 0$, where ϵ is the reciprocal of the Ginzburg-Landau parameter, we prove Gamma-convergence of the Lawrence-Doniach energy as ϵ and the interlayer distance s tend to zero, under the additional assumption that the layers are weakly coupled.

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MS63

Analysis and Stability of a Landau-de Gennes Model for the Switching Mechanism in the $B_{\mathbf{1RevTilted}}$ Phase of Bent-Core Liquid Crystals

The $B_{1\mathrm{RevTilted}}$ is a smectic tilted columnar phase of bent-core molecule liquid crystals, in which it is possible to reorient the spontaneous polarization by applying an electric field. The reorientation can be achieved by either a rotation around the smectic cone or the molecular axis, or more in general by a combination of both. In our work, we consider a Landau-de Gennes-type energy functional used in the physics literature to model experimental results of the switching mechanism seen in this columnar phase. As the width of the column tends to infinity, Γ-convergence shows that rotation around the smectic tilt cone is favored, provided the coefficient of the coupling term, between the polar parameter, the nematic parameter, and the layer normal is large. We will also discuss the existence and stability of positive solutions to simplified Euler-Lagrange equations.

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MS64

Improved Non-Overlapping Domain Decomposition Algorithms for the Eddy Current Problem

Abstract Not Available At Time Of Publication.

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MS64

A High-Order Perturbation of Surfaces Method for Scattering of Linear Waves by Periodic Multiply Layered Gratings in Two and Three Dimensions

Abstract Not Available At Time Of Publication.

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MS64

Scattering by a Periodic Array of Narrow Slits: Field Enhancement and Anomalous Diffraction

In this talk, I will present mathematical studies of field enhancement by the scattering of a periodic array of perfect conducting narrow slits. The scattering problem in three different configurations will be investigated, where the geometry in different configurations varies depending on the scaling between the size of slits, the size of period, and the wavelength of the incident wave. Based upon the layer potential technique, asymptotic analysis and the homogenization theory, the enhancement mechanisms in these three regimes are studied quantitatively.

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MS64

The Imaging of Small Perturbations in An

Anisotropic Media

Abstract Not Available At Time Of Publication.

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MS65

Precise Asymptotics of the Aris Equations Via Poisson Summation

Understanding the behavior of a passive tracer distribution in laminar, pressure-driven pipe flow requires understanding of the moments – mean, variance, skewness – of the distribution along flow lines throughout the cross section. In particular, the skewness has nontrivial dependence on the cross section of the pipe, which has motivated us to explore of the importance of cross section on the distribution's moments in general. In the case of flow between infinite parallel plates, the Aris moment equations have been shown to have explicit, single-series solutions for the first three moments. Here, we show how the form of these solutions allows them to be rewritten, using Poisson summation, as an equivalent series which is well-ordered at short time. This allows for an excellent two-term method of images approximation for the moments before diffusive timescales, and from these approximations we derive higher-order correction terms to the short time asymptotics of the skewness. After this, we explore the potential of using images of the same functional form for deriving correction terms in the asymptotics of the moments for a general cross section, without the need for the explicit solutions for the tracer moments, and comparisons to numerical simulation will be shown for a few families of cross sections.

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MS65

How Boundaries Shape Chemical Deliveries in Microfluidics

We present the results of a combined theoretical, computational and experimental study of the dispersion of a passive scalar in laminar shear flow through various pipe geometries. First, we derive the single-series longitudinal moments of the scalar concentration through exact analysis valid at all times. Then we show through Monte Carlo simulation, asymptotic analysis, and experiments that the cross-sectional aspect ratio sets the sign of the average skewness at long times (relative to the Taylor diffusion timescale). The skewness describes the longitudinal asymmetry of the tracer distribution and universally, thin channels (aspect ratio $\ll 1$) result in negative average skewness, whereas thick channels (aspect ratio ~ 1) result in positive average skewness. Our analysis also allows us to define a "golden aspect ratio which separates thin from thick channels. More exotic geometries will be discussed as well as possible microfluidics applications.

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MS65

Porous Spheres Settling in Stratified Fluids

Marine snow, aggregates composed of organic and inorganic matter, are fundamental to the carbon flux from the surface ocean to the deep ocean. Most of these macroscopic particles are extremely porous, allowing diffusion of a stratifying agent from the ambient fluid to affect the density and therefore the settling dynamics. We study the case of a single spherical particle settling in water stratified by salt, focusing on effects of porosity and diffusion. A parametric study of the settling behaviors and comparisons between modeling and experiments will be presented.

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MS65

Modeling Viscous Film Flows Driven by Oscillatory Airflow in a Tube

The flow of an annular liquid film lining the inside of a vertical tube arises in both biological and engineering problems. In the absence of airflow in the tube, the film will flow downwards due to gravity; when the air inside the core region of the tube is forced to flow due to an imposed pressure gradient, the annular film may be driven downwards or upwards. In this talk, we focus on films driven by periodic airflow with a net volume flux of zero over each period. Physical experiments have shown that if such periodic airflow is biased, e.g. having relatively fast upwards flow for less than half the period and relatively slow downwards flow for the remainder of the period, it is possible for the airflow to transport the film upwards against gravity. A recently-derived model for the flow of a viscous film driven by either steady or oscillatory airflow inside a tube will be discussed; the model is a single nonlinear partial differential equation that describes the evolution of the free surface of the film. Linear stability analysis of the model demonstrates improved agreement with experiments when compared with earlier versions of the model in the case of steady airflow. Model solutions found numerically will be shown to qualitatively match results of earlier film transport experiments. Finally, the implications of asymptotic assumptions made in deriving the model will be discussed briefly.

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MS66

Fast Flow Asymptotics for Stochastic Incompressible Viscous Fluids in the Plane and Spdes on Graphs

Fast advection asymptotics for a stochastic reaction-diffusion-advection equation is studied in this paper. To describe the asymptotics, one should consider a suitable class of SPDEs defined on a graph, corresponding to the stream function of the underlying incompressible flow.

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MS66

Stochastic Damped Navier-Stokes in R^d

We deal with the damped Navier-Stokes equations in R^d with a multiplicative noise forcing term, with low space regularity. We prove the existence of martingale solutions for $d = 2$ or $d = 3$ and, for $d = 2$, the pathwise uniqueness of solutions. Moreover, we prove existence of invariant measures for $d = 2$ and existence of stationary solutions for $d = 3$. This is based on a joint work with Z. Brzezniak.

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MS66

Existence of a Density on Finite Projections of the 2D Stochastic Navier Stokes Equation Driven by Lévy Processes or Fractional Brownian Motion

Let us consider the 2D Navier Stokes Equation a torus $\mathbb{T}^2$ driven by a Levy noise or a fractional Brownian motion and let us denote the solution process by u. In the talk we will present regularity properties of the probability measure induced by the solution process. To be more precise, if $F \subset L^2(\mathbb{T})$ is a finite dimensional subspace and $t > 0$, then we present under which conditions on the characteristic measure of the Lévy process or the Hurst parameter of the fractal Brownian motion, the, on F by $u(t)$ induced measure, is absolutely continuous with respect to the Lebesgue measure on F. First we will present the deterministic 2D Navier Stokes and some control theoretical results. Then I will present in which they these control properties of the deterministic equation corresponds to regularity properties of the probability measure induced by the solution process. This is a joint work with P. Razafimandimby.

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MS66

Data Assimilation Algorithm Based on Feedback Control Theory

We investigate the effectiveness of a simple finite-dimensional feedback control scheme for globally stabilizing solutions of infinite-dimensional dissipative evolution equations introduced by Azouani and Titi. This feedback control algorithm overcomes some of the major difficulties in control of multi-scale processes: It does not require the presence of separation of scales nor does it assume the existence of a finite-dimensional globally invariant inertial manifold. We present a theoretical framework for a control algorithm which allows us to give a systematic stability analysis, and present the parameter regime where stabilization or control objective is attained. In addition, the number of observables and controllers that were derived analytically and implemented in our numerical studies is consistent with the finite number of determining modes that are relevant to the underlying physical system. We verify the results computationally in the context of the Chafee-Infante reaction-diffusion equation, the Kuramoto-Sivashinsky equation, and other applied control problems, and observe that the control strategy is robust and independent of the model equation describing the dissipative system. This is joint work with Edriss S. Titi.

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MS67

Spectrwm: Spectral Random Walk Method for Stochastic Partial Differential Equations

The numerical solution of stochastic partial differential equations (SPDE) presents challenges not encountered in the simulation of PDEs or SDEs. Indeed, the roughness of the noise in conjunction with nonlinearities in the drift typically make these equations particularly challenging to simulate. In practice, this means that it is tricky to construct, operate, and validate numerical methods for SPDEs. This is especially true if one is interested in path-dependent expected values, long-time simulations, or in the simulation of SPDEs whose solutions have constraints on their domains. To address some of these issues, this talk introduces a Markov jump process approximation for SPDEs, which we refer to as the spectral random walk method (SPECTRWM).

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MS67

Regularity and Decay Results for Point Defects in Complex Crystals

Crystal defects play an important role in determining the mechanical and electrical properties of crystalline materials. In this talk, we formulate a model for a point defect in a multilattice crystal with an empirical interatomic potential interaction and quantify the decay of the long-range elastic fields with increasing distance from the defect. These decay estimates are essential in quantifying approximation errors in coarse-grained models and in developing multiscale atomistic-to-continuum methods. We present an example of how the decay rates are used in the construction of an optimal numerical method for approximating a Stone-Wales defect in graphene using the blended force-based quasicontinuum method.

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MS67

First-principle Modeling of Large-scale Atomistic Systems with Applications

We discuss new computational methods based on the FEAST eigensolver that can positively impact the existing methodologies used in first-principle DFT ground state and TDDFT excited states calculations of complex molecular systems and nanostructures. Simulation results with applications will be presented ranging from computational electronic spectroscopy of molecules, to plasmonic excitations in carbon-based nanostructures.

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MS67

Homogenization Theory for Biased Random Walks on Graphs Embedded in the Euclidean Space

We study the homogenization limit of a biased random walk on a periodic graph embedded in the multidimensional Euclidean space. Under certain conditions and under appropriate scaling we show that the random walk converges to a Brownian motion. Our model problem is inspired by the problem of solute diffusion in an aqueous polymer environment where both obstruction of solute by the polymer as well as interactions between the solute and polymer in the form of attraction, repulsion or bond formation play a role in determining effective solute diffusivity. The presence of interactions necessitates biased random walk models. Prediction of effective solute diffusivity in aqueous polymer environments enables the design of polymer-based drug and protein delivery devices as well as cell scaffolds for tissue engineering, among other applications. Our rationale for considering a random walk on a graph as the finescale model instead of a Brownian motion with drift and reflections, is to account for the fact that the mean path length of a diffusing solute may not be negligible in comparison with the finescale length of the structures of interest. When the finescale length of interest is only a few nanometers, as in the case of polymer gel networks, the case for our starting point is quite strong. We present both formal asymptotics as well as rigorous convergence results.

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MS67

Accelerated Transition Path Sampling for Molecular Dynamics

A common question in the study of atomistic systems is how transitions occur between different conformations of the system, usually corresponding to distinct minima of a potential energy landscape. Here, we model our system by the overdamped Langevin equation and consider the problem of sampling from the conditioned diffusion, where particular arrangements are assumed at fixed initial and terminal times. Using relative entropy, we are able to compute Gaussian approximations of the path space distribution which can then be used to accelerate exact sampling of the conditioned diffusion. Numerical examples and pitfalls of this approach will be presented.

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MS68

Stability of Fast Traveling Waves for a Doubly-Diffusive FitzHugh-Nagumo System

The Maslov index is a topological invariant assigned to curves of Lagrangian planes. It has been used in recent years to understand the spectra of linear operators, often arising in the stability analysis of nonlinear waves. In the context of waves, the Maslov index can be thought of as a generalization of Sturm-Liouville theory to systems of equations. One issue plaguing the application of the Maslov index to stability problems is that it is difficult to calculate in practice. This typically entails tracking the tangent space to an invariant manifold as it moves around phase space. We address this issue by analyzing traveling pulses in a FitzHugh-Nagumo system. The timescale separation in the traveling wave equation allows us to reduce the dimension of the problem and make the calculation of the index tractable. We use this calculation in conjunction with a recent result relating the Maslov index to stability in skew-gradient systems to prove that the fast traveling pulses are stable.

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MS68

Defects in Oscillating Spatially Extended Systems

We look at defects in oscillating spatially extended systems, such as chemical reactions or arrays of oscillators. Here, defects are represented as inhomogeneities which can be modeled as perturbations of the relevant equations. It is well known that when these inhomogeneities are stationary they can lead to interesting behavior like target and spiral waves. Here we look instead at effects of moving defects and show that, depending on their speed, the level sets of the solutions' phase can have different profiles. Since the linearization about the steady state has a zero eigenvalue embedded in the essential spectrum, finding solutions via perturbation theory is not straight forward. One can resolve this issue with the help of weighted Sobolev spaces which make the operator Fredholm.

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MS68

Traveling Waves in Gray-Scott Model in Bistable

Regime

Using singularly perturbed nature of the Gray-Scott model, we apply multi-scale analysis in a systematic way to show the existence and stability of a traveling front and a traveling pulse. While the traveling front is stable, the pulse is unstable.

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MS68

The Maslov Index and the Spectra of Second Order Elliptic Operators

In this talk I will discuss a formula relating the spectral flow of the one-parameter families of second order elliptic operators to the Maslov index, the topological invariant counting the signed number of conjugate points of certain paths of Lagrangian planes. In addition, I will present formulas expressing the Morse index, the number of negative eigenvalues, in terms of the Maslov index for several classes of second order operators: the $\theta-$periodic Schrödinger operators on a period cell $Q \subset \mathbb{R}^n$, the elliptic operators with Robin-type boundary conditions, and the abstract self-adjoint extensions of the Schrödinger operators on star-shaped domains. This is joint work with Y. Latushkin.

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PP1

Traveling Waves in Mass and Spring Dimer Fermi-Pasta-Ulam-Tsingou Lattices

The Fermi-Pasta-Ulam-Tsingou (FPUT) lattice is an infinite chain of particles connected by springs and constrained to move on a horizontal line. We investigate wave behavior in two classes of heterogeneous FPUT lattices: the mass dimer, in which the particles alternate in mass but the springs are identical, and the spring dimer, in which all the particles are the same but the spring forces alternate. In each case, we prove the existence of traveling waves that are nanopterons. These traveling waves are not classical solitary waves but instead are asymptotic at spatial infinity to periodic waves with extremely small amplitude.

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PP1

Adi Extrapolated Crank-Nicolson Orthogonal Spline Collocation for Burgers' Equation in Two Space Variables

Burgers' equation in two space variables is a coupled system of non-linear parabolic problems. We discretize these equations in space using orthogonal spline collocation with splines of degree $r \geq 3$ and we use ADI extrapolated Crank-Nicolson scheme for time discretization. The scheme is initialized with a predictor/corrector method. We show theoretically that the H^1 norm of the error at the final time level is of optimal order r in space and of order 2 in time. Our numerical results demonstrate also that the maximum norm of the error at the final time level is of optimal order $r + 1$ in space and of order 2 in time.

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PP1

Suppression of Blow-Up in Patlak-Keller-Segel Via Shear Flows

In this paper we consider the parabolic-elliptic Patlak-Keller-Segel models in $\mathbb{T}^d$ with $d = 2, 3$ with the additional effect of advection by a large shear flow. Without the shear flow, the model is L^1 critical in two dimensions with critical mass 8π; solutions with mass less than 8π are global and solutions with mass larger than 8π with finite second moment, all blow up in finite time. In three dimensions, the model is $L^{3/2}$ critical and L^1 supercritical; there exists solutions with arbitrarily small mass which blow up in finite time arbitrarily fast. We show that the additional shear flow, if it is chosen sufficiently large, suppresses one dimension of the dynamics and hence can suppress blow-up. In two dimensions, the problem becomes effectively L^1 subcritical and so all solutions are global in time (if the shear flow is chosen large). In three dimensions, the problem is effectively L^1 critical, and solutions with mass less than 8π are global in time (and for all mass larger than 8π, there exists solutions which blow up in finite time).

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PP1

Development Towards a Methodology for Predicting Long-Time Algebraic Growth in Linear Wave Equations.

One of the lesser understood topics of fluid instability is long time algebraic growth that can occur when a fluid is deemed classically (exponentially) neutrally stable. The aim of this work is to develop a methodology that would allow one to predict possible long time algebraic growth of disturbances in fluids (for example, coating processes), given the partial differential equations that describe the evolution of the disturbance. Specifically, progress has been made towards an algorithm that one may use to predict the algebraic growth rate.

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PP1

Almost Planar Waves on Square Lattices

We consider traveling wave solutions to the spatially discrete reaction-diffusion equation posed on the square lattice and look for traveling corners solutions that bifurcate from planar waves. Due to the discrete setting of the problem, we made use of a global center manifold reduction on a difference equations system posed on Banach spaces. We prove the existence of interior or exterior corners depending on the geometry of the angular wave speed function.

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PP1

Pulse Solutions for the Discrete FitzHugh-Nagumo Equation with Infinite-Range Interactions

We establish the existence and nonlinear stability of travelling pulse solutions for the discrete FitzHugh-Nagumo equation with infinite-range interactions close to the continuum limit. For the verification of the spectral properties, we need to study a functional differential equation of mixed type (MFDE) with unbounded shifts. We avoid the use of exponential dichotomies and phase spaces, by building on a technique developed by Bates, Chen and Chmaj for the discrete Nagumo equation. This allows us to transfer several crucial Fredholm properties from the PDE setting to our discrete setting.

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PP1

Modeling the Development of Mutated Patterns on Zebrafish

Zebrafish (Danio rerio) is a small fish with distinctive black and yellow patterns that form due to the self-organizing interactions of different pigment cells. While wild-type zebrafish feature stripes, altered cell interactions produce a wide range of mutations on the body of the growing fish, including spots and labyrinth curves. Working closely with the biological data, we present an agent-based model for the development of wild-type stripes on growing domains and discuss associated continuum limits. Our model identifies altered cell interactions that lead to patterns consistent with zebrafish mutations as well as close relatives within the Danio genus.

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Notes

PD17 Organizer and Speaker Index

SIAM Conference on

Analysis of
Partial Differential Equations

December 9–12, 2017
The Baltimore Convention Center
Baltimore, Maryland, USA

Italicized names indicate session organizers

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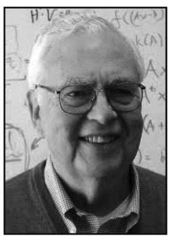
Gene Golub g2S3 2018 SIAM Summer School

June 17-30, 2018
Breckenridge, Colorado, USA

Inverse Problems: Systematic Integration of Data with Models under Uncertainty



The ninth Gene Golub SIAM Summer School will take place at the Double Tree by Hilton in Breckenridge, Colorado, USA.

The summer school aims to introduce graduate students to the mathematical and computational aspects of inverse problems, particularly modern developments that emphasize the quantification of uncertainty in the inverse solution within the framework of Bayesian inference. The target audience is PhD and appropriate MS students in mathematics and related fields such as computer science, statistics, engineering, and science.

The central question we address is: How do we learn from data through the lens of models? The summer school will feature an integrated and coherent presentation that begins with ill-posedness and regularization, develops the ideas and tools for deterministic inversion via nonlinear least squares optimization, and elaborates formulations and solution methods for the modern Bayesian perspective, building on several of the deterministic tools. The concepts introduced in the morning lectures will be reinforced and put into practice in afternoon hands-on laboratory sessions using open-source software (hIPPYlib, MUQ) implementing state-of-the-art deterministic and Bayesian inversion methods. Students will work together on projects that will be presented on the last day of the school.

The summer school is being organized by Omar Ghattas (The University of Texas at Austin), Youssef Marzouk (MIT), Matthew Parno (US Army Corps of Engineers), Noemi Petra (University of California, Merced), Georg Stadler (New York University), and Umberto Villa (The University of Texas at Austin).

Applicants selected to participate pay no registration fee. Funding for local accommodations and meal expenses will be available for all participants.

Aspen Stand, woodcut by Leon Loughridge

Application deadline: February 1, 2018

As information becomes available on how to apply, it will be posted at:

http://www.siam.org/students/g2s3/

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For more information about prior summer schools and Professor Gene Golub go to
http://www.siam.org/students/g2s3/

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Notes

PD17 Budget

Conference Budget
SIAM Conference on Analysis of Partial Differential Equations
December 9-12, 2017
Baltimore, Maryland, USA

Expected Paid Attendance		370
Revenue		
Registration Income		$134,705.00
	Total	$134,705.00
Expenses		
Printing		$5,100.00
Organizing Committee		$3,800.00
Invited Speakers		$11,250.00
Food and Beverage		$24,000.00
AV Equipment and Telecommunication		$27,200.00
Advertising		$5,700.00
Conference Labor (including benefits)		$47,878.00
Other (supplies, staff travel, freight, misc.)		$6,850.00
Administrative		$13,138.00
Accounting/Distribution & Shipping		$7,181.00
Information Systems		$13,204.00
Customer Service		$4,947.00
Marketing		$7,636.00
Office Space (Building)		$5,047.00
Other SIAM Services		$5,260.00
	Total	$188,191
Net Conference Expense		($53,486)
Support Provided by SIAM		$53,486
		$0
Estimated Support for Travel Awards not included above:		
Early Career and Students	14	$9,800

The Baltimore Convention Center Floor Plan