SIAM Conference on

Analysis of Partial Differential Equations

December 11-14, 2019

La Quinta Resort & Club
La Quinta, California, U.S.

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

This activity group fosters activity in the analysis of partial differential equations and enhances communication between analysts, computational scientists and the broad partial differential equations 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 partial differential equations, to increase conference activity in partial differential equations, and to enhance connections between SIAM and the mathematics community.

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North Carolina State University, U.S.

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Conference Themes

Nonlocal PDEs
Kinetic Theory
Conservation Laws
Coupled Multi-Physics PDE Systems
Fluid Dynamics
Numerical Analysis of PDEs
Control and Optimization
Variational Methods
Nonlinear Waves
Stochastic PDEs
PDEs in Biological and Complex Systems
Multiscale Analysis
Geometric PDEs and Optimal Transport
Mathematical Physics

Applications of PDEs including:
Biology, Medicine and Imaging
PDEs on Graphs and Networks
Geophysical Flows

SIAM Registration Desk

The SIAM registration desk is located in the Flores Foyer, La Quinta Resort & Club. It is open during the following hours:

Tuesday, December 10
4:00 p.m. – 8:00 p.m.
Wednesday, December 11
7:30 a.m. – 5:30 p.m.
Thursday, December 12
8:00 a.m. – 3:30 p.m.
Friday, December 13
8:00 a.m. – 4:00 p.m.
Saturday, December 14
8:00 a.m. – 3:00 p.m.

Hotel Address

La Quinta Resort & Club
49-499 Eisenhower Drive
La Quinta, CA 92253, U.S.

Hotel Telephone Number

To reach an attendee or leave a message, call +1-760-564-4111. 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 3:00 p.m.
Check-out time is 12:00 p.m.

Child Care

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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. In recognition of their support, non-member attendees who are employed by the following organizations are entitled to the SIAM member registration rate.

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List current as of October 2019

Funding Agency

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

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SIAM members save up to $140 on full registration for the 2019 SIAM Conference on Analysis of Partial Differential Equations! Join your peers in supporting the premier professional society for applied mathematicians and computational scientists. SIAM members receive subscriptions to *SIAM Review*, *SIAM News* and *SIAM Unwrapped*, and enjoy substantial discounts on SIAM books, journal subscriptions, and conference registrations.

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If you are a SIAM member, it only costs $15 to join the SIAM Activity Group on the Analysis of Partial Differential Equations (SIAG/APDE). As a SIAG/APDE member, you are eligible for an additional $15 discount on this conference, so if you paid the SIAM member rate to attend the conference, you might be eligible for a free SIAG/APDE membership. Check at the registration desk.

Students who paid the Student Non-Member Rate will be automatically enrolled as SIAM Student Members. Please go to *https://my.siam.org* to update your education and contact information in your profile. If you attend a SIAM Academic Member Institution or are part of a SIAM Student Chapter you will be able to renew next year for free.

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SIAM does not provide computers for any speaker. When giving an electronic presentation, speakers must provide their own computers. SIAM is not responsible for the safety and security of speakers' computers.

A data (LCD) projector and screen will be provided in all technical session meeting rooms. The data projectors support both VGA and HDMI connections. Presenters requiring an alternate connection must provide their own adaptor.

Internet Access

SIAM has arranged wireless internet access in the meeting space and in the guest rooms (booked within the SIAM block of rooms). This service is being provided to attendees at no additional cost.

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 members of SIAM Activity Group on Analysis of Partial Differential Equations)

Coffee breaks daily

Room set-ups and audio/visual equipment

Welcome Reception and Poster Session

Job Postings

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

Poster Participant Information

The poster session is scheduled for Tuesday, December 10 from 6:00 p.m. to 8:00 p.m. Poster presenters must set-up their poster material on the 4' x 6' poster boards in the Flores Foyer between the hours of 4:30 p.m. and 5:45 p.m. All materials must be posted by Tuesday, December 10, 6:00 p.m., the official start time of the session. Posters will remain on display through Thursday, December 12. **Posters must be removed by Friday, December 13 at 9:00 a.m.**

SIAM Books and Journals

Please stop by the SIAM books table to browse and purchase our selection of textbooks and monographs. Some new titles of interest include PDE Dynamics: An Introduction by Christian Kuehn, Finite Element Exterior Calculus by Douglas N. Arnold, Numerical Analysis of PDEs Using Maple and MATLAB by Martin J. Gander and Felix Kwok, and many more. Enjoy discounted prices and free shipping. Complimentary copies of selected SIAM journals are available, as well. The books booth will be staffed from 9:00 a.m. through 5:00 p.m. Wednesday, Thursday, and Friday. One of our acquisitions editors (Paula Callaghan) will be available if you have a book idea you'd like to discuss. The books table will not be open on Saturday, but you can pick up a copy of the Titles on Display for online orders.

Table Top Displays

SIAM

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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
Tuesday, December 10
6:00 p.m. – 8:00 p.m.

Business Meeting
(open to SIAG/APDE members)
Wednesday, December 11
5:00 p.m. – 5:45 p.m.
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.

If you have experienced or observed behavior that is not consistent with the principles expressed above, you are encouraged to report any violation using the SIAM hotline, hosted by the third-party hotline provider, EthicsPoint. The information you provide will be sent to us by EthicsPoint on a totally confidential and anonymous basis if you should choose. You have our guarantee that your comments will be heard. Please submit reports at *http://siam.ethicspoint.com/*.

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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, 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 #SIAMPD19.

SIAM's Twitter handle is @TheSIAMNews.

Changes to the Printed Program

The printed program was current at the time of printing, however, please review the online program schedule (*http://meetings.siam.org/program.cfm?CONFCODE=PD19*) or use the mobile app for up-to-date information.

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Invited Plenary Speakers

*** All Invited Plenary Presentations will take place in Flores 5 ***

Wednesday, December 11

11:00 a.m. - 11:45 a.m.

IP1 Non Exchangeability and Synchronization Mechanisms in Multi-Agent Systems
Pierre-Emmanuel Jabin, *University of Maryland, U.S.*

11:45 a.m. - 12:30 p.m.

IP2 Scalable Block Preconditioning of Implicit / IMEX FE Continuum Plasma Physics Models
John N. Shadid, *Sandia National Laboratories, U.S.*

Thursday, December 12

11:00 a.m. - 11:45 a.m.

IP3 Singularity Formation in Critical Parabolic Problems
Manuel del Pino, *University of Bath, United Kingdom*

11:45 a.m. - 12:30 p.m.

IP4 Bound-Preserving High Order Schemes for Hyperbolic Equations: Survey and Recent Developments
Chi-Wang Shu, *Brown University, U.S.*

Friday, December 13

11:00 a.m. - 11:45 a.m.

IP5 Crowd Motion and the Muskat Problem via Optimal Transport
Inwon Kim, *University of California, Los Angeles, U.S.*

11:45 a.m. - 12:30 p.m.

IP6 An Application of the Sharp Caffarelli-Kohn-Nirenberg Inequalities
Michael Loss, *Georgia Institute of Technology, U.S.*

Saturday, December 14

11:00 a.m. - 11:45 a.m.

IP7 Collisional Kinetics of Multi-Component System Models
Irene M. Gamba, *University of Texas, Austin, U.S.*

11:45 a.m. - 12:30 p.m.

IP8 Kalman-Wasserstein Gradient Flows
Andrew Stuart, *California Institute of Technology, U.S.*

Minitutorials

*** All Minitutorials will take place in Flores 5 ***

Wednesday, December 11

8:30 a.m. - 10:30 a.m.

MT1 Partial Differential Equations on Graphs for Data Classification

Organizers and Speakers: **Andrea L. Bertozzi,** *University of California, Los Angeles, U.S.*

Yves van Gennip, *Delft University of Technology, Netherlands*

Friday, December 13

8:30 a.m. - 10:30 a.m.

MT2 Population Dynamics in Moving Environments

Organizer and Speaker: **Mark Lewis,** *University of Alberta, Canada*

Prize Lecture

*** The Prize Lecture will take place in Flores 5 ***

Friday, December 13

2:00 p.m. - 2:45 p.m.

SP1 SIAG/Analysis of Partial Differential Equations Prize Lecture

Inviscid Damping and the Asymptotic Stability of Planar Shear Flows in the 2D Euler Equations

Recipients:

Jacob Bedrossian, *University of Maryland, U.S.*

Nader Masmoudi, *New York University, U.S.*

Presenting Author:

Jacob Bedrossian, *University of Maryland, U.S.*

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

www.siam.org/Activity-Groups/APDE

A great way to get involved!

Collaborate and interact with mathematicians and applied scientists whose work involves the analysis of partial differential equations.

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ACTIVITIES INCLUDE

- SIAG/APDE Website
- Special sessions at SIAM meetings
- Biennial conference
- SIAM Activity Group on Analysis of Partial Differential Equations Prize

BENEFITS OF SIAG/APDE MEMBERSHIP

- Listing in the SIAG's online membership directory
- Additional $15 discount on registration at the SIAM Conference on Analysis of Partial Differential Equations excludes students)
- Electronic communications about recent developments in your specialty
- Eligibility for candidacy for SIAG/APDE office
- Participation in the selection of SIAG/APDE officers

ELIGIBILITY

- Be a current SIAM member.

COST

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

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SIAM Conference on

Analysis of Partial Differential Equations

December 11-14, 2019

La Quinta Resort & Club
La Quinta, California, U.S.

Tuesday, December 10

Registration

4:00 p.m.-8:00 p.m.

Room: Flores Foyer

Tuesday, December 10

PP1

Welcome Reception and Poster Session

6:00 p.m.-8:00 p.m.

Room: Flores Foyer/Flores Veranda

Two-Phase Hele-Shaw Flows Induced by Dynamical Mother Bodies
Lanre Akinyemi and Tatiana Savin, Ohio University, U.S.

Numerical Solution for a System of 3D Partial Differential Equations
Badr Alkahtani, King Saud University, Saudia Arabia

Time Domain Finite Element Method for Nonlinear Maxwell's Equations
Asad Anees and Lutz Angermann, Techniche Universität Clausthal, Germany

A Mean Field Game Model of Innovation
Matthew Barker, Pierre Degond, Mirabelle Muuls, and Ralf Martin, Imperial College London, United Kingdom

Generalised Langevin Dynamics with Simulated Annealing for Optimisation
Martin Chak, Grigorios Pavliotis, and Nikolas Kantas, Imperial College London, United Kingdom

Global Well-Posedness of the Adiabatic Limit of Quantum Zakharov System in 1D
Brian J. Choi, Boston University, U.S.

Model Reduction for Fractional Elliptic Problems Using Kato's Formula
Huy Dinh, University of Utah, U.S.

A Spectral Flow Method for Computing Nodal Deficiencies on Graphs
Wesley Hamilton, University of North Carolina at Chapel Hill, U.S.

Generalized (s,S) Policy for Concave Piecewise Linear Ordering Cost
Md Abu Helal, University of Texas at Dallas, U.S.; Alain Bensoussan, The University of Texas at Dallas and City University of Hong Kong, Hong Kong; Suresh Sethi and Viswanath Ramakrishna, University of Texas at Dallas, U.S.

Biot-Pressure System with Unilateral Displacement Constraints
Alireza Hosseinkhan and Ralph Showalter, Oregon State University, U.S.

Approximation of the Two-Parameter Mittag-Leffler Function using a Real Distinct Poles Rational Function
Olaniyi S. Iyiola, California University of Pennsylvania, U.S.

A Robust Numerical Technique for Nonlinear Differential Equations
Jagbir Kaur and Dr. Vivek Sangwan, Thapar Institute of Engineering and Technology, Patiala, India

On Existence and Uniqueness of Solutions to Nonlocal Conservation Laws
Alexander Keimer, University of California, Berkeley, U.S.; Lukas Pflug and Michele Spinola, Friedrich-Alexander Universitaet Erlangen-Nuernberg, Germany

Discontinuous Galerkin Methods using Poly-Sinc Approximation
Omar A. Khalil, German University in Cairo, Egypt; Gerd Baumann, German University in Cairo, Egypt and University of Ulm, Germany

Big Data Simulation and Analysis of Numerical Solutions from the Elder Problem
Roman Khotyachuk, NORCE Norwegian Research Centre, Norway

Discrete-Time Disease Model with Population Motion under the Kolmogorov Equation View
Ye Li, Texas Tech University, U.S.

Convergence of a Stochastic Structure-Preserving Scheme for Computing Effective Diffusivity in Random Flows
Junlong Lyu, University of Hong Kong, Hong Kong

Parameterization Method for Nonlinear Manifolds of PDEs
Jalen Morgan, Brigham Young University, U.S.

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A Mathematical Analysis of Stock Price Oscillations within Financial Markets
Leonard Mushunje, Midlands State University, Zimbabwe

Global Existence of the Nonisentropic Compressible Euler Equations with Vacuum Boundary Surrounding a Variable Entropy State
Calum Rickard, University of Southern California, U.S.; Mahir Hadzic, King's College, United Kingdom; Juhi Jang, University of Southern California, U.S.

PDEs: a Transport-Diffusion Analysis of the Effect of Migrating Leachate on Aquifers
Patience A. Sakyi, National Institute for Mathematical Sciences, Ghana

Spatio-Temporal Gamma Oscillations in a Mean Field Model of Electroencephalographic Activity in the Neocortex
Farshad Shirani, Georgetown University, U.S.

On a Cahn-Hilliard Variational Model for Lithium Batteries
Kerrek Stinson, Irene Fonseca, and Giovanni Leoni, Carnegie Mellon University, U.S.

A Model for Currency Exchange Rates
Sundar Tamang, University of Alabama at Birmingham, U.S.

Primal-Dual Weak Galerkin Finite Element Methods for PDEs
Chunmei Wang, Texas Tech University, U.S.

Global Sobolev Persistence for the Fractional Boussinesq Equations with Zero Diffusivity
Weinan Wang and Igor Kukavica, University of Southern California, U.S.

The Landau Equation as a Gradient Flow
Jeremy Wu, Imperial College London, United Kingdom

Wednesday, December 11

Registration

7:30 a.m.-5:30 p.m.

Room: Flores Foyer

Wednesday, December 11

MT1

Partial Differential Equations on Graphs for Data Classification

8:30 a.m.-10:30 a.m.

Room: Flores 5

Calculus of variations is a well-known area of partial differential equations (PDEs) with applications in the physical sciences such as phase separation of materials. Recent years have seen a development of these ideas for machine learning applications for data analysis. In image processing, the total variation semi-norm is very important for applications like denoising, segmentation, and image inpainting, leading to novel uses of nonlinear PDEs in the continuum setting. The field of variational methods and PDEs on graphs brings the continuum theory into the discrete network setting to study high dimensional data. In this tutorial we encounter the graph Ginzburg-Landau model and the total variation functional on graphs. Methods based on these models are extremely well suited for applications such as data clustering, data classification, community detection in networks, and image segmentation. Theoretically there are also interesting questions to ask, for example about the Gamma-convergence properties of the Ginzburg-Landau functional and the relationships between its associated differential equations. We also explain how these models lead to efficient algorithms for a variety of machine learning applications including semi-supervised learning, Cheeger cuts, modularity optimization on networks, hyperspectral image analysis, ego-motion analysis of video, and biological classification problems.

Organizers and Speakers:

Andrea L. Bertozzi, University of California, Los Angeles, U.S.

Yves van Gennip, Delft University of Technology, Netherlands

Wednesday, December 11

MS1

Structure Preserving Numerical Methods for Gradient Flow Equations - Part I of II

8:30 a.m.-10:30 a.m.

Room: Flores 1

For Part 2 see MS15

Equations with a gradient flow structure are ubiquitous in many fields, such as material design, biological modeling, kinetic theory, image processing, and optimisation. Solutions to such equations possess many favourable properties: Positivity, energy decay, and convergence to steady state. This poses a challenge in numerical simulation as efficient and robust numerical methods should preserve the same properties at the discrete level. This minisymposium brings researchers from diverse fields working on the gradient flow equations with the common theme of structure preserving numerical methods.

Organizer: Jingwei Hu
Purdue University, U.S.

Organizer: Erlend Skaldehaug Riis
University of Cambridge, United Kingdom

8:30-8:55 An Entropy Stable High-Order Discontinuous Galerkin Method for Cross-Diffusion Gradient Flow Systems
Zheng Sun, Ohio State University, U.S.

9:00-9:25 Structure Preserving Schemes for Nonlinear Fokker-Planck Equations with Anisotropic Diffusion
Nadia Loy, Politecnico di Torino, Italy

9:30-9:55 Energy-Decaying and Positivity-Preserving Schemes for Kinetic Gradient Flows
Rafael Bailo, Imperial College London, United Kingdom

10:00-10:25 A Fully Discrete Positivity-Preserving and Energy-Dissipative Finite Difference Scheme for Poisson-Nernst-Planck Equations
Jingwei Hu, Purdue University, U.S.

Wednesday, December 11

MS2

Recent Advances in Analysis for PDEs and Applications

8:30 a.m.-10:30 a.m.

Room: Flores 2

The purpose of this minisymposium is to enable contact between researchers working on analysis for partial differential equations (PDEs) and their applications with an update on recent progress in this field. It brings together researchers who have made substantial contributions to mathematical analysis of PDEs to overview the current research and trending topics. In particular, the minisymposium will assess the use of methods in analysis of models arising in composite and other heterogeneous media. Issues that will be addressed but not limited to are analysis for singular fields, inverse problems, and computational tools for complex inhomogeneous media.

Organizer: Yuliya Gorb
University of Houston, U.S.

8:30-8:55 On the Principal Frequency of the p-Laplacian
Marian Bocea, National Science Foundation, U.S.

9:00-9:25 The Stieltjes Function Method for Solving a Class of IPDE with Memory Terms
Miao-Jung Y. Ou, University of Delaware, U.S.

9:30-9:55 Homogenization for a Stiff Variational Problem with a Slip Boundary Condition Arising in Mechanics
Silvia Jimenez Bolanos, Colgate University, U.S.; Yvonne Ou, University of Delaware, U.S.

10:00-10:25 Asymptotic Expansions for High-Contrast Scalar and Vectorial PDEs
Yuliya Gorb, University of Houston, U.S.

Wednesday, December 11

MS3

Analysis of Evolution Partial Differential Equations and Applications - Part I of III

8:30 a.m.-10:30 a.m.

Room: Flores 3

For Part 2 see MS17

Evolution partial differential equations have been at the epicenter of mathematical research for a long time. They play a fundamental role in tackling beautiful yet extremely challenging problems with a strong background in physical and other important applications, for which progress is achieved through a variety of techniques from a broad range of different mathematical areas. Topics studied for these equations include, among others, local and global well-posedness, stability, asymptotic behavior, traveling waves and integrability.

Organizer: Satbir Malhi
Franklin & Marshall College, U.S.

Organizer: Dionyssis Mantzavinos
University of Kansas, U.S.

8:30-8:55 On the Existence and Stability of Standing Waves in Three Types of NLS Equations
Wen Feng, Oklahoma State University, U.S.; Milena Stanislavova, University of Kansas, Lawrence, U.S.

9:00-9:25 Uniform Decay Properties of Structural Acoustic PDE Models
George Avalos, University of Nebraska, Lincoln, U.S.

9:30-9:55 Long Time Properties of a Multilayered Structure-Fluid PDE System
Pelin Guven Geredeli, Iowa State University, U.S.; George Avalos, University of Nebraska, Lincoln, U.S.; B. Muha, University of Zagreb, Croatia

10:00-10:25 A Note on the Resolvent Estimates of the Damped Wave Equation via Observability Estimate
Satbir Malhi, Franklin & Marshall College, U.S.

Wednesday, December 11

MS4

Nonlocal PDEs in Fluid Dynamics - Part I of II

8:30 a.m.-10:30 a.m.

Room: Flores 6

For Part 2 see MS18

Nonlocal PDEs arises in many models in fluid dynamics and related areas. The presence of nonlocality brings challenges towards the understanding of the analytical features of the equations. This minisymposium focuses on recent developments of analytical techniques of nonlocal PDEs and applications in fluid dynamics as well as other areas such as kinetic theory, mathematical biology. The main topics include well-posedness theory, qualitative properties of nonlocal operators and the solutions of the equations, singular limits and other relevant issues.

Organizer: Geng Chen
University of Kansas, U.S.

Organizer: Changhui Tan
Rice University, U.S.

8:30-8:55 Barotropic Instability of Shear Flows
Zhiwu Lin, Georgia Institute of Technology, U.S.

9:00-9:25 Regularity and Long-Time Behavior for Hydrodynamic Flocking Models
Trevor Leslie, University of Wisconsin, Madison, U.S.; Roman Shvydkoy, University of Illinois, Chicago, U.S.

9:30-9:55 Anticipation Breeds Alignment
Ruiwen Shu, University of Maryland, College Park, U.S.

10:00-10:25 Eulerian Dynamics in Multi-Dimensions with Radial Symmetry
Changhui Tan, Rice University, U.S.

Wednesday, December 11

MS5

Mathematical Challenges in Computational Plasma Physics - Part I of III

8:30 a.m.-10:30 a.m.

Room: Flores 7

For Part 2 see MS19

The partial differential equations associated to the study of the behavior of plasmas are often non-linear, high dimensional, are defined on domains with complex geometries and range over multiple scales. From the point of view of plasma physics, accurate and robust numerical methods for the solution of these problems are vital for the further development of the field. From the computational point of view, the challenging nature of the problems make the area a rich source of mathematical interest on its own right. Thus, the interaction between computational physicists and mathematicians is likely to yield fruitful collaborations resulting on the development of novel computational techniques and the solution of challenging physical problems. However, the interaction of both communities does not always happen naturally. The goal of the mini symposium is to bring together computational plasma physicists and numerical analysts in an environment that encourages discussion and the exchange of ideas that may lead to successful interdisciplinary collaborations. The topics include, among others, kinetic and fluid simulations, application of integral equation methods, adjoint formulations and sensitivity analysis for reactor design, continuous and discontinuous Galerkin formulations for magnetic equilibrium, and application of fast integral equation methods.

Organizer: Tonatiuh Sanchez-Vizuet
New York University, U.S.

Organizer: Antoine Cerfon
Courant Institute of Mathematical Sciences, New York University, U.S.

8:30-8:55 Implicit Multiderivative Time Integrators for the Hall Magnetohydrodynamics Equations
David C. Seal, United States Naval Academy, U.S.

9:00-9:25 Lax-Wendroff Schemes for Quasi-Exponential Moment-Closure Approximations in Plasma Physics
James A. Rossmanith, Iowa State University, U.S.

9:30-9:55 Exponential Integration for Stiff Problems in Plasma Physics
Mayya Tokman, University of California, Merced, U.S.; Toan Nguen, Brown University, U.S.; Ian Joseph, University of Michigan, Medical School, U.S.; John Loffeld, Lawrence Livermore National Laboratory, U.S.

10:00-10:25 Quantifying the Uncertainty on Magnetic Equilibrium Computations for Tokamaks
Tonatiuh Sanchez-Vizuet, New York University, U.S.; Jiaxing Liang, University of Maryland, U.S.; Howard C. Elman, University of Maryland, College Park, U.S.

continued in next column

Wednesday, December 11

MS6

Stability and Dynamics within Variational Models of Complex Materials - Part I of III

8:30 a.m.-10:30 a.m.

Room: Flores 8

For Part 2 see MS20

Models of materials and fluids grow in complexity as we attempt to couple diverse effects that operate on ranges of length and time scales. Variational formulations provide a self-consistent framework for the coupling of sophisticated processes. By splitting the model construction into two key steps: the derivation of an energy landscape and an accompanying dissipation mechanism, this approach allows for the construction of strongly coupled evolution equations that preserve fundamental properties such as energy decay while allowing for multispecies mass conservation under multiphysics interactions. This minisymposium presents new models of complex materials and new techniques for the rigorous analysis of the stability and dynamics of minimizing and quasi-minimizing structures.

Organizer: Yuan Chen
Michigan State University, U.S.

Organizer: Keith Promislow
Michigan State University, U.S.

8:30-8:55 Temporal Oscillations in Coagulation-Fragmentation Models
Robert Pego, Carnegie Mellon University, U.S.; Juan Velazquez, University of Bonn, Germany

9:00-9:25 Pattern Selection from Directional Quenching
Arnd Scheel, University of Minnesota, Twin Cities, U.S.; Montie Avery, University of Minnesota, U.S.; Ryan Goh, Boston University, U.S.; Antoine Pauthier, University of Minnesota, U.S.; Jasper Weinburd, Harvey Mudd College, U.S.

9:30-9:55 Robustness of Planar Target Patterns
Ang Li and Björn Sandstede, Brown University, U.S.

10:00-10:25 Stability of Growing Stripes in the Complex Ginzburg-Landau Equation
Ryan Goh, Boston University, U.S.; Bjorn de Rijk, Universität Stuttgart, Germany

Wednesday, December 11

MS7

Rigorous and Computational Studies of Data Assimilation - Part I of III

8:30 a.m.-10:30 a.m.

Room: Capra A

For Part 2 see MS21

Data assimilation is a technique for combining observations with model output with the objective of improving the latter. It is used in (weather) forecasting in order to mitigate the effect of (i) lack of knowledge of the initial conditions (ii) lack of knowledge of the model itself (parameters, functional form etc) (iii) noise in the model and/or in the observed data (iv) all of the above. There are a variety of methods for combining data with mathematical models. This includes the statistical approach of Kalman filter methods as well as the addition of nudging to PDEs. The objectives are to obtain a better forecast as well as gauge uncertainty. Data assimilation has wide ranging applications in environmental sciences (oceanography, glaciology, fluid-biology coupling), atmospheric sciences (numerical weather prediction), geosciences (seismology, geomagnetism, geo-dynamics), and human and social sciences (economics and finance, traffic control). Others include cancer treatments, hydrology and atmospheric chemistry. This minisymposium will bring together researchers to share rigorous analysis of these methods as well as numerical studies of their efficacy.

Organizer: Animikh Biswas
University of Maryland, Baltimore County, U.S.

Organizer: Michael S. Jolly
Indiana University, U.S.

8:30-8:55 Data Assimilation and Model Bias Estimation During Extreme Events
Eric J. Kostelich, Juan Durazo, and A. Mahalov, Arizona State University, U.S.

9:00-9:25 Geomagnetic Data Assimilation using an Ensemble Kalman Filter
Andrew Tangborn, University of Maryland, Baltimore County and NASA, U.S.

9:30-9:55 Data Assimilation for PDEs using Adaptive Moving Meshes
Erik Van Vleck, University of Kansas, U.S.

10:00-10:25 Lagrangian Uncertainty Quantification and Information Inequalities for Stochastic Flows
Michal Branicki, University of Edinburgh, United Kingdom

continued in next column

Wednesday, December 11

MS8

Mean-Field Models for Large Interacting Agent Systems - Part I of III

8:30 a.m.-10:30 a.m.

Room: Capra B

For Part 2 see MS22

Large interacting particle systems appear in a variety of applications ranging from physics and engineering to mathematical biology, economics, social sciences and machine learning. Mean-field models have been used successfully to capture the fine dynamics correctly and understand the complex behavior of the overall system as the number of particles tends to infinity. However many questions related to the derivation of the respective mean-field equations in suitable scaling limits as well as the development of computational methods that are able to resolve the behavior of the relevant scales adequately, are still open. In this minisymposium we will focus on recent analytic and computational advances in mean field models and their derivations from particle dynamics, with a particular focus on developments in optimal transportation, probability theory, kinetic theory and numerical analysis.

Organizer: Franca Hoffmann
California Institute of Technology, U.S.

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

8:30-8:55 A Viscek-Type Model for Self-Propelled Diffusions
Michela Ottobre, Heriot-Watt University, United Kingdom

9:00-9:25 Many Particle Limit for a System of PDEs with Newtonian Nonlocal Interactions
José A. Carrillo, Imperial College London, United Kingdom; Marco di Francesco, Universita di L'Aquila, Italy; *Antonio Esposito*, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; Simone Fagioli, Universita di L'Aquila, Italy; Markus Schmidtchen, Imperial College London, United Kingdom

9:30-9:55 A Multiscale Derivative-Free Approach to Bayesian Inverse Problems
Urbain Vaes, Imperial College, United Kingdom

10:00-10:25 Kinetic Model with Thermalization for a Gas with Total Energy Conservation
Gianluca Favre, Christian Schmeiser, Marlies Pirner, and Paul Stocker, University of Vienna, Austria

Wednesday, December 11

MS9

Gradient Flows and Beyond: New Directions in Geometric Flows and Partial Differential Equations - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra C

For Part 2 see MS23

Gradient flows are classical tools in the study of partial differential equations, and over the past twenty years, the study of gradient flows with respect to new metrics — particularly the Wasserstein metric — has significantly expanded the range of PDEs which can be studied using these techniques. Recently, the reach of these techniques has been extended a second time, with new results on generalized gradient flows, graphical flows, and novel metrics. From the perspective of applications, these new results are extending classical techniques to new problems in materials science, machine learning, and kinetic theory. This minisymposium will bring together junior and senior researchers working in these directions and expanding the frontiers of geometric flows in partial differential equations.

Organizer: Li Wang
University of Minnesota, U.S.

Organizer: Katy Craig
University of California, Santa Barbara, U.S.

8:30-8:55 Scaling Limits of Discrete Optimal Transport
Peter Gladbach, University of Leipzig, Germany; Eva Kopfer, Universitaet Bonn, Germany; *Jan Mass* and Lorenzo Portinale, Institute of Science and Technology, Austria

9:00-9:25 Nonlocal-Interaction Equations on Graphs and their Continuum Limits
Antonio Esposito, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; Francesco Patacchini, Carnegie Mellon University, U.S.; André Schlichting, Universitaet Bonn, Germany; *Dejan Slepcev*, Carnegie Mellon University, U.S.

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Wednesday, December 11

MS9

Gradient Flows and Beyond: New Directions in Geometric Flows and Partial Differential Equations - Part I of II

continued

9:30-9:55 Kalman-Wasserstein Gradient Flows
Alfredo Garbuno Inigo and *Franca Hoffmann*, California Institute of Technology, U.S.; Wuchen Li, University of California, Los Angeles, U.S.; Andrew Stuart, California Institute of Technology, U.S.

10:00-10:25 Evolutionary Artificial Intelligence via Optimal Transport
Javier Morales, University of Maryland, U.S.

Wednesday, December 11

MS10

Convex Integration Applied to the Equations of Fluid Mechanics - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra D

For Part 2 see MS24

The theory of hyperbolic conservation laws and compressible fluid flow equations is at an exciting crossroad now. In conservation laws the one space dimensional theory has reached some level of maturity. The one-dimensional theory seems not to carry over to two and three space dimensions, and we are vexed by not really knowing what to do instead. Onsager's conjecture has been cracked for the incompressible Euler equations. Might the way the method of convex integration was used there give us a hint for the compressible case? This minisymposium will gather contributions of the current state of developments for the two and three dimensional compressible and incompressible Euler and Navier-Stokes equations and related equations. We hope that this will spark new ideas, so that we can move on to a better understanding of what seems to be so impenetrable now.

Organizer: Christian F. Klingenberg
Wurzburg University, Germany

Organizer: Simon Markfelder
Universitaet Wuerzburg, Germany

8:30-8:55 Compressible Euler Equations in 2-D: Weak Solutions Obtained by Convex Integration
Christian F. Klingenberg, Wurzburg University, Germany

9:00-9:25 Onsager's Conjecture with Physical Boundaries and an Application to the Vanishing Viscosity Limit
Emil Wiedemann, University of Ulm, Germany

9:30-9:55 On Ill-Posedness of Euler Systems with Non-Local Interactions
Agnieszka Swierczewska, University of Warsaw, Poland

10:00-10:25 Weak-Strong Uniqueness for Solutions of Some Compressible Fluid Models
Eduard Feireisl, Academy of Sciences of the Czech Republic, Prague, Czech Republic

Wednesday, December 11

MS11

Nonlinear Waves in Discrete and Continuous Media - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra E

For Part 2 see MS25

This minisymposium will highlight recent results for partial differential equations modeling nonlinear wave behavior in discrete and continuous media. In particular, connections between problems posed for water waves and infinite discrete lattices will be considered. Special attention will also be paid to the existence, asymptotic, and stability of traveling waves and localized and nonlocal solitary waves in these distinct media.

Organizer: Bente Hilde Bakker
Universiteit Leiden, Netherlands

Organizer: Timothy E. Faver
Leiden University, Netherlands

8:30-8:55 Nonlocal Solitary Waves in Diatomic Fermi-Pasta-Ulam-Tsingou Lattices under the Equal Mass Limit
Timothy E. Faver and Hermen Jan Hupkes, Leiden University, Netherlands

9:00-9:25 Nonlinear Stability and Interactions of High-Energy Solitary Waves in Fermi-Pasta-Ulam-Tsingou Chains
Karsten Matthies, University of Bath, United Kingdom

9:30-9:55 Solitary Water Waves with Discontinuous Vorticity
Adelaide Akers, Emporia State University, U.S.

10:00-10:25 Numerical Bifurcation and Spectral Stability of Wavetrains in Bidirectional Whitham Models
Kyle M. Claassen, Rose-Hulman Institute of Technology, U.S.

Wednesday, December 11

MS12

Mathematical Aspects of Several Topics Arising from Material Science - Part I of III

8:30 a.m.-10:30 a.m.

Room: The Studios

For Part 2 see MS26

Many topics arsing from material science are closely related to modern ideas and tools in Calculus of Variations as well as PDE, which include (but are not limited to) nonlinear elasticity, microstructures, phase transitions, material defects, etc. On one hand, such problems in material science stimulate the rapid development of new ideas/skills in Calculus of Variations and PDE; on the other hand, rigorous mathematical study of such problems give us a better understanding of many real life problems. The aim of this minisymposium is to bring together a group of mathematicians with expertise in this area, so that the latest results will be presented, and new scientific ideas will be communicated. The invited speakers are widespread across the country, among which many are researchers at the beginning level and the underrepresented minorities.

Organizer: Xiang Xu
Old Dominion University, U.S.

Organizer: Guanying Peng
University of Arizona, U.S.

8:30-8:55 Poiseuille Flow of Nematic Liquid Crystals via the Full Ericksen-Leslie Model
Geng Chen, University of Kansas, U.S.; *Tao Huang*, Wayne State University, U.S.; Weishi Liu, University of Kansas, U.S.

9:00-9:25 Two-Dimensional Stokes Immersed Boundary Problem and its Regularizations: Well-Posedness, Singular Limit, and Error Estimates
Fang-Hua Lin, Courant Institute of Mathematical Sciences, New York University, U.S.; *Jiajun Tong*, University of California, Los Angeles, U.S.

9:30-9:55 Bistable Features of Orthogonal Smectic Bent-Core Liquid Crystals
Sookyung Joo, Old Dominion University, U.S.

10:00-10:25 Suitable Weak Solutions for the Co-Rotational Beris-Edwards System in Dimension Three
Changyou Wang and Hengrong Du, Purdue University, U.S.; Xianpeng Hu, City University of Hong Kong, Hong Kong

Wednesday, December 11

MS13

Applicable Analysis and Control Theory for Fluid and Fluid-Structure PDE - Part I of III

8:30 a.m.-10:30 a.m.

Room: Fiesta 8

For Part 2 see MS27

The Minisymposium will feature speakers who have research expertise in the continuous analysis, numerical analysis, and mathematical control of partial differential equation (PDE) models which describe, coupled and uncoupled fluid flows as they occur in the physical world. The fluid flow dynamics under consideration might evolve as a single entity, or as one or more components of a coupled fluid-structure PDE system. In the latter case, the agency of coupling between fluid and structure PDE components involves a boundary interface between the distinct domains within which each disparate 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). For such fluid flow and fluid-structure PDE interactions, some of our Minisymposium Speakers will present their recent results on wellposedness analysis and control theory. In particular, some of our speakers will discourse on regularity and longtime behavior properties of linear and nonlinear fluid and fluid-structure PDE dynamics, with or without the presence of open loop or feedback control. Moreover, there will be speakers in our Minisymposium who will present new results in the numerical analysis and efficacious scientific computation of the solution variables. These numerical results will include the invocation of nonstandard finite element and discontinuous Galerkin methods.

Organizer: George Avalos
University of Nebraska, Lincoln, U.S.

Organizer: Pelin Guven Geredeli
Iowa State University, U.S.

8:30-8:55 Numerical Schemes for Stochastic Navier-Stokes Equations and Related Models
Hakima Bessaih, University of Wyoming, U.S.

continued in next column

9:00-9:25 Rough Solutions to the Compressible Euler Equations
Marcelo Disconzi, Vanderbilt University, U.S.

9:30-9:55 Boundary Controllability of a Membrane or Plate Enclosing a Potential Fluid
Scott Hansen, Iowa State University, U.S.

10:00-10:25 On Weak Solutions of 2D Primitive Equations
Ning Ju, Oklahoma State University, U.S.

Wednesday, December 11

CP1

Asymptotics and Approximations

8:30 a.m.-10:30 a.m.

Room: Santa Rosa

Chair: Vineet Kumar Singh, Indian Institute of Technology (Banaras Hindu University), India

8:30-8:45 Numerical Solution of Fractional Initial Boundary Value Problem
Gunvant A. Birajdar, Tata Institute of Social Sciences Tuljapur, India

8:50-9:05 Geometric Properties of Eigenfunctions on Annuli and Applications
Ashok Kumar K, Indian Institute of Technology, India; Anoop T. V., Indian Institute of Tecnology Madras, India

9:10-9:25 Convergence and Error Analysis of HPM Solution for Nonlinear Partial Differential Equations
Dinkar Sharma, Lyallpur Khalsa College, Jalandhar, India

9:30-9:45 A Composite Algorithm for Computational Modeling of Two-Dimensional Coupled Burgers' Equations
Sukhveer Singh, Thapar University, India

9:50-10:05 Multistep Finite Difference Scheme for Fractional Partial Differential Equation with Dirichlet Boundary Conditions
Vineet Kumar Singh, Indian Institute of Technology (Banaras Hindu University), India

10:10-10:25 Finite Difference Scheme for Electromagnetic Waves Model Arising from Dielectric Media
Rahul Kumar Maurya, Vinita Devi, and Vineet Kumar Singh, Indian Institute of Technology (Banaras Hindu University), India

Wednesday, December 11

CP2

Variational Problems

8:30 a.m.-10:10 a.m.

Room: Flores B/C

Chair: Reshmi Biswas, Indian Institute of Technology, Guwahati, India

8:30-8:45 A Study of the Concentration Compactness Type Principle for Fractional Sobolev Spaces and Applications
Akasmika Panda and Debajyoti Choudhuri, National Institute of Technology, Rourkela, India

8:50-9:05 Existence Result for Fractional Kirchhoff Equations Involving Choquard Exponential Nonlinearity
Sarika Sarika, Bennett University, Greater Noida, India; Tuhina Mukherjee, Tata Institute of Fundamental Research, India

9:10-9:25 Volume Preserving Mean Curvature Flow for Star-Shaped Sets
Dohyun Kwon and Inwon Kim, University of California, Los Angeles, U.S.

9:30-9:45 Recent Developments on Nonlocal Fractional Problems Involving Variable Exponents
Reshmi Biswas and Sweta Tiwari, Indian Institute of Technology, Guwahati, India

9:50-10:05 On a Class of Generalized Monge-Ampere Type Equations
Weifeng Qiu, City University of Hong Kong, Hong Kong; Lan Tang, Central China Normal University, China

Coffee Break

10:30 a.m.-10:50 a.m.

Room: Flores 4

Welcome Remarks

10:50 a.m.-11:00 a.m.

Room: Flores 5

Wednesday, December 11

IP1

Non Exchangeability and Synchronization Mechanisms in Multi-Agent Systems

11:00 a.m.-11:45 a.m.

Room: Flores 5

Chair: Jianfeng Lu, Duke University, U.S.

The aim of this talk is to investigate the behavior of large networks of interacting but non identical agents. Because agents are not indistinguishable, the possible interactions between agents are described through a connectivity graph which may be fixed or evolve in time through some feedback or learning mechanisms between pairs of agents. Correlations between agents are reinforced through the connectivities so that this type of models and its variants are often studied where synchronization between agents is expected or desired and they encompasses a broad set of applications from synchronized oscillators, to neuron networks (biological or artificial). Mean-field limits remain an attractive approach due to the large size of the systems but the usual concept of propagation of chaos cannot be applied which requires a new framework.

Pierre-Emmanuel Jabin
University of Maryland, U.S.

Wednesday, December 11

IP2

Scalable Block Preconditioning of Implicit / IMEX FE Continuum Plasma Physics Models

11:45 a.m.-12:30 p.m.

Room: Flores 5

Chair: Konstantina Trivisa, University of Maryland, College Park, U.S.

Continuum plasma physics models are used to study important phenomena in astrophysics and in technology applications such as magnetic confinement (e.g. tokamak), and pulsed inertial confinement (e.g. NIF, Z-pinch) fusion devices. The computational simulation of these systems, requires solution of the governing PDEs for conservation of mass, momentum, and energy, along with various approximations to Maxwell's equations. The resulting systems are characterized by strong nonlinear coupling of fluid and electromagnetic phenomena, as well as the significant range of time- and length-scales that these interactions produce. To enable accurate, and stable approximation of these systems, a wide-range of spatial discretizations that include mixed integration, stabilized, and structure-preserving approaches are employed. For effective long-time-scale integration some implicitness is required. In this context, fully-implicit, and implicit-explicit methods have shown considerable promise. These characteristics make scalable and efficient iterative solution, of the resulting poorly-conditioned discrete systems, extremely difficult. Our approach to overcome these challenges has been the development of efficient fully-coupled multilevel preconditioned Newton-Krylov methods. This talk considers the structure of these algorithms, demonstrates the flexibility of this approach, and presents results on scaling of the methods on up to 1M cores.

John N. Shadid
Sandia National Laboratories, U.S.

Lunch Break

12:30 p.m.-2:30 p.m.

Attendees on own

Wednesday, December 11

MS14

Partial Differential Equations in Mean Field Games and Mean Field Control - Part I of III

2:30 p.m.-4:30 p.m.

Room: Flores 5

For Part 2 see MS28

Recent advances have shown that Mean Field Games (MFGs) and Mean Field Control (MFC) offer an exciting source of new challenges for the analysis of nonlinear Partial Differential Equations (PDEs). In this spirit, the minisymposium will gather researchers who contributed recently to the field. It is expected to highlight interactions with the theory of the Master Equation of these systems, of Optimal Transport, and the development of new numerical procedures, especially those based on Machine Learning (ML) tools, as they appear as a promising approach to the computation of the solutions of these high dimensional nonlinear PDEs.

Organizer: Rene Carmona
Princeton University, U.S.

Organizer: Maria Gualdani
The University of Texas at Austin, U.S.

2:30-2:55 Mean Field Models of Crowd Interactions and Surveillance-Evasion Games
Alexander Vladimirsky and Elliot Cartee, Cornell University, U.S.

3:00-3:25 Some Extended Mean Field Games with Jumps
Jameson Graber, Baylor University, U.S.

3:30-3:55 Deep Learning Algorithms for Solving High-Dimensional PDEs
Justin Sirignano, University of Illinois at Urbana-Champaign, U.S.

4:00-4:25 A Deep Learning Algorithm for Solving Partial Differential Equations
Konstantinos Spiliopoulos, Boston University, U.S.; Justin Sirignano, University of Illinois at Urbana-Champaign, U.S.

Wednesday, December 11

MS15

Structure Preserving Numerical Methods for Gradient Flow Equations - Part II of II

2:30 p.m.-4:00 p.m.

Room: Flores 1

For Part 1 see MS1

Equations with a gradient flow structure are ubiquitous in many fields, such as material design, biological modeling, kinetic theory, image processing, and optimisation. Solutions to such equations possess many favourable properties: Positivity, energy decay, and convergence to steady state. This poses a challenge in numerical simulation as efficient and robust numerical methods should preserve the same properties at the discrete level. This minisymposium brings researchers from diverse fields working on the gradient flow equations with the common theme of structure preserving numerical methods.

Organizer: Jingwei Hu
Purdue University, U.S.

Organizer: Erlend Skaldehaug Riis
University of Cambridge, United Kingdom

2:30-2:55 Gradient-Based Optimization: Dynamical, Control-Theoretic and Symplectic Perspectives
Michael I. Jordan, University of California, Berkeley, U.S.

3:00-3:25 Primal Dual Methods for Wasserstein Gradient Flows
Katy Craig, University of California, Santa Barbara, U.S.

3:30-3:55 Dissipative Schemes for Gradient Flows on Riemmanian Manifolds
Sølve Eidnes, Norwegian University of Science and Technology, Norway

4:00-4:25 A Geometric Integration Approach to Nonsmooth, Nonconvex Optimization
Erlend Skaldehaug Riis, University of Cambridge, United Kingdom

Wednesday, December 11

MS16

From Variational Models in Nonlinear Elasticity to Evolutionary Problems of Elastodynamics - Part I of III

2:30 p.m.-4:30 p.m.

Room: Flores 2

For Part 2 see MS30

The following question received large attention in the past decade: which elastic theories of thin objects (such as rods, plates, shells) are predicted by the 3d nonlinear theory? As is now well understood, there exist a plethora of viable models, each valid under different regimes of stored energies, geometrical constraints, boundary conditions or internal prestrain mechanisms. These models have been obtained, by large, departing from the variational description of equilibria in nonlinear elasticity. At the same time, much less is known in the similar contexts for time-dependent problems, despite a large body of work available in relation to elastodynamics, von Karman evolutions or fluid structure interaction. The scope of this minisymposium is to bring together scientists with background in diverse fields involving elasticity: from dimension reduction, through quasi-static evolution, to free boundary problems; to investigate connections between these problems and to discuss challenges from different perspectives.

Organizer: Davit Harutyunyan
University of California, Santa Barbara, U.S.

Organizer: Marta Lewicka
University of Pittsburgh, U.S.

2:30-2:55 Nonresonance and Global Existence in Isotropic Elastodynamics
Thomas Sideris, University of California, Santa Barbara, U.S.

3:00-3:25 Control and Sensitivity Analysis in Fluid-Elasticity Interactions
Lorena Bociu, North Carolina State University, U.S.

3:30-3:55 Partitioned Numerical Methods for Fluid-Structure Interaction Problems with Large Deformations
Martina Bukac, Anyastassia Seboldt, and Oyekola Oyekole, University of Notre Dame, U.S.

4:00-4:25 Modeling of Nano-Sized Objects with Surface-Energetic Boundaries
Anna Zemlyanova, Kansas State University, U.S.

Wednesday, December 11

MS17

Analysis of Evolution Partial Differential Equations and Applications - Part II of III

2:30 p.m.-4:30 p.m.

Room: Flores 3

For Part 1 see MS3
For Part 3 see MS31

Evolution partial differential equations have been at the epicenter of mathematical research for a long time. They play a fundamental role in tackling beautiful yet extremely challenging problems with a strong background in physical and other important applications, for which progress is achieved through a variety of techniques from a broad range of different mathematical areas. Topics studied for these equations include, among others, local and global well-posedness, stability, asymptotic behavior, traveling waves and integrability.

Organizer: Satbir Malhi
Franklin & Marshall College, U.S.

Organizer: Dionyssis Mantzavinos
University of Kansas, U.S.

2:30-2:55 Existence and Stability of Solitary Waves for the Inhomogeneous NLS - A Complete Classification
Abba Ramadan and Atanas Stefanov, University of Kansas, U.S.

3:00-3:25 Asymptotics for the Wave Equations on Curved Spaces
Stefanos Aretakis, University of Toronto, Canada

3:30-3:55 A Construction of Semi-Global Impulsive Gravitational Wave Spacetimes
Yannis Angelopoulos, University of California, Los Angeles, U.S.

4:00-4:25 Initial-Boundary Value Problems for Nonlinear Dispersive PDEs in One and Higher Dimensions
Alex Himonas, University of Notre Dame, U.S.; *Dionyssis Mantzavinos*, University of Kansas, U.S.

Wednesday, December 11

MS18

Nonlocal PDEs in Fluid Dynamics - Part II of II

2:30 p.m.-4:00 p.m.

Room: Flores 6

For Part 1 see MS4

Nonlocal PDEs arises in many models in fluid dynamics and related areas. The presence of nonlocality brings challenges towards the understanding of the analytical features of the equations. This minisymposium focuses on recent developments of analytical techniques of nonlocal PDEs and applications in fluid dynamics as well as other areas such as kinetic theory, mathematical biology. The main topics include well-posedness theory, qualitative properties of nonlocal operators and the solutions of the equations, singular limits and other relevant issues.

Organizer: Geng Chen
University of Kansas, U.S.

Organizer: Changhui Tan
Rice University, U.S.

2:30-2:55 Burgers Equation with Some Nonlocal Sources
Tien Khai E. Nguyen, North Carolina State University, U.S.

3:00-3:25 Solutions of Generalized SQG Front Problems
Qingtian Zhang, University of California, Davis, U.S.

3:30-3:55 Suppression of Blow-Up in Patlak-Keller-Segel via Fluid Flows
Siming He, Duke University, U.S.

Wednesday, December 11

MS19

Mathematical Challenges in Computational Plasma Physics - Part II of III

2:30 p.m.-4:30 p.m.

Room: Flores 7

For Part 1 see MS5
For Part 3 see MS33

The partial differential equations associated to the study of the behavior of plasmas are often non-linear, high dimensional, are defined on domains with complex geometries and range over multiple scales. From the point of view of plasma physics, accurate and robust numerical methods for the solution of these problems are vital for the further development of the field. From the computational point of view, the challenging nature of the problems make the area a rich source of mathematical interest on its own right. Thus, the interaction between computational physicists and mathematicians is likely to yield fruitful collaborations resulting on the development of novel computational techniques and the solution of challenging physical problems. However, the interaction of both communities does not always happen naturally. The goal of the mini symposium is to bring together computational plasma physicists and numerical analysts in an environment that encourages discussion and the exchange of ideas that may lead to successful interdisciplinary collaborations. The topics include, among others, kinetic and fluid simulations, application of integral equation methods, adjoint formulations and sensitivity analysis for reactor design, continuous and discontinuous Galerkin formulations for magnetic equilibrium, and application of fast integral equation methods.

Organizer: Tonatiuh Sanchez-Vizuet
New York University, U.S.

Organizer: Antoine Cerfon
Courant Institute of Mathematical Sciences, New York University, U.S.

2:30-2:55 Generalized Plane Waves and Vector Valued Equations
Lise-Marie Imbert-Gerard, University of Maryland, U.S.; Jean-Francois Fritsch, ENSTA ParisTech, France

3:00-3:25 A Modal, Alias-Free Discontinuous Galerkin Algorithm for Plasma Kinetic Equations
James Juno, University of Maryland, U.S.; Ammar Hakim, Princeton Plasma Physics Laboratory, U.S.; Manaure Francisquez, Massachusetts Institute of Technology, U.S.; Jason TenBarge, Princeton University, U.S.; William Dorland, University of Maryland, U.S.

3:30-3:55 Implicit Energy and Charge-Conserving Particle in Cell Methods on Sparse Grids
Lee Ricketson, Lawrence Livermore National Laboratory, U.S.; Guangye Chen, Los Alamos National Laboratory, U.S.

4:00-4:25 Topology Optimization of Permanent Magnets for Stellarators to Confine Plasmas
Caoxiang Zhu, Kenneth Hammond, Michael Zarnstoff, and Steven Cowley, Princeton University, U.S.

Wednesday, December 11

MS20

Stability and Dynamics within Variational Models of Complex Materials - Part II of III

2:30 p.m.-4:30 p.m.

Room: Flores 8

For Part 1 see MS6
For Part 3 see MS34

Models of materials and fluids grow in complexity as we attempt to couple diverse effects that operate on ranges of length and time scales. Variational formulations provide a self-consistent framework for the coupling of sophisticated processes. By splitting the model construction into two key steps: the derivation of an energy landscape and an accompanying dissipation mechanism, this approach allows for the construction of strongly coupled evolution equations that preserve fundamental properties such as energy decay while allowing for multispecies mass conservation under multiphysics interactions. This minisymposium presents new models of complex materials and new techniques for the rigorous analysis of the stability and dynamics of minimizing and quasi-minimizing structures.

Organizer: Yuan Chen
Michigan State University, U.S.

Organizer: Keith Promislow
Michigan State University, U.S.

2:30-2:55 Analysis of Three Dimensional Solitary Waves in Liquid Crystals
Carme Calderer, University of Minnesota, U.S.

3:00-3:25 Disclinations in 3D Landau-De Gennes Theory
Yong Yu, Chinese University of Hong Kong, Hong Kong

3:30-3:55 A New Flow Dynamic Method for Generalized Gradient Flow and Diffusion Problems based on Energetic Variational Approach
Qing Cheng, Illinois Institute of Technology, U.S.

4:00-4:25 Regularized Curve Lengthening within Strongly Functionalized Cahn-Hilliard
Yuan Chen and Keith Promislow, Michigan State University, U.S.

continued in next column

Wednesday, December 11

MS21

Rigorous and Computational Studies of Data Assimilation - Part II of III

2:30 p.m.-4:30 p.m.

Room: Capra A

For Part 1 see MS7
For Part 3 see MS50

Data assimilation is a technique for combining observations with model output with the objective of improving the latter. It is used in (weather) forecasting in order to mitigate the effect of (i) lack of knowledge of the initial conditions (ii) lack of knowledge of the model itself (parameters, functional form etc) (iii) noise in the model and/or in the observed data (iv) all of the above. There are a variety of methods for combining data with mathematical models. This includes the statistical approach of Kalman filter methods as well as the addition of nudging to PDEs. The objectives are to obtain a better forecast as well as gauge uncertainty. Data assimilation has wide ranging applications in environmental sciences (oceanography, glaciology, fluid-biology coupling), atmospheric sciences (numerical weather prediction), geosciences (seismology, geomagnetism, geo-dynamics), and human and social sciences (economics and finance, traffic control). Others include cancer treatments, hydrology and atmospheric chemistry. This minisymposium will bring together researchers to share rigorous analysis of these methods as well as numerical studies of their efficacy.

Organizer: Animikh Biswas
University of Maryland, Baltimore County, U.S.

Organizer: Michael S. Jolly
Indiana University, U.S.

2:30-2:55 An Analysis of Parameter Recovery and Sensitivity in Continuous Data Assimilation of Turbulent Flow, with Applications to Geophysical Models
Elizabeth Carlson, University of Nebraska, U.S.

3:00-3:25 Parameter Recovery using Data Assimilation for the Navier-Stokes Equations with Velocity Measurements
Joshua Hudson, Johns Hopkins University, U.S.; Adam Larios, University of Nebraska-Lincoln, U.S.; Elizabeth Carlson, University of Nebraska, U.S.

3:30-3:55 Statistical Data Assimilation in the Presence of Model and Observational Error
Animikh Biswas, University of Maryland, Baltimore County, U.S.

4:00-4:25 A Comparison of How Measurement Error Affects Two Discrete-in-Time Data Assimilation Algorithms
Eric Olson, University of Nevada, Reno, U.S.; Emine Celik, Sakarya University, Turkey

continued in next column

Wednesday, December 11

MS22

Mean-Field Models for Large Interacting Agent Systems - Part II of III

2:30 p.m.-4:30 p.m.

Room: Capra B

For Part 1 see MS8
For Part 3 see MS36

Large interacting particle systems appear in a variety of applications ranging from physics and engineering to mathematical biology, economics, social sciences and machine learning. Mean-field models have been used successfully to capture the fine dynamics correctly and understand the complex behavior of the overall system as the number of particles tends to infinity. However many questions related to the derivation of the respective mean-field equations in suitable scaling limits as well as the development of computational methods that are able to resolve the behavior of the relevant scales adequately, are still open. In this minisymposium we will focus on recent analytic and computational advances in mean field models and their derivations from particle dynamics, with a particular focus on developments in optimal transportation, probability theory, kinetic theory and numerical analysis.

Organizer: Franca Hoffmann
California Institute of Technology, U.S.

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

2:30-2:55 Optimal Control for Interacting Agent Systems - From Crowds to Pedestrians
Claudia Totzeck, Technische Universität Kaiserslautern, Germany

3:00-3:25 Asymptotic Limits of Kinetic Equations with Methylation Level
Weiran Sun, Simon Fraser University, Canada

3:30-3:55 Large-Scale Dynamics of Nematic Interactions
Sara Merino-Aceituno, University of Vienna, Austria

4:00-4:25 Continuous Time Opinion Formation on a Graph
Heather Zinn Brooks, University of California, Los Angeles, U.S.

Wednesday, December 11

MS23

Gradient Flows and Beyond: New Directions in Geometric Flows and Partial Differential Equations - Part II of II

2:30 p.m.-4:30 p.m.

Room: Capra C

For Part 1 see MS9

Gradient flows are classical tools in the study of partial differential equations, and over the past twenty years, the study of gradient flows with respect to new metrics — particularly the Wasserstein metric — has significantly expanded the range of PDEs which can be studied using these techniques. Recently, the reach of these techniques has been extended a second time, with new results on generalized gradient flows, graphical flows, and novel metrics. From the perspective of applications, these new results are extending classical techniques to new problems in materials science, machine learning, and kinetic theory. This minisymposium will bring together junior and senior researchers working in these directions and expanding the frontiers of geometric flows in partial differential equations.

Organizer: Li Wang
University of Minnesota, U.S.

Organizer: Katy Craig
University of California, Santa Barbara, U.S.

2:30-2:55 A Proximal-Gradient Algorithm for a 4th Order PDE with Exponential Mobility from Crystal Surface Evolution
Jeremy L. Marzuola, University of North Carolina, Chapel Hill, U.S.

3:00-3:25 Gradient Flows in Wasserstein Spaces and the Mean Shift Algorithm
Katy Craig, University of California, Santa Barbara, U.S.; *Nicolas Garcia Trillos*, University of Wisconsin, Madison, U.S.; Dejan Slepcev, Carnegie Mellon University, U.S.

3:30-3:55 Hopf–Cole Transformation via Generalized Schrödinger Bridge Problem
Flavien Leger, University of California, Los Angeles, U.S.

4:00-4:25 Unnormalized Optimal Transport
Wuchen Li, University of California, Los Angeles, U.S.

Wednesday, December 11

MS24

Convex Integration Applied to the Equations of Fluid Mechanics - Part II of II

2:30 p.m.-4:30 p.m.

Room: Capra D

For Part 1 see MS10

The theory of hyperbolic conservation laws and compressible fluid flow equations is at an exciting crossroad now. In conservation laws the one space dimensional theory has reached some level of maturity. The one-dimensional theory seems not to carry over to two and three space dimensions, and we are vexed by not really knowing what to do instead. Onsager's conjecture has been cracked for the incompressible Euler equations. Might the way the method of convex integration was used there give us a hint for the compressible case? This minisymposium will gather contributions of the current state of developments for the two and three dimensional compressible and incompressible Euler and Navier-Stokes equations and related equations. We hope that this will spark new ideas, so that we can move on to a better understanding of what seems to be so impenetrable now.

Organizer: Christian F. Klingenberg
Wurzburg University, Germany

Organizer: Simon Markfelder
Universitaet Wuerzburg, Germany

2:30-2:55 On the Density of 'Wild' Initial Data for the Compressible Euler System
Simon Markfelder, Universitaet Wuerzburg, Germany

3:00-3:25 Non-Uniqueness of Admissible Weak Solution to the Riemann Problem for the Full Euler System in 2D
Ondrej Kreml, Mathematical Institute ASCR, Prague, Czech Republic

3:30-3:55 Discontinuous and Stationary Weak Solutions of the 3D Navier-Stokes Equations
Xiaoyutao Luo, University of Illinois, Chicago, U.S.

4:00-4:25 Dissipative Measure Valued Solutions for General Conservation Laws
Piotre Gwiazd, University of Warsaw, Poland

Wednesday, December 11

MS25

Nonlinear Waves in Discrete and Continuous Media - Part II of II

2:30 p.m.-4:30 p.m.

Room: Capra E

For Part 1 see MS11

This minisymposium will highlight recent results for partial differential equations modeling nonlinear wave behavior in discrete and continuous media. In particular, connections between problems posed for water waves and infinite discrete lattices will be considered. Special attention will also be paid to the existence, asymptotics, and stability of traveling waves and localized and nonlocal solitary waves in these distinct media.

Organizer: Bente Hilde Bakker
Universiteit Leiden, Netherlands

Organizer: Timothy E. Faver
Leiden University, Netherlands

2:30-2:55 Conley-Floer Theory for Waves in Lattices
Bente Hilde Bakker, Universiteit Leiden, Netherlands

3:00-3:25 Traveling Waves in Discrete and Continuous Neural Field Equations
Gregory Faye, CNRS, Institut de Mathématiques de Toulouse, France

3:30-3:55 Moving Defects in Nonlocal Oscillatory Media
Gabriela Jaramillo, University of Houston, U.S.

4:00-4:25 Dynamics on 2D Lattices
Hermen Jan Hupkes, University of Leiden, Netherlands

Wednesday, December 11

MS26

Mathematical Aspects of Several Topics Arising from Material Science - Part II of III

2:30 p.m.-4:30 p.m.

Room: The Studios

For Part 1 see MS12
For Part 3 see MS40

Many topics arsing from material science are closely related to modern ideas and tools in Calculus of Variations as well as PDE, which include (but are not limited to) nonlinear elasticity, microstructures, phase transitions, material defects, etc. On one hand, such problems in material science stimulate the rapid development of new ideas/skills in Calculus of Variations and PDE; on the other hand, rigorous mathematical study of such problems give us a better understanding of many real life problems. The aim of this minisymposium is to bring together a group of mathematicians with expertise in this area, so that the latest results will be presented, and new scientific ideas will be communicated. The invited speakers are widespread across the country, among which many are researchers at the beginning level and the underrepresented minorities.

Organizer: Xiang Xu
Old Dominion University, U.S.

Organizer: Guanying Peng
University of Arizona, U.S.

2:30-2:55 Bent-Core Ferroelectric SmA Phase in Thin Samples
Tiziana Giorgi, New Mexico State University, U.S.; Sookyung Joo, Old Dominion University, U.S.; Carlos Garcia-Cervera, University of California, Santa Barbara, U.S.

3:00-3:25 Null Lagrangian Measures
Andrew Lorent, University of Cincinnati, U.S.

3:30-3:55 Quasicrystals: A Paradigm for Almost Periodic Homogenization
Raghavendra Venkatraman and Irene Fonseca, Carnegie Mellon University, U.S.; Rita Ferreira, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

4:00-4:25 Elliptic Equations Arising from Composite Materials
Hongjie Dong, Brown University, U.S.

Wednesday, December 11

MS27

Applicable Analysis and Control Theory for Fluid and Fluid-Structure PDE - Part II of III

2:30 p.m.-4:30 p.m.

Room: Fiesta 8

For Part 1 see MS13
For Part 3 see MS41

The Minisymposium will feature speakers who have research expertise in the continuous analysis, numerical analysis, and mathematical control of partial differential equation (PDE) models which describe, coupled and uncoupled fluid flows as they occur in the physical world. The fluid flow dynamics under consideration might evolve as a single entity, or as one or more components of a coupled fluid-structure PDE system. In the latter case, the agency of coupling between fluid and structure PDE components involves a boundary interface between the distinct domains within which each disparate 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). For such fluid flow and fluid-structure PDE interactions, some of our Minisymposium Speakers will present their recent results on wellposedness analysis and control theory. In particular, some of our speakers will discourse on regularity and longtime behavior properties of linear and nonlinear fluid and fluid-structure PDE dynamics, with or without the presence of open loop or feedback control. Moreover, there will be speakers in our Minisymposium who will present new results in the numerical analysis and efficacious scientific computation of the solution variables. These numerical results will include the invocation of nonstandard finite element and discontinuous Galerkin methods.

Organizer: George Avalos
University of Nebraska, Lincoln, U.S.

Organizer: Pelin Guven Geredeli
Iowa State University, U.S.

2:30-2:55 Continuous Data Assimilation with Moving Observers
Adam Larios, University of Nebraska-Lincoln, U.S.; Elizabeth Carlson, University of Nebraska, U.S.; Joshua Hudson, Johns Hopkins University, U.S.

continued in next column

3:00-3:25 Boundary Stabilization of the Moore-Gibson-Thompson Equation Arising in Nonlinear Acoustics with a Second Sound
Marcelo Bongarti and *Irena M. Lasiecka*, University of Memphis, U.S.

3:30-3:55 Finite Determining Parameters Feedback Control for Distributed Nonlinear Dissipative Systems - a Computational Study
Evelyn Lunasin, United States Naval Academy, U.S.; Edriss S. Titi, Texas A&M University, U.S. and Weizmann Institute of Science, Israel

4:00-4:25 Reduced Convergence Rates on Pre-Asymptotic Meshes in Mixed Methods for the Time-Dependent (Navier) Stokes Equations
Leo Rebholz, Clemson University, U.S.

Wednesday, December 11

CP3

Elliptic and Parabolic PDE

2:30 p.m.-3:50 p.m.

Room: Santa Rosa

Chair: Danijela Rajter-Ciric, University of Novi Sad, Serbia

2:30-2:45 Coron Problem for Nonlocal Equations Involving Choquard Nonlinearity
Divya Goel, Indian Institute of Technology, Delhi, India; Vicenctiu Radulescu, Institute of Mathematics and Statistics, Bucharest, Romania; Konijeti Sreenadh, Indian Institute of Technology, Delhi, India

2:50-3:05 Concentration Phenomena in the Critical Exponent Problems on Hyperbolic Space
Tuhina Mukherjee, Tata Institute of Fundamental Research, India

3:10-3:25 Homogenization of a Phase Transition Problem with Prescribed Normal Velocity
Michael Eden, University of Bremen, Germany

3:30-3:45 Stochastic Heat Equation with Variable Thermal Conductivity
Danijela Rajter-Ciric and Milos Japundzic, University of Novi Sad, Serbia

Wednesday, December 11

CP4

Wave Propagation

2:30 p.m.-4:10 p.m.

Room: Flores B/C

Chair: Sanja Konjik, University of Novi Sad, Serbia

2:30-2:45 Wave Propagation in Viscoelastic Media and Energy Dissipation
Ljubica Oparnica, University of Gent, Belgium; Dusan Zorica, Mathematical Institute of the Serbian Academy of Sciences and Arts, Serbia

2:50-3:05 Analysis of Hydrodynamic Mixture Models
Kun Zhao, Tulane University, U.S.; Dong Li, Hong Kong University of Science and Technology, Hong Kong

3:10-3:25 Using Multiple Scales for Obtaining Asymptotic Solutions of the Quadratic and Cubic Nonlinear Klein-Gordon Equations
Matthew E. Edwards and Samuel Uba, Alabama A&M University, U.S.

3:30-3:45 Mathematical Modeling and Analysis of Viscoelastic Waves within Fractional Framework
Sanja Konjik, University of Novi Sad, Serbia

3:50-4:05 Space-Time Discontinuous Galerkin Method for the One-Dimensional Wave Equation
Helmi Temimi, Gulf University for Science and Technology, Kuwait

Wednesday, December 11

Intermission

4:30 p.m.-5:00 p.m.

SIAG/APDE Business Meeting

5:00 p.m.-5:45 p.m.

Room: Flores 5

Complimentary beer and wine will be served.

SIMA Editorial Board Dinner

6:30 p.m.-8:30 p.m.

Room: Grgich Room

Thursday, December 12

Registration

8:00 a.m.-3:30 p.m.

Room: Flores Foyer

Thursday, December 12

MS28

Partial Differential Equations in Mean Field Games and Mean Field Control - Part II of III

8:30 a.m.-10:30 a.m.

Room: Flores 5

For Part 1 see MS14
For Part 3 see MS42

Recent advances have shown that Mean Field Games (MFGs) and Mean Field Control (MFC) offer an exciting source of new challenges for the analysis of nonlinear Partial Differential Equations (PDEs). In this spirit, the minisymposium will gather researchers who contributed recently to the field. It is expected to highlight interactions with the theory of the Master Equation of these systems, of Optimal Transport, and the development of new numerical procedures, especially those based on Machine Learning (ML) tools, as they appear as a promising approach to the computation of the solutions of these high dimensional nonlinear PDEs.

Organizer: Rene Carmona
Princeton University, U.S.

Organizer: Maria Gualdani
The University of Texas at Austin, U.S.

8:30-8:55 Machine Learning for the Optimal Control of McKean-Vlasov Dynamics and Mean Field Games in Fnite Time Horizon
Mathieu Lauriere and Rene Carmona, Princeton University, U.S.

9:00-9:25 PDE Regularization in Machine Learning
Adam M. Oberman, McGill University, Canada

9:30-9:55 The Dyson and Coulomb Games
Mark Cerenzia, University of Chicago, U.S.

10:00-10:25 Title Not Available
Eric Vanden Eijnden, Courant Institute of Mathematical Sciences, New York University, U.S.

Thursday, December 12

MS29

Recent Progress in Fluid Mechanics: Classical Flows, Geophysical Models and Complex Fluids - Part I of III

8:30 a.m.-10:30 a.m.

Room: Flores 1

For Part 2 see MS43

In the last decades the active research in fluid mechanics has led to new important analytical results in different directions. Most of these developments have been motivated by the necessity of solving complex systems of partial differential equations arising from fundamental applications in real life. Among many fascinating areas, we aim to focus on three main topics: primitive equations and shallow water systems for the description of the dynamics of the atmosphere and the oceans, diffuse interface models for motion and interaction in binary mixtures, and models for the evolution of microstructures in complex fluids, such as polymers and liquid crystals. The purpose of this session is to bring together researchers who will exchange ideas and present novel methods, which may foster collaborations and lead to new insights.

Organizer: Andrea Giorgini
Indiana University, U.S.

Organizer: Roger M. Temam
Indiana University, U.S.

8:30-8:55 On the Free-Boundary Euler Equations
Igor Kukavica, University of Southern California, U.S.

9:00-9:25 Stratified Regularity in Fluid Equations and Related PDEs
James P. Kelliher, University of California, Riverside, U.S.; Hantaek Bae, Ulsan National Institute of Science and Technology, South Korea

9:30-9:55 Ill-Posedness of Magneto-Hydrodynamics Models
Mimi Dai, University of Illinois, Chicago, U.S.

10:00-10:25 Title Not Available
Walter Rusin, Oklahoma State University, U.S.

Thursday, December 12

MS30

From Variational Models in Nonlinear Elasticity to Evolutionary Problems of Elastodynamics - Part II of III

8:30 a.m.-10:30 a.m.

Room: Flores 2

For Part 1 see MS16
For Part 3 see MS44

The following question received large attention in the past decade: which elastic theories of thin objects (such as rods, plates, shells) are predicted by the 3d nonlinear theory? As is now well understood, there exist a plethora of viable models, each valid under different regimes of stored energies, geometrical constraints, boundary conditions or internal prestrain mechanisms. These models have been obtained, by large, departing from the variational description of equilibria in nonlinear elasticity. At the same time, much less is known in the similar contexts for time-dependent problems, despite a large body of work available in relation to elastodynamics, von Karman evolutions or fluid structure interaction. The scope of this minisymposium is to bring together scientists with background in diverse fields involving elasticity: from dimension reduction, through quasi-static evolution, to free boundary problems; to investigate connections between these problems and to discuss challenges from different perspectives.

Organizer: Davit Harutyunyan
University of California, Santa Barbara, U.S.

Organizer: Marta Lewicka
University of Pittsburgh, U.S.

8:30-8:55 An Algebraic Approach to Elastic Binodal
Yury Grabovsky, Temple University, U.S.

9:00-9:25 Relative Bending Energy for Weakly Prestrained Shells
Silvia Jimenez Bolanos, Colgate University, U.S.; Anna Zemlyanova, Kansas State University, U.S.

9:30-9:55 Defect Measures and Elastic Patterns
Ian Tobasco, University of Illinois at Chicago, U.S.

10:00-10:25 Homogenization of Thin Shells in Non-Linear Elasticity
Igor Velcic, University of Zagreb, Croatia

Thursday, December 12

MS31

Analysis of Evolution Partial Differential Equations and Applications - Part III of III

8:30 a.m.-10:30 a.m.

Room: Flores 3

For Part 2 see MS17

Evolution partial differential equations have been at the epicenter of mathematical research for a long time. They play a fundamental role in tackling beautiful yet extremely challenging problems with a strong background in physical and other important applications, for which progress is achieved through a variety of techniques from a broad range of different mathematical areas. Topics studied for these equations include, among others, local and global well-posedness, stability, asymptotic behavior, traveling waves and integrability.

Organizer: Satbir Malhi
Franklin & Marshall College, U.S.

Organizer: Dionyssis Mantzavinos
University of Kansas, U.S.

8:30-8:55 Bifurcation Analysis of Nonlinear PDEs using Deflated Continuation
Efstathios G. Charalampidis, California Polytechnic State University, San Luis Obispo, U.S.

9:00-9:25 Rogue Waves in the Focusing NLS Equation
Robert E. White, McMaster University, Canada

9:30-9:55 Sharp Relaxation Rates for Plane Waves of Reaction-Diffusion System
Fazel Hadadifard, Drexel University, U.S.

10:00-10:25 On the Energy Decay Rate of the Fractional Wave Equation with Relatively Dense Damping
Walton Green, Clemson University, U.S.

Thursday, December 12

MS32

Asymptotic Preserving Schemes for Multiscale Hyperbolic and Kinetic Equations - Part I of II

8:30 a.m.-10:30 a.m.

Room: Flores 6

For Part 2 see MS46

Hyperbolic and kinetic equations often have multiple time and spatial scales that lead asymptotically from one (microscopic) scale to another (macroscopic)scales. Notable examples include the fluid dynamic limit of the Boltzmann and Landau equations, diffusion limit of transport and radiative transfer equations, quasi-neutral limit of the Vlasov-Poisson and Vlasov-Maxwell system, low Mach limit of the compressible fluid equations, etc. Such scale variations bring computational challenges that need special care when a numerical scheme is designed. An active area of research in such multiscale problems is the design of asymptotic-preserving (AP) schemes that mimic the asymptotic transition from one scale to another at the discrete level. In this minisymposium, we will present state-of-the-art AP schemes for multiscale hyperbolic and kinetic equations, and will bring researchers that blend theory, computation and applications for problems arising from rarefied gas, plasma, fluids, to biology.

Organizer: Alexander Kurganov
Southern University of Science and Technology, China

Organizer: Shi Jin
Shanghai Jiaotong University, China

8:30-8:55 Random Batch Methods for Interacting Particle Systems
Shi Jin, Shanghai Jiaotong University, China

9:00-9:25 Asymptotic Preserving Schemes Versus Fully-Well-Balanced Schemes: Some Recent Developments
Christophe Berthon, Université de Nantes, France

9:30-9:55 Boundary Corrections for the First Collision Source
Cory Hauck, Oak Ridge National Laboratory, U.S.

continued on next page

Thursday, December 12

MS32

Asymptotic Preserving Schemes for Multiscale Hyperbolic and Kinetic Equations - Part I of II

continued

10:00-10:25 Numerical Schemes for Highly Oscillatory Transport Equations with Varying Frequency

Mohammed Lemou, Université de Rennes 1, France

Thursday, December 12

MS33

Mathematical Challenges in Computational Plasma Physics - Part III of III

8:30 a.m.-10:30 a.m.

Room: Flores 7

For Part 2 see MS19

The partial differential equations associated to the study of the behavior of plasmas are often non-linear, high dimensional, are defined on domains with complex geometries and range over multiple scales. From the point of view of plasma physics, accurate and robust numerical methods for the solution of these problems are vital for the further development of the field. From the computational point of view, the challenging nature of the problems make the area a rich source of mathematical interest on its own right. Thus, the interaction between computational physicists and mathematicians is likely to yield fruitful collaborations resulting on the development of novel computational techniques and the solution of challenging physical problems. However, the interaction of both communities does not always happen naturally. The goal of the mini symposium is to bring together computational plasma physicists and numerical analysts in an environment that encourages discussion and the exchange of ideas that may lead to successful interdisciplinary collaborations. The topics include, among others, kinetic and fluid simulations, application of integral equation methods, adjoint formulations and sensitivity analysis for reactor design, continuous and discontinuous Galerkin formulations for magnetic equilibrium, and application of fast integral equation methods.

Organizer: Tonatiuh Sanchez-Vizuet
New York University, U.S.

Organizer: Antoine Cerfon
Courant Institute of Mathematical Sciences, New York University, U.S.

8:30-8:55 Adjoint-Based Vacuum-Field Stellarator Optimization

Andrew Giuliani, Courant Institute of Mathematical Sciences, New York University, U.S.

9:00-9:25 Adjoint Methods for Efficient Shape Optimization and Sensitivity Analysis of Magnetic Confinement Configurations

Elizabeth Paul, Matt Landreman, Thomas Antonsen, and Ian Abel, University of Maryland, U.S.; Wilfred Cooper, Swiss Alps Fusion Energy, Switzerland; William Dorland, University of Maryland, U.S.

9:30-9:55 Integral Equation Methods for Computing Stepped Pressure Equilibria in Stellarators

Dhairya Malhotra and Antoine Cerfon, Courant Institute of Mathematical Sciences, New York University, U.S.; Lise-Marie Imbert-Gerard, University of Maryland, U.S.; Michael O'Neil, New York University, U.S.

10:00-10:25 Surrogate Methods for Optimizing Fusion Device Designs

David S. Bindel, Cornell University, U.S.

continued in next column

Thursday, December 12

MS34

Stability and Dynamics within Variational Models of Complex Materials - Part III of III

8:30 a.m.-10:00 a.m.

Room: Flores 8

For Part 2 see MS20

Models of materials and fluids grow in complexity as we attempt to couple diverse effects that operate on ranges of length and time scales. Variational formulations provide a self-consistent framework for the coupling of sophisticated processes. By splitting the model construction into two key steps: the derivation of an energy landscape and an accompanying dissipation mechanism, this approach allows for the construction of strongly coupled evolution equations that preserve fundamental properties such as energy decay while allowing for multispecies mass conservation under multiphysics interactions. This minisymposium presents new models of complex materials and new techniques for the rigorous analysis of the stability and dynamics of minimizing and quasi-minimizing structures.

Organizer: Yuan Chen
Michigan State University, U.S.

Organizer: Keith Promislow
Michigan State University, U.S.

8:30-8:55 Mean Field Models for Thin Film Droplet Coarsening
Shibin Dai, University of Alabama, U.S

9:00-9:25 End-Cap Structures in the Functionalized Cahn-Hilliard Model
Qiliang Wu, Ohio University, U.S.

9:30-9:55 Modeling and Analysis of Patterns in Multi-Constituent Systems
Chong Wang, McMaster University, Canada; Xiaofeng Ren and Yanxiang Zhao, George Washington University, U.S.

Thursday, December 12

MS35

Regularity, Singularity and Turbulence in Fluids - Part I of III

8:30 a.m.-10:30 a.m.

Room: Capra A

For Part 2 see MS49

Turbulent flows are ubiquitous in the world around us; from trailing airplane wakes to swirling cream in our morning coffee. Despite its prevalence, basic mathematical questions about this complex non-linear phenomenon persist. This is, in part, because fluid phenomena involve many spatiotemporal scales which interact dynamically and often lead to singular or nearly singular behavior. The formation and persistence of singularities are often thought of as mathematical avatars of many well-known phenomena in turbulence such as anomalous dissipation and persistent energy scale-transfer, enhanced and chaotic mixing of Lagrangian trajectories and the unpredictability of the Cauchy problem at high Reynolds numbers. Understanding these fundamental issues, discussing recent progress and outlining future directions is the core aim of this minisymposium.

Organizer: Theodore D. Drivas
Princeton University, U.S.

Organizer: Vincent Martinez
Hunter College, U.S.

Organizer: Huy Nguyen
Brown University, U.S.

8:30-8:55 The Batchelor Spectrum in Passive Scalar Turbulence for Stochastic Fluid Models
Samuel Punshon-Smith, Brown University, U.S.

9:00-9:25 Shvydkoy Confirmed/tbd
Roman Shvydkoy, University of Illinois, Chicago, U.S.

9:30-9:55 Sufficient Conditions for Turbulence Scaling Laws in 2D and 3D
Michele Coti-Zelati, Imperial College London, United Kingdom

10:00-10:25 On the Inviscid Limit
Peter Constantin, Princeton University, U.S.

Thursday, December 12

MS36

Mean-Field Models for Large Interacting Agent Systems - Part III of III

8:30 a.m.-9:30 a.m.

Room: Capra B

For Part 2 see MS22

Large interacting particle systems appear in a variety of applications ranging from physics and engineering to mathematical biology, economics, social sciences and machine learning. Mean-field models have been used successfully to capture the fine dynamics correctly and understand the complex behavior of the overall system as the number of particles tends to infinity. However many questions related to the derivation of the respective mean-field equations in suitable scaling limits as well as the development of computational methods that are able to resolve the behavior of the relevant scales adequately, are still open. In this minisymposium we will focus on recent analytic and computational advances in mean field models and their derivations from particle dynamics, with a particular focus on developments in optimal transportation, probability theory, kinetic theory and numerical analysis.

Organizer: Franca Hoffmann
California Institute of Technology, U.S.

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

8:30-8:55 The Ideal Free Distribution, the Allee Effect and Competition: A Story on Good Versus Bad Relocation Strategies
Nancy Rodriguez, University of Colorado Boulder, U.S.; Chris Cosner, University of Miami, U.S.; Henri Berestycki, CNRS, France

9:00-9:25 The Mean Field Planning Problem as Regularized Mass Transport
Alpar Meszaros, University of California, Los Angeles, U.S.

Thursday, December 12

MS37

Transport Equations - Mathematical Biology and Other Applications - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra C

For Part 2 see MS51

Transport equations form a large and significant part of partial differential equations, and often are basic tools in biological sciences, such as microbiology, biochemistry, genomics and proteomics, epidemiology and others. Being a natural language for modeling complex dynamics, they are following and paralleling this research in a systematic way as biologists turn to mathematicians to model and analyse, and mathematicians turn to biologists in search of new, exciting applications of their methodology. Many traditional biology contexts lead to systems of ODEs or systems of delay-differential equations. More detailed modeling efforts may lead to equations which include diffusion or transport terms. The former are commonly included, usually with constant diffusivities, where random ("diffusive') dispersion of a population in space is assumed; the latter can arise from a variety of modeling assumptions, and not necessarily from spatial transport processes alone. In this minisymposium we wish to focus not only on various applications of transport equations, but also on their mathematical analysis and computational issues.

Organizer: Piotr Gwiazda
Warsaw University, Poland

Organizer: Karolina Kropielnicka
University of Gdansk, Poland

8:30-8:55 Structured Population Equations, from Qualitative Modelling to Experimentally Validated Models
Tomasz Debiec, University of Warsaw, Poland; *Marie Doumic*, Inria Rocquencourt, France; Piotr Gwiazda, Warsaw University, Poland; Emil Wiedemann, Leibniz University Hannover, Germany

9:00-9:25 Title Not Available
Sander Hille, Universiteit Leiden, Netherlands

continued in next column

9:30-9:55 Optimal Control of Conservation Law Models in Biology
Rinaldo M. Colombo, University of Brescia, Italy

10:00-10:25 Nonlinear Aggregation-Diffusion Equations: Stationary States, Functional Inequalities and Stabilization
José A. Carrillo, Imperial College London, United Kingdom

Thursday, December 12

MS39

Recent Developments on Steklov Eigenproblems - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra E

For Part 2 see MS53

Steklov eigenproblems are eigenvalue problems where the eigenvalue appears in the boundary condition. The Steklov spectrum coincides with that of the Dirichlet-to-Neumann map and has many important applications, such as sloshing fluids and imaging (medical, geophysical, etc..). Recently there has been progress on several topics, including (i) computational methods, (ii) shape optimization (iii) spectral asymptotics, and (iv) generalized problems for, e.g., Maxwell operator. This minisymposium aims to bring together mathematicians working on such problems to share new results and exchange ideas.

Organizer: Braxton Osting
University of Utah, U.S.

Organizer: Chiu-Yen Kao
Claremont McKenna College, U.S.

8:30-8:55 The Polya Conjecture for the Steklov Operator
Nilima Nigam, Simon Fraser University, Canada

9:00-9:25 Critical Regime Homogenisation for the Steklov Problem
Jean Lagacé, University College London, United Kingdom

9:30-9:55 Shape-Perturbation of Steklov Eigenvalues in Nearly-Circular and Nearly-Spherical Domains
Robert Viator, Southern Methodist University, U.S.; Braxton Osting, University of Utah, U.S.

10:00-10:25 Steklov Representations of Solutions of the Biharmonic Equation
Giles Auchmuty, University of Houston, U.S.

Thursday, December 12

MS40

Mathematical Aspects of Several Topics Arising from Material Science - Part III of III

8:30 a.m.-10:30 a.m.

Room: The Studios

For Part 2 see MS26

Many topics arsing from material science are closely related to modern ideas and tools in Calculus of Variations as well as PDE, which include (but are not limited to) nonlinear elasticity, microstructures, phase transitions, material defects, etc. On one hand, such problems in material science stimulate the rapid development of new ideas/skills in Calculus of Variations and PDE; on the other hand, rigorous mathematical study of such problems give us a better understanding of many real life problems. The aim of this minisymposium is to bring together a group of mathematicians with expertise in this area, so that the latest results will be presented, and new scientific ideas will be communicated. The invited speakers are widespread across the country, among which many are researchers at the beginning level and the underrepresented minorities.

Organizer: Xiang Xu
Old Dominion University, U.S.

Organizer: Guanying Peng
University of Arizona, U.S.

8:30-8:55 Patterns in Martensites: A Calculus of Variations Prospective
Oleksandr Misiats, Virginia Commonwealth University, U.S.

9:00-9:25 Energy Stable Semi-Implicit Schemes for Allen-Cahn-Ohta-Kawasaki Model in Binary System
Yanxiang Zhao, George Washington University, U.S.

9:30-9:55 The Fractional Porous Medium Equation on Manifolds with Conic Singularities
Yuanzhen Shao, University of Alabama, U.S

10:00-10:25 Uniqueness and Non-Uniqueness of Steady States of Aggregation-Diffusion Equations
Xukai Yan, Georgia Institute of Technology, U.S.

Thursday, December 12

MS41

Applicable Analysis and Control Theory for Fluid and Fluid-Structure PDE - Part III of III

8:30 a.m.-10:30 a.m.

Room: Fiesta 8

For Part 2 see MS27

The Minisymposium will feature speakers who have research expertise in the continuous analysis, numerical analysis, and mathematical control of partial differential equation (PDE) models which describe, coupled and uncoupled fluid flows as they occur in the physical world. The fluid flow dynamics under consideration might evolve as a single entity, or as one or more components of a coupled fluid-structure PDE system. In the latter case, the agency of coupling between fluid and structure PDE components involves a boundary interface between the distinct domains within which each disparate 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). For such fluid flow and fluid-structure PDE interactions, some of our Minisymposium Speakers will present their recent results on wellposedness analysis and control theory. In particular, some of our speakers will discourse on regularity and longtime behavior properties of linear and nonlinear fluid and fluid-structure PDE dynamics, with or without the presence of open loop or feedback control. Moreover, there will be speakers in our Minisymposium who will present new results in the numerical analysis and efficacious scientific computation of the solution variables. These numerical results will include the invocation of nonstandard finite element and discontinuous Galerkin methods.

Organizer: George Avalos
University of Nebraska, Lincoln, U.S.

Organizer: Pelin Guven Geredeli
Iowa State University, U.S.

8:30-8:55 Immersed Boundary and Immersed Domain Methods for Fluid-Structure Interaction
Jin Wang, University of Tennessee, Chattanooga, U.S.

9:00-9:25 Well-Posedness of Inextensible Beams with Applications to Flutter
Justin T. Webster and Maria Deliyianni, University of Maryland, Baltimore County, U.S.

9:30-9:55 High Order Symmetric Direct Discontinuous Galerkin Finite Element Method for Elliptic Interface Problems with Body-Fitted Mesh
Jue Yan, Iowa State University, U.S.

10:00-10:25 On Some Complex Coupled Multi-Physics PDE
Amnon J. Meir, Southern Methodist University, U.S.

continued in next column

Thursday, December 12

CP5

Equations of Mathematical Physics and Other Applications I

8:30 a.m.-10:30 a.m.

Room: Santa Rosa

Chair: Om Prakash Keshri, Central University of Rajasthan, India

8:30-8:45 Existence and Uniqueness of Magnetic Field for a Superconductor in the Presence of Electric Field
Fatima El Azzouzi and Mohammed El Khomssi, Université Sidi Mohamed Ben Abdellah, Morocco

8:50-9:05 The Impact of Time Delay in a Tumor Model
Xinyue E. Zhao and Bei Hu, University of Notre Dame, U.S.

9:10-9:25 Lie Symmetry Analysis of Short Pulse Type Equation
Vikas Kumar, D. A. V. College Pundri, India

9:30-9:45 A Integrable Hierarchy, a Bi-Hamiltonian Reduction, and Some Explicit Solutions
Morgan A. Mcanally, University of Tampa, U.S.

9:50-10:05 Controllability of Stochastic Second-Order Neutral Differential Systems with State Dependent and Infinite Delay
Sanjukta Das, Mahindra Ecole Centrale, India

10:10-10:25 Effect of Internal Heat Source on Magneto-Stationary Convection of Couple Stress Fluid under Magnetic Field Modulation
Om Prakash Keshri, Central University of Rajasthan, India

Thursday, December 12

CP6

Computational Methods I

8:30 a.m.-10:30 a.m.

Room: Flores B/C

Chair: Lina Zhao, Chinese University of Hong Kong, Hong Kong

8:30-8:45 A Class of Upwind Methods based on Generalized Eigenvectors for Weakly Hyperbolic Systems
Naveen K. Garg, Southern University of Sciences and Technology, China

8:50-9:05 Oberst-Riquier based Algorithm for Trajectory Generation of Infinite-Dimensional Systems
Debasattam Pal and Ayan Sengupta, Indian Institute of Technology-Bombay, India

9:10-9:25 MHD Carreau-Yasuda Model for Blood Flow and Heat Transfer through a Bifurcated Artery having Saccular Aneurysm
Ankita Dubey and B. Vasu, Mnnit Allahabad, India

9:30-9:45 Eulerian Fluid-Structure Interaction Methods for Cardiovascular Modeling
Aymen Laadhari, Zayed University, Abu Dhabi, United Arab Emirates; Pierre Saramito, Grenoble University, France; Alfio Quarteroni, École Polytechnique Fédérale de Lausanne, Switzerland; Gabor Szekely, ETH Zürich, Switzerland

9:50-10:05 On Convergent Schemes for a Two-Phase Oldroyd-B Type Model with Variable Polymer Density
Oliver Sieber, Friedrich-Alexander Universitaet Erlangen-Nuernberg, Germany

10:10-10:25 An Analysis of the NLMC Upscaling Method for Elliptic Problems with High Contrast
Lina Zhao and Eric Chung, Chinese University of Hong Kong, Hong Kong; Yang Liu, Donghua University, China

Coffee Break

10:30 a.m.-10:55 a.m.

Room: Flores 4

Announcements

10:55 a.m.-11:00 a.m.

Room: Flores 5

Thursday, December 12

IP3

Singularity Formation in Critical Parabolic Problems

11:00 a.m.-11:45 a.m.

Room: Flores 5

Chair: Roman Shvydkoy, University of Illinois, Chicago, U.S.

Singularity formation in evolution problems is a central issue in many mathematical models. It usually arises as the blow-up of a quantity reflecting regularity of the solution on some lower-dimensional set. We deal with construction and stability analysis of blow-up of solutions for a class of parabolic equations, classical in the PDE literature, that involve bubbling phenomena, corresponding to gradient flows of variational energies. The term bubbling refers to the presence of families of solutions which at main order look like scalings of a single stationary solution which in the limit become singular but at the same time have an approximately constant energy level. This phenomenon arises in various problems where critical loss of compactness for the underlying energy appears. Specifically, we present construction of threshold-dynamic solutions with infinite time blow-up in the Sobolev critical semilinear heat equation in R^n, and finite time blow up for the harmonic map flow from a two-dimensional domain into S^2. This is done by "gluing methods" matching inner regimes (close to the singular set) and outer regimes, that are naturally considered at different scales.

Manuel del Pino
University of Bath, United Kingdom

Thursday, December 12

IP4

Bound-Preserving High Order Schemes for Hyperbolic Equations: Survey and Recent Developments

11:45 a.m.-12:30 p.m.

Room: Flores 5

Chair: Alexander Kurganov, Southern University of Science and Technology, China

Solutions to many hyperbolic equations have convex invariant regions, for example solutions to scalar conservation laws satisfy maximum principle, solutions to compressible Euler equations satisfy positivity-preserving property for density and internal energy, etc. It is however a challenge to design schemes whose solutions also honor such invariant regions. This is especially the case for high order accurate schemes. In this talk we will first survey strategies in the literature to design high order bound-preserving schemes, including the general framework in constructing high order bound-preserving finite volume and discontinuous Galerkin schemes for scalar and systems of hyperbolic equations through a simple scaling limiter and a convex combination argument based on first order bound-preserving building blocks, and various flux limiters to design high order bound-preserving finite difference schemes. We will then discuss a few recent developments, including high order bound-preserving schemes for relativistic hydrodynamics, high order discontinuous Galerkin Lagrangian schemes, high order discontinuous Galerkin methods for radiative transfer equations, high order discontinuous Galerkin methods for MHD, and implicit bound-preserving schemes. Numerical tests demonstrating the good performance of these schemes will be reported.

Chi-Wang Shu
Brown University, U.S.

Lunch Break

12:30 p.m.-2:30 p.m.

Attendees on own

Thursday, December 12

MS42

Partial Differential Equations in Mean Field Games and Mean Field Control - Part III of III

2:30 p.m.-4:30 p.m.

Room: Flores 5

For Part 2 see MS28

Recent advances have shown that Mean Field Games (MFGs) and Mean Field Control (MFC) offer an exciting source of new challenges for the analysis of nonlinear Partial Differential Equations (PDEs). In this spirit, the mini symposium will gather researchers who contributed recently to the field. It is expected to highlight interactions with the theory of the Master Equation of these systems, of Optimal Transport, and the development of new numerical procedures, especially those based on Machine Learning (ML) tools, as they appear as a promising approach to the computation of the solutions of these high dimensional nonlinear PDEs.

Organizer: Rene Carmona
Princeton University, U.S.

Organizer: Maria Gualdani
The University of Texas at Austin, U.S.

2:30-2:55 Inverse Optimal Transport
Marie-Therese Wolfram and A. Stuart, University of Warwick, United Kingdom

3:00-3:25 Viscosity Solutions for Controlled McKean–Vlasov Jump-Diffusions
Anders Max Reppen, Princeton University, U.S.

3:30-3:55 Many-Player Games of Optimal Consumption and Investment under Relative Performance Criteria
Agathe Soret and Daniel Lacker, Columbia University, U.S.

4:00-4:25 Weak Solutions for Mean Field Game Master Equations
Jianfeng Zhang, University of Southern California, U.S.

Thursday, December 12

MS43

Recent Progress in Fluid Mechanics: Classical Flows, Geophysical Models and Complex Fluids - Part II of III

2:30 p.m.-4:30 p.m.

Room: Flores 1

For Part 1 see MS29
For Part 3 see MS55

In the last decades the active research in fluid mechanics has led to new important analytical results in different directions. Most of these developments have been motivated by the necessity of solving complex systems of partial differential equations arising from fundamental applications in real life. Among many fascinating areas, we aim to focus on three main topics: primitive equations and shallow water systems for the description of the dynamics of the atmosphere and the oceans, diffuse interface models for motion and interaction in binary mixtures, and models for the evolution of microstructures in complex fluids, such as polymers and liquid crystals. The purpose of this session is to bring together researchers who will exchange ideas and present novel methods, which may foster collaborations and lead to new insights.

Organizer: Andrea Giorgini
Indiana University, U.S.

Organizer: Roger M. Temam
Indiana University, U.S.

2:30-2:55 Thermal Effects in General Diffusion with Biological Applications
Chun Liu, Illinois Institute of Technology, U.S.

3:00-3:25 Strict/Uniform Physicality of a Gradient Flow Generated by the Anisotropic Landau-de Gennes Energy with a Singular Potential
Xiang Xu, Old Dominion University, U.S.; Yuning Liu, New York University-Shanghai, China; Xin Yang Lu, Lakehead University, Canada

3:30-3:55 Gevrey Class Well Posedness for Non Diffusive Active Scalar Equations
Susan Friedlander, University of Southern California, U.S.

4:00-4:25 Analysis of Hydrodynamic Mixture Models
Kun Zhao, Tulane University, U.S.

Thursday, December 12

MS44

From Variational Models in Nonlinear Elasticity to Evolutionary Problems of Elastodynamics - Part III of III

2:30 p.m.-4:00 p.m.

Room: Flores 2

For Part 2 see MS30

The following question received large attention in the past decade: which elastic theories of thin objects (such as rods, plates, shells) are predicted by the 3d nonlinear theory? As is now well understood, there exist a plethora of viable models, each valid under different regimes of stored energies, geometrical constraints, boundary conditions or internal prestrain mechanisms. These models have been obtained, by large, departing from the variational description of equilibria in nonlinear elasticity. At the same time, much less is known in the similar contexts for time-dependent problems, despite a large body of work available in relation to elastodynamics, von Karman evolutions or fluid structure interaction. The scope of this minisymposium is to bring together scientists with background in diverse fields involving elasticity: from dimension reduction, through quasi-static evolution, to free boundary problems; to investigate connections between these problems and to discuss challenges from different perspectives.

Organizer: Davit Harutyunyan
University of California, Santa Barbara, U.S.

Organizer: Marta Lewicka
University of Pittsburgh, U.S.

2:30-2:55 Nonlinear Shell Models of Koiter's Type with Polyconvex Stored Energy Functions
Cristinel Mardare, Sorbonne Universités, France

3:00-3:25 The Deformation of Rod-Like Objects due to Surface Tension
Ethan O'Brian, Carnegie Mellon University, U.S.

3:30-3:55 On the Role of Boundary Conditions and Curvature in the Rigidity of Shells
Davit Harutyunyan, University of California, Santa Barbara, U.S.

Thursday, December 12

MS46

Asymptotic Preserving Schemes for Multiscale Hyperbolic and Kinetic Equations - Part II of II

2:30 p.m.-4:30 p.m.

Room: Flores 6

For Part 1 see MS32

Hyperbolic and kinetic equations often have multiple time and spatial scales that lead asymptotically from one (microscopic) scale to another (macroscopic) scales. Notable examples include the fluid dynamic limit of the Boltzmann and Landau equations, diffusion limit of transport and radiative transfer equations, quasi-neutral limit of the Vlasov-Poisson and Vlasov-Maxwell system, low Mach limit of the compressible fluid equations, etc. Such scale variations bring computational challenges that need special care when a numerical scheme is designed. An active area of research in such multiscale problems is the design of asymptotic-preserving (AP) schemes that mimic the asymptotic transition from one scale to another at the discrete level. In this minisymposium, we will present state-of-the-art AP schemes for multiscale hyperbolic and kinetic equations, and will bring researchers that blend theory, computation and applications for problems arising from rarefied gas, plasma, fluids, to biology.

Organizer: Alexander Kurganov
Southern University of Science and Technology, China

Organizer: Shi Jin
Shanghai Jiaotong University, China

2:30-2:55 An Asymptotic Preserving Scheme for the Two-Dimensional Shallow Water Equations with Coriolis Forces
Alexander Kurganov, Southern University of Science and Technology, China

3:00-3:25 An Asymptotic Preserving Scheme for the Euler Equations of Gas Dynamics
Alina Chertock, North Carolina State University, U.S.

3:30-3:55 Asymptotic Error Estimates for Low Mach Number Flows
Maria Lukacova-Medvidova, University of Mainz, Germany

4:00-4:25 Asymptotic Preserving Front Capturing Scheme for Nonlinear Transport Equation
Li Wang, University of Minnesota, U.S.

continued in next column

Thursday, December 12

MS47

Mixing and Stability in Fluids - Part I of II

2:30 p.m.-4:30 p.m.

Room: Flores 7

For Part 2 see MS59

Hydrodynamical turbulence, with its involved flow patterns of interwoven webs of eddies changing erratically in time, is a fascinating phenomenon occurring in nature from microscopic scales to astronomical ones and exposed to our scrutiny in everyday experience. Despite the ubiquity of turbulence, many fundamental mathematical questions remain unanswered. This session will focus on the effect of transport and diffusion in relevant systems in fluid dynamics. Specifically, it will revolve around analytical and computational aspects of a variety of interconnected topics, such as the quantification of rates of turbulent transport, the effect of mixing and dissipation in passive scalars, and nonlinear effects related to inviscid damping and enhanced dissipation. This session will bring together a group of world leading experts and young researchers working at the intersection of the fields of partial differential equations and numerical analysis.

Organizer: Michele Coti Zelati
Imperial College London, United Kingdom

Organizer: Tarek Elgindi
University of California, San Diego, U.S.

2:30-2:55 On the Stability of Anisotropic Fluid Models
David Gérard-Varet, Universite Paris Diderot, France

3:00-3:25 Linear Stability of Shear Flows Close to Couette in the 2D Isothermal Compressible Euler Setting
Michele Dolce, Gran Sasso Science Institute, Italy

3:30-3:55 Lagrangian Chaos and Scalar Mixing for Models in Fluid Mechanics
Alex Blumenthal, New York University, U.S.

4:00-4:25 Almost-Sure Exponential Mixing and Enhanced Dissipation in Stochastic Navier-Stokes
Jacob Bedrossian, University of Maryland, U.S.

Thursday, December 12

MS48

Mean Field Limits of Interacting Particle Systems

2:30 p.m.-4:30 p.m.

Room: Flores 8

Interacting particles is ubiquitous in modelling the microscopic dynamics of physical systems, such as the dynamics of galaxies under the Newton's law of gravity. Usually the number of particles in the system is extremely huge, which makes the the analysis and computation of particle systems prohibitively difficult. On the other hand, the behavior of interacting particle systems tend to become simpler as the number of particles grow up to infinity, leading to corresponding macroscopic PDE models (or the mean field limits). In recent years, driven by the rapid development of data science, interacting particles have also started playing a role in machine learning, such as the modelling of neural networks. Understanding their mean field limits provides new perspectives on the theoretical performance of algorithms. The goal of this minisymposium is to bring together researchers who have been working on interacting particle models from physics, chemical biology and machine learning and to communicate the techniques and methods of analyzing the interacting particles and their mean field limits and also discuss their practical implications.

Organizer: Yulong Lu
Duke University, U.S.

2:30-2:55 Propagation of Chaos for Large Systems of Interacting Particles with Almost Poisson Kernels
Zhenfu Wang, University of Pennsylvania, U.S.

3:00-3:25 Propagation of Chaos in the Stochastic Bimolecular Chemical Reaction-Diffusion Systems
Tau-Shean Lim, Duke University, U.S.

3:30-3:55 Mean Field Limits and Phase Transitions for Multi-Well and Multi-Scale Diffusions
Susana Gomes, University of Warwick, United Kingdom

4:00-4:25 Noisy Ensemble Kalman Inversion
Alfredo Garbuno Inigo, California Institute of Technology, U.S.

Thursday, December 12

MS49

Regularity, Singularity and Turbulence in Fluids - Part II of III

2:30 p.m.-4:30 p.m.

Room: Capra A

For Part 1 see MS35
For Part 3 see MS61

Turbulent flows are ubiquitous in the world around us; from trailing airplane wakes to swirling cream in our morning coffee. Despite its prevalence, basic mathematical questions about this complex non-linear phenomenon persist. This is, in part, because fluid phenomena involve many spatiotemporal scales which interact dynamically and often lead to singular or nearly singular behavior. The formation and persistence of singularities are often thought of as mathematical avatars of many well-known phenomena in turbulence such as anomalous dissipation and persistent energy scale-transfer, enhanced and chaotic mixing of Lagrangian trajectories and the unpredictability of the Cauchy problem at high Reynolds numbers. Understanding these fundamental issues, discussing recent progress and outlining future directions is the core aim of this minisymposium.

Organizer: Vincent Martinez
Hunter College, U.S.

Organizer: Huy Nguyen
Brown University, U.S.

Organizer: Theodore D. Drivas
Princeton University, U.S.

2:30-2:55 A Global Attractor for the Critical MG Equation
Susan Friedlander, University of Southern California, U.S.

3:00-3:25 Dynamics of Euler Flows
Tarek Elgindi, University of California, San Diego, U.S.

3:30-3:55 Energy Dissipation in Solutions to the Euler Equations
Phil Isett, California Institute of Technology, U.S.

4:00-4:25 Electrodiffusion of Ions in Fluids
Mihaela Ignatova, Temple University, U.S.

Thursday, December 12

MS50

Rigorous and Computational Studies of Data Assimilation - Part III of III

2:30 p.m.-4:30 p.m.

Room: Capra B

For Part 2 see MS21

Data assimilation is a technique for combining observations with model output with the objective of improving the latter. It is used in (weather) forecasting in order to mitigate the effect of (i) lack of knowledge of the initial conditions (ii) lack of knowledge of the model itself (parameters, functional form etc) (iii) noise in the model and/or in the observed data (iv) all of the above. There are a variety of methods for combining data with mathematical models. This includes the statistical approach of Kalman filter methods as well as the addition of nudging to PDEs. The objectives are to obtain a better forecast as well as gauge uncertainty. Data assimilation has wide ranging applications in environmental sciences (oceanography, glaciology, fluid-biology coupling), atmospheric sciences (numerical weather prediction), geosciences (seismology, geomagnetism, geo-dynamics), and human and social sciences (economics and finance, traffic control). Others include cancer treatments, hydrology and atmospheric chemistry. This minisymposium will bring together researchers to share rigorous analysis of these methods as well as numerical studies of their efficacy.

Organizer: Animikh Biswas
University of Maryland, Baltimore County, U.S.

Organizer: Michael S. Jolly
Indiana University, U.S.

2:30-2:55 Nudging Data Assimilation Algorithms for Geophysical Fluids
Aseel Farhat, Florida State University, U.S.

3:00-3:25 Continuous Data Assimilation for Large-Prandtl Rayleigh-Benard Convection from Thermal Measurements
Vincent Martinez, Hunter College, U.S.

3:30-3:55 Approximating Continuous Data Assimilation for PDEs with Observable Data
Yuan Pei, Western Washington University, U.S.; Adam Larios, University of Nebraska-Lincoln, U.S.

4:00-4:25 Nudging of the Stress-Free Rayleigh-Benard System, Analysis and Computations
Yu Cao and *Michael S. Jolly*, Indiana University, U.S.; Edriss S. Titi, Texas A&M University, U.S. and Cambridge University, U.K.; Jared P. Whitehead, Brigham Young University, U.S.

Thursday, December 12

MS51

Transport Equations - Mathematical Biology and Other Applications - Part II of II

2:30 p.m.-4:30 p.m.

Room: Capra C

For Part 1 see MS37

Transport equations form a large and significant part of partial differential equations, and often are basic tools in biological sciences, such as microbiology, biochemistry, genomics and proteomics, epidemiology and others. Being a natural language for modeling complex dynamics, they are following and paralleling this research in a systematic way as biologists turn to mathematicians to model and analyse, and mathematicians turn to biologists in search of new, exciting applications of their methodology. Many traditional biology contexts lead to systems of ODEs or systems of delay-differential equations. More detailed modeling efforts may lead to equations which include diffusion or transport terms. The former are commonly included, usually with constant diffusivities, where random ("diffusive") dispersion of a population in space is assumed; the latter can arise from a variety of modeling assumptions, and not necessarily from spatial transport processes alone. In this minisymposium we wish to focus not only on various applications of transport equations, but also on their mathematical analysis and computational issues.

Organizer: Piotr Gwiazda
Warsaw University, Poland

Organizer: Karolina Kropielnicka
University of Gdansk, Poland

2:30-2:55 Models for Memory Effects in Animal Migration
Pierre-Emmanuel Jabin and Hsin-Yi Lin, University of Maryland, U.S.

3:00-3:25 Computational Methods for Transport Equations in Various Applications
Karolina Kropielnicka, University of Gdansk, Poland

continued in next column

continued on next page

3:30-3:55 Differential Equations in Traffic Modeling
Francesca Marcellini, University of Brescia, Italy

4:00-4:25 A Two Species Hyperbolic-Parabolic Model of Tissue Growth
Agnieszka Swierczewska-Gwiazda, University of Warsaw, Poland

Thursday, December 12

MS53

Recent Developments on Steklov Eigenproblems - Part II of II

2:30 p.m.-4:30 p.m.

Room: Capra E

For Part 1 see MS39

Steklov eigenproblems are eigenvalue problems where the eigenvalue appears in the boundary condition. The Steklov spectrum coincides with that of the Dirichlet-to-Neumann map and has many important applications, such as sloshing fluids and imaging (medical, geophysical, etc..). Recently there has been progress on several topics, including (i) computational methods, (ii) shape optimization (iii) spectral asymptotics, and (iv) generalized problems for, e.g., Maxwell operator. This minisymposium aims to bring together mathematicians working on such problems to share new results and exchange ideas.

Organizer: Braxton Osting
University of Utah, U.S.

Organizer: Chiu-Yen Kao
Claremont McKenna College, U.S.

2:30-2:55 Steklov Spectral Asymptotics for Polygons
Michael Levitin, University of Reading, United Kingdom; Leonid Parnovski, University College London, United Kingdom; Iosif Polterovich, Université de Montréal, Canada; *David Sher*, DePaul University, U.S.

3:00-3:25 Dirichlet-to-Neumann Operators on Differential Forms
Mikhail Karpukhin, University of California, Irvine, U.S.

3:30-3:55 An Isoperimetric Problem for Sloshing with Surface Tension in a Shallow Container
Chee Han Tan, Christel Hohenegger, and Braxton Osting, University of Utah, U.S.

4:00-4:25 Steklov Representations and Approximations of Regularized Harmonic Functions
Manki Cho, University of Houston, Clear Lake, U.S.

Thursday, December 12

MS54

Modeling and Analysis of Complex Interfacial Problems in Advanced Materials - Part I of II

2:30 p.m.-4:30 p.m.

Room: The Studios

For Part 2 see MS66

Behavior of advanced materials is shaped by the competition between thermodynamic forces operating on different length scales. This mechanism was identified in many energy-driven systems, such as copolymers, various types of ferromagnetic systems, type-I superconductors, Langmuir layers, molecular solvation models, etc. Such balance of forces ensures that optimal configurations generally exhibit a high degree of regularity, often leading to interesting phenomena. This minisymposium aims to bring together researchers to discuss their recent advances in techniques, insights, and understanding to the interface problems arising in advanced materials.

Organizer: Chong Wang
McMaster University, Canada

Organizer: Yanxiang Zhao
George Washington University, U.S.

Organizer: Xin Yang Lu
Lakehead University, Canada

2:30-2:55 Multi-Phase Models of Amphiphilic Systems
Karl Glasner, University of Arizona, U.S.

3:00-3:25 Curve Lengthening and Phase Separation for Bilayers
Keith Promislow, Michigan State University, U.S.

3:30-3:55 Non-Hexagonal Lattices from a Two Species Interacting System
Senping Luo, University of British Columbia, Canada; *Xiaofeng Ren*, George Washington University, U.S.; Juncheng Wei, University of British Columbia, Canada

4:00-4:25 A Study of the Toughness of Epoxy Resins: Phase-Field Modeling of Fracture
Shuangquan Xie and Yasumasa Nishiura, Tohoku University, Japan; Takahashi Takaishi, Musashino University, Japan

Thursday, December 12

MS104

Optimization with PDE Constraints: Analysis and Numerics

2:30 p.m.-4:30 p.m.

Room: Flores 3

Many complex systems are accurately modeled by partial differential equations (PDEs). Optimization with such PDE constraints is a rapidly growing field with important applications in optimal control, shape and topology optimization, inverse problems etc. There are tremendous analytical, numerical, and algorithmic challenges to deal with such optimization problems. The purpose of this timely minisymposium is to bring together experts in the field and also to give an opportunity to postdocs and graduate students to share their research and to learn from the experts.

Organizer: Harbir Antil
George Mason University, U.S.

Organizer: Dmitriy Leykekhman
University of Connecticut, U.S.

2:30-2:55 Numerical Analysis of Sparse Initial Data Identification for Parabolic Problems
Dmitriy Leykekhman, University of Connecticut, U.S.

3:00-3:25 A Priori Error Estimates for Space-Time Finite Element Discretization of Parabolic Time-Optimal Control Problems
Boris Vexler, Technische Universität München, Germany

3:30-3:55 A Spatially Distributed Parameter Fractional Model in Image Processing
Carlos N. Rautenberg, Humboldt University Berlin, Germany

4:00-4:25 Control of Elastic Waves in Piezoelectric Solids
Thomas Brown, George Mason University, U.S.

Thursday, December 12

CP7

Computational Methods II

2:30 p.m.-4:30 p.m.

Room: Fiesta 8

Chair: Dimitri Papadimitriou, Antwerp University, Belgium

2:30-2:45 Efficient Calculation of Heterogeneous Non-Equilibrium Dynamics in Coupled Network Models
Cheng Ly, Virginia Commonwealth University, U.S.; Andrea K. Barreiro, Southern Methodist University, U.S.; Woodrow Shew, University of Arkansas, U.S.

2:50-3:05 An Asymptotic Preserving Multilevel Monte Carlo Method for Particle Based Simulation of Kinetic Equations
Emil Loevbak, Giovanni Samaey, and Stefan Vandewalle, Katholieke Universiteit Leuven, Belgium

3:10-3:25 Inverse Problems for Seismic Exploration Based on Topology Optimization and GPU Processing
Wilfredo Montealegre-Rubio, Universidad Nacional de Colombia, Colombia

3:30-3:45 A Finite Volume Scheme for Stochastic PDEs
Sergio P. Perez, Antonio Russo, Miguel A. Duran-Oivencia, Peter Yatsyshin, José A. Carrillo, and Serafim Kalliadasis, Imperial College London, United Kingdom

3:50-4:05 Weak Approximation Techniques for Mixed-Integer PDE-Constrained Optimization
Paul Manns and Christian Kirches, Technische Universität Braunschweig, Germany

4:10-4:25 Solving Non-Linear PDEs by Training Neural Networks with Augmented Lagrangian Method
Dimitri Papadimitriou, Antwerp University, Belgium

Thursday, December 12

CP8

Equations of Mathematical Physics and Other Applications II

2:30 p.m.-3:50 p.m.

Room: Flores B/C

Chair: Kenneth K. Yamamoto, University of Arizona, U.S.

2:30-2:45 Analysis of the Bi-Anisotropic Maxwell System in Lipschitz Domains and Free Space
Eric Stachura, Kennesaw State University, U.S.

2:50-3:05 Existence of Solution to a System of Parabolic Partial Differential Equations with Discontinuous Boundary Conditions Modeling Mass Transfer in Heterogeneous Catalysis
Riuji Sato, Worcester Polytechnic Institute, U.S.

3:10-3:25 Convergence Rates for the Three-Scale Singular Limit of the Mhd Equations
Steve Schochet, Tel Aviv University, Israel; Bin Cheng, University of Surrey, United Kingdom; Qiangchang Ju, Institute of Applied Physics and Computational Mathematics Beijing, China

3:30-3:45 Discrete Geometry and PDE-Constrained Optimization for Mechanics of Hyperbolic Elastic Sheets
Kenneth K. Yamamoto and Shankar C. Venkataramani, University of Arizona, U.S.

Friday, December 13

Registration

8:00 a.m.-4:00 p.m.

Room: Flores Foyer

Friday, December 13

MT2

Population Dynamics in Moving Environments

8:30 a.m.-10:30 a.m.

Room: Flores 5

Organizer and Speaker: Mark Lewis, University of Alberta, Canada

Classical population dynamics problems assume constant unchanging environments. However, realistic environments fluctuate in both space and time. My lectures will focus on the analysis of population dynamics in environments that shift spatially, due either to advective flow (eg., river population dynamics) or to changing environmental conditions (eg., climate change). The emphasis will be on the analysis of nonlinear advection-diffusion-reaction equations in the case where there is strong advection and environments are heterogeneous. I will use methods of spreading speed analysis, net reproductive rate and inside dynamics to understand qualitative outcomes. Applications will be made to river populations in one- and two-dimensions and to the genetic structure of populations subject to climate change.

Friday, December 13

MS45

Eigenproblems in Elliptic PDEs and Their Applications

8:30 a.m.-10:30 a.m.

Room: Flores B/C

Eigenproblems have been the topic of intense mathematical investigation over the past decades in the subject of spectral geometry. This session brings together researchers interested in the properties of eigenproblems for linear or nonlinear elliptic PDEs and their applications that arise in fluid mechanics, electrostatic, gravitational and electromagnetic field theories as well as geophysical boundary problems. From theoretical analysis to computational methods, this minisymposium focuses on new results in the studies of various geometric features of the eigenvalues and eigenfunctions in elliptic PDEs. Specially speakers will address questions regarding shape optimization of Schrödinger-Steklov eigenvalues, spectral asymptotics for eigenvalue problems, and Steklov representations for elliptic PDE solutions.

Organizer: Manki Cho
University of Houston, Clear Lake, U.S.

8:30-8:55 Representations of Solutions of Laplace's Equation on Planar Polygons
Giles Auchmuty, University of Houston, U.S.

9:00-9:25 A Conformal Mapping Approach to Steklov Eigenvalue Problems
Weaam Alhejaili, Claremont Graduate University, U.S.; *Chiu-Yen Kao*, Claremont McKenna College, U.S.

9:30-9:55 Eigencurves for the Breve p-Laplacian in Modeling Slow Dynamics of Phase Transition
Mauricio A. Rivas, North Carolina A&T State University, U.S.

10:00-10:25 Extremal Spectral Gaps for Periodic Schrödinger Operators
Braxton Osting, University of Utah, U.S.; Chiu-Yen Kao, Claremont McKenna College, U.S.

Friday, December 13

MS55

Recent Progress in Fluid Mechanics: Classical Flows, Geophysical Models and Complex Fluids - Part III of III

8:30 a.m.-10:30 a.m.

Room: Flores 1

For Part 2 see MS43

In the last decades the active research in fluid mechanics has led to new important analytical results in different directions. Most of these developments have been motivated by the necessity of solving complex systems of partial differential equations arising from fundamental applications in real life. Among many fascinating areas, we aim to focus on three main topics: primitive equations and shallow water systems for the description of the dynamics of the atmosphere and the oceans, diffuse interface models for motion and interaction in binary mixtures, and models for the evolution of microstructures in complex fluids, such as polymers and liquid crystals. The purpose of this session is to bring together researchers who will exchange ideas and present novel methods, which may foster collaborations and lead to new insights.

Organizer: Andrea Giorgini
Indiana University, U.S.

Organizer: Roger M. Temam
Indiana University, U.S.

8:30-8:55 Global Solutions for the Active Hydrodynamics
Dehua Wang, University of Pittsburgh, U.S.

9:00-9:25 Uniqueness and Regularity Results of Diffuse Interface Models for Binary Fluids
Andrea Giorgini, Indiana University, U.S.

9:30-9:55 Inertial Manifolds for the Hyperviscous Navier-Stokes Equations
Yanqiu Guo, Florida International University, U.S.

10:00-10:25 Partial Regularity Results of Solutions to the 3D Incompressible Navier--Stokes Equations and Other Models
Wojciech Ozanski, University of Southern California, U.S.

Friday, December 13

MS56

Traveling Waves: Selection Principles and Stability - Part I of II

8:30 a.m.-10:30 a.m.

Room: Flores 2

For Part 2 see MS69

Traveling waves arise in a variety of physical systems from combustion and chemical reactions to population dynamics and invasion processes. Since traveling waves determine the speed of propagation for information in a system, they can be seen as organizing the dynamics. Dating back to the Fisher-KPP equation, there is a rich intersection of traveling wave analysis and techniques from dynamical systems and functional analysis. This minisymposium brings together experts who develop and employ these techniques to determine the speed, profile, and stability of traveling waves in a range of physical systems and model PDEs.

Organizer: Jasper Weinburd
Harvey Mudd College, U.S.

Organizer: Paul Carter
University of Arizona, U.S.

8:30-8:55 Fisher-KPP Dynamics in a Diffusive Rosenzweig-MacArthur Model
Hong Cai, Brown University, U.S.; *Anna Ghazaryan*, Miami University, U.S.; Vahagn Manukian, Miami University Hamilton, U.S.

9:00-9:25 Slow and Fast Traveling Waves for a General Fisher-Keller-Segel Equation
Christopher Henderson, University of Chicago, U.S.; Francois Hamel, Université d'Aix-Marseille III, France

9:30-9:55 Zigzagging of Stripe Patterns in Growing Domains
Montie Avery, University of Minnesota, U.S.; Arnd Scheel, University of Minnesota, Twin Cities, U.S.; Ryan Goh, Boston University, U.S.; Alexandre Milewski, University of Bristol, United Kingdom; Oscar Goodloe, Arizona State University, U.S.

10:00-10:25 Traveling Waves of a Go-or-Grow Model of Glioma Growth
Tracy L. Stepien, University of Florida, U.S.; Erica Rutter, University of California, Merced, U.S.; Yang Kuang, Arizona State University, U.S.

continued in next column

Friday, December 13

MS57

Gauge Theory and Partial Differential Equations - Part I of IV

8:30 a.m.-10:30 a.m.

Room: Flores 3

For Part 2 see MS70

Almost all of the speakers are experts on the Yang-Mills or coupled Yang-Mills equations. Yang-Mills gauge theory seeks to describe the behavior of elementary particles using non-Abelian Lie groups and is at the core of the unification of the electromagnetic force and weak forces (i.e., U(1) x SU(2)) as well as quantum chromodynamics, the theory of the strong force (based on SU(3)). Thus, it forms the basis of our understanding of the Standard Model of particle physics. Coupled Yang-Mills equations arise when one considers Euler-Lagrange equations for an energy function that intertwines a connection A and one more sections of vector bundles associated with P and this has is a very active area of research, due to their roles in theoretical physics and applications to differential geometry, representation theory, symplectic geometry, and low-dimensional topology. Examples include the Hitchin-Simpson equations (1987, 1988), Kapustin-Witten equations, SO(3) monopole equations, Seiberg-Witten monopole equations, Vafa-Witten equations, as well as other coupled Yang-Mills equations arising in particle physics. Many of our speakers will describe their work on such coupled Yang-Mills equations, including central questions of compactness and geometry of the moduli spaces of solutions and applications to the definition of invariants.

Organizer: Paul Feehan
Rutgers University, U.S.

Organizer: Duong Phong
Columbia University, U.S.

8:30-8:55 Interior Schauder Estimates for the Fourth Order Hamiltonian Stationary Equation
Arunima Bhattacharya, University of Washington, U.S.

9:00-9:25 Gluing in Geometric Analysis via Maps of Banach Manifolds with Corners and Applications to Gauge Theory
Paul Feehan, Rutgers University, U.S.

9:30-9:55 A Generalization of the Tristram-Levine Knot Signatures as a Singular Furuta-Ohta Invariant for Tori
Mariano Echeverria, Rutgers University and University of Virginia, U.S.

10:00-10:25 The Asymptotic Geometry of the Hitchin Moduli Space
Laura Fredrickson, Stanford University, U.S.

continued in next column

Friday, December 13

MS58

Layered 2D Materials and Edge States - Part I of II

8:30 a.m.-10:30 a.m.

Room: Flores 6

For Part 2 see MS106

In recent years 2d materials such as graphene have generated intense interest for engineering applications. One feature of such materials is that they may host ``edge states': electronic states localized at the physical edge of, or along interfaces between, 2d materials. Such states (and their counterparts in photonic analogs of such materials) have potential for robust wave-guiding applications. This minisymposium will bring together mathematicians working on edge states with those working on layered 2d materials (novel materials created by stacking 2d materials on top of each other) in the hope of catalyzing interaction between these exciting areas.

Organizer: Alexander Watson
Duke University, U.S.

8:30-8:55 Analysis on Topologically Protected Wave Motion
Yi Zhu, Tsinghua University, China

9:00-9:25 Relaxation of 2D Incommensurate Heterostructures and Networks of Domain Walls
Paul Cazeaux, University of Kansas, U.S.

9:30-9:55 Floquet Ti: Laser-Driven Graphene Observables and Edge States
Daniel Massatt, University of Minnesota, U.S.

10:00-10:25 Topological Equivalence of Continuum Models with their Discrete Tight-Binding Limits in the IQHE
Jacob Shapiro, Columbia University, U.S.

Friday, December 13

MS59

Mixing and Stability in Fluids - Part II of II

8:30 a.m.-10:30 a.m.

Room: Flores 7

For Part 1 see MS47

Hydrodynamical turbulence, with its involved flow patterns of interwoven webs of eddies changing erratically in time, is a fascinating phenomenon occurring in nature from microscopic scales to astronomical ones and exposed to our scrutiny in everyday experience. Despite the ubiquity of turbulence, many fundamental mathematical questions remain unanswered. This session will focus on the effect of transport and diffusion in relevant systems in fluid dynamics. Specifically, it will revolve around analytical and computational aspects of a variety of interconnected topics, such as the quantification of rates of turbulent transport, the effect of mixing and dissipation in passive scalars, and nonlinear effects related to inviscid damping and enhanced dissipation. This session will bring together a group of world leading experts and young researchers working at the intersection of the fields of partial differential equations and numerical analysis.

Organizer: Michele Coti Zelati
Imperial College London, United Kingdom

Organizer: Tarek Elgindi
University of California, San Diego, U.S.

8:30-8:55 On Singularity Formation for the Two Dimensional Unsteady Prandtl's System
Slim Ibrahim, University of Victoria, Canada

9:00-9:25 Long Time Dynamics in the Rotating Euler Equations
Klaus Widmayer, EPFL, Switzerland

9:30-9:55 Dissipation Enhancement by Mixing and Applications to Cahn-Hilliard Equation
Yuanyuan Feng, Pennsylvania State University, U.S.

10:00-10:25 On Universal Mixers
Andrej Zlatos, University of California, San Diego, U.S.

Friday, December 13

MS60

Recent Developments of Discontinuous Galerkin Methods for Partial Differential Equations

8:30 a.m.-10:30 a.m.

Room: Flores 8

This minisymposium is to bring people together to discuss the recent advances and exchange ideas in the algorithm design of discontinuous Galerkin methods for hyperbolic and parabolic equations and other high-order partial different equations, including the implementation, numerical analysis. In the minisymposium, the speakers will apply those high-order numerical methods to computational fluid, biology and physics, etc. This minisymposium is a good opportunity for people to discuss with researchers from different areas, and explore more applications and future research collaborations. We expect 4 speakers to present in this minisymposium.

Organizer: Yang Yang
Michigan Technological University, U.S.

8:30-8:55 High-Order Bound-Preserving Discontinuous Galerkin Methods for Stiff Multispecies Detonation
Jie Du, Tsinghua University, P. R. China; *Yang Yang*, Michigan Technological University, U.S.

9:00-9:25 Maximum-Principle-Preserving Third-Order Local Discontinuous Galerkin Method for Convection-Diffusion Equations on Overlapping Meshes
Jie Du, Tsinghua University, P. R. China; Yang Yang, Michigan Technological University, U.S.

9:30-9:55 Well-Balanced Discontinuous Galerkin Method for Shallow Water Equations with Constant Subtraction Techniques on Unstructured Meshes
Yuan Liu, Mississippi State University, U.S.

10:00-10:25 Third Order Positivity-Preserving Direct DG Method for One-Dimensional Compressible Navier-Stokes Equations
Patrick Bernard, CEREMADE Universite Paris 9 Dauphine, France

Friday, December 13

MS61

Regularity, Singularity and Turbulence in Fluids - Part III of III

8:30 a.m.-10:30 a.m.

Room: Capra A

For Part 2 see MS49

Turbulent flows are ubiquitous in the world around us; from trailing airplane wakes to swirling cream in our morning coffee. Despite its prevalence, basic mathematical questions about this complex non-linear phenomenon persist. This is, in part, because fluid phenomena involve many spatiotemporal scales which interact dynamically and often lead to singular or nearly singular behavior. The formation and persistence of singularities are often thought of as mathematical avatars of many well-known phenomena in turbulence such as anomalous dissipation and persistent energy scale-transfer, enhanced and chaotic mixing of Lagrangian trajectories and the unpredictability of the Cauchy problem at high Reynolds numbers. Understanding these fundamental issues, discussing recent progress and outlining future directions is the core aim of this minisymposium.

Organizer: Huy Nguyen
Brown University, U.S.

Organizer: Theodore D. Drivas
Princeton University, U.S.

Organizer: Vincent Martinez
Hunter College, U.S.

8:30-8:55 3D Gravity Water Waves with Vorticity
Daniel Ginsberg, Johns Hopkins University, U.S.

9:00-9:25 Dynamics of Singular Vortex Patches
In-Jee Jeong, Korea Institute for Advanced Study, Korea

9:30-9:55 Contour Dynamics for SQG Fronts
John Hunter, University of California, Davis, U.S.

10:00-10:25 Formation of Shocks for the 2D Euler Equations
Steve Shkoller, University of California, Davis, U.S.

Friday, December 13

MS63

Inviscid Fluid Dynamics - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra C

For Part 2 see MS76

One of the fundamental systems in fluid mechanics is the Euler system describing flows of inviscid fluids. Although the system was formulated in the eighteenth century, only now we are observing incredible progress both in the well-posedness (or rather ill-posedness) theory and in the observation of various fundamental properties of solutions. The minisymposium addresses recent progress not only for Euler system, but more generally for inviscid fluid dynamics. The most emerging topics in this field include the resolution of the famous Onsager's conjecture, existence and uniqueness of different notions of solutions or the phenomenon of weak-strong uniqueness among many other questions.

Organizer: Agnieszka Swierczewska-Gwiazda
University of Warsaw, Poland

Organizer: Emil Wiedemann
University of Ulm, Germany

8:30-8:55 Remarks Around the Euler Equations
Peter Constantin, Princeton University, U.S.

9:00-9:25 On the Extension of Onsager's Conjecture for General Conservation Laws
Piotr Gwiazda, Warsaw University, Poland

9:30-9:55 Vanishing Viscosity Limit and Renormalized Solutions to Euler Equations
Camilla Nobili, Universitat Hamburg, Germany

10:00-10:25 Energy Conservation for Compressible Fluid Equations with Vacuum
Jack Skipper, University of Ulm, Germany

Friday, December 13

MS64

Singular Solutions to Geometric Problems in Continuum and Discrete Mechanics - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra D

For Part 2 see MS77

Geometric ideas play a key role in the analysis of PDEs, including, but not limited to, an understanding of PDEs as in terms of rigidity/flexibility through an investigation of geometric structures in solutions, and the quest for methods that respect/exploit the natural geometric features that are intrinsic to the PDE. In our minisymposium, we plan to bring together scientists studying multi-scale solutions to various (geometric, variational, integrable, etc) PDEs using geometrical ideas. The goal is to encourage interactions among different mathematical communities, to organize a forum for investigating connections between problems and techniques and to discuss advances and challenges from different perspectives. We will give particular attention to "singular" and “discrete” constructions and methods that inform and enrich the descriptions available via "continuum" theories. The minisymposium will be organized around the following interrelated topics: (1) Discrete geometry and “structure-preserving” methods for PDEs; (2) Rough solutions and convex integration constructions for elasticity, fluids and transport equations; (3) Variational problems and the geometry of defects.

Organizer: Marta Lewicka
University of Pittsburgh, U.S.

Organizer: Shankar C. Venkataramani
University of Arizona, U.S.

8:30-8:55 Microstructures in Shape-Memory Alloys: Rigidity, Flexibility and Some Numerical Simulations
Angkana Ruland, Max Planck Institute for Mathematics in the Sciences, Germany

9:00-9:25 A Unified Lie-Algebraic Formulation for Surfaces of Prescribed Mean Curvature in Euclidean, Timelike, and Spacelike Surfaces
Patrick Shipman, Colorado State University, U.S.

9:30-9:55 Solving Variational Problems on Triangle Meshes using Nonlinear Rotation-Invariant Coordinates
Josua Sassen and Behrend Heeren, University of Bonn, Germany; Klaus Hildebrandt, Delft University of Technology, Netherlands; Martin Rumpf, University of Bonn, Germany

10:00-10:25 Title Not Available
Marta Lewicka, University of Pittsburgh, U.S.

continued in next column

Friday, December 13

MS65

Patterns in Fluids and Materials: Analytical and Numerical Perspectives - Part I of III

8:30 a.m.-10:30 a.m.

Room: Capra E

For Part 2 see MS78

The purpose of this minisymposium is to bring senior and junior researchers in the field of pattern formation, in a rather broad sense. Recent breakthroughs in the field from diverse applications inspires the search for recurring and perhaps unifying themes. The goal of the minisymposium is to exchange new ideas on the study of mathematical models arising as descriptions of patterns in complex physical and biological systems; examples include swarming, complex fluids and solids. Such systems form patterns and defects, undergo phase transitions, and are often sensitive to external forces. Mathematical models and numerical simulations can help understanding, predicting and controlling these phenomena better. The speakers of this minisymposium will present recent advances on the modeling, mathematical and numerical analysis of defect dynamics, instabilities and phase transitions in applications such as convection, swarming and complex materials. The minisymposium will highlight the role of partial differential equations in these application areas, serve as a forum for the dissemination of new scientific ideas and discoveries and will enhance scientific communication.

Organizer: Franziska Weber
Carnegie Mellon University, U.S.

Organizer: Raghav Venkatraman
Carnegie Mellon University, U.S.

8:30-8:55 Phase Extraction and Defect Dynamics in Convection Patterns
Shankar C. Venkataramani and Guanying Peng, University of Arizona, U.S.

9:00-9:25 Instability of a Non-Isotropic Micropolar Fluid
Antoine Remond-Tiedrez, Carnegie Mellon University, U.S.

9:30-9:55 On the Dynamics of Polymeric Fluids
Konstantina Trivisa, University of Maryland, U.S.

10:00-10:25 Agent-Based and Continuous Models of Swarms: Insights Gained Through the Lens of Dynamical Systems
Andrew J. Bernoff and Jasper Weinburd, Harvey Mudd College, U.S.

continued in next column

Friday, December 13

MS66

Modeling and Analysis of Complex Interfacial Problems in Advanced Materials - Part II of II

8:30 a.m.-10:30 a.m.

Room: The Studios

For Part 1 see MS54

Behavior of advanced materials is shaped by the competition between thermodynamic forces operating on different length scales. This mechanism was identified in many energy-driven systems, such as copolymers, various types of ferromagnetic systems, type-I superconductors, Langmuir layers, molecular solvation models, etc. Such balance of forces ensures that optimal configurations generally exhibit a high degree of regularity, often leading to interesting phenomena. This Minisymposium aims to bring together researchers to discuss their recent advances in techniques, insights, and understanding to the interface problems arising in advanced materials.

Organizer: Chong Wang
McMaster University, Canada

Organizer: Yanxiang Zhao
George Washington University, U.S.

Organizer: Xin Yang Lu
Lakehead University, Canada

8:30-8:55 Self-Organizing Patterns in Biological Systems
Chao-Nien Chen, National Tsinghua University, Taiwan; Yung-Sze Choi, University of Connecticut, U.S.; *Yeyao Hu*, University of Texas, San Antonio, U.S.; Xiaofeng Ren, George Washington University, U.S.

9:00-9:25 A Diffuse Domain Method for Solving PDEs in Complex Geometries
Zhenlin Guo, University of California, Irvine, U.S.

continued on next page

9:30-9:55 The Threshold Dynamics Method for Wetting Dynamics
Dong Wang, University of Utah, U.S.; Xianmin Xu, Chinese Academy of Sciences, China; Xiao-Ping Wang, Hong Kong University of Science and Technology, Hong Kong

10:00-10:25 Computational Modeling of Dense Bacterial Colonies Growing on Hard Agar
Paul Sun, California State University, Long Beach, U.S.

Friday, December 13

CP9

Control and Optimization

8:30 a.m.-10:10 a.m.

Room: Fiesta 8

Chair: Soniya Singh, Indian Institute of Technology Roorkee, India

8:30-8:45 Optimal Control Dynamics: Multi-Therapies with Dual Immune Response for Treatment of Dual Delayed HIV-HBV Infections
Bassey E. Bassey, Cross River University of Technology, Nigeria

8:50-9:05 Approximate Controllability of Semilinear Impulsive Functional Differential Systems with Non Local Conditions
Soniya Singh and Jaydev Dabas, Indian Institute of Technology Roorkee, India

9:10-9:25 External Optimal Control of Fractional Parabolic PDEs
Deepanshu Verma and Harbir Antil, George Mason University, U.S.; Mahamadi Warma, University of Puerto Rico, Río Piedras, Puerto Rico

9:30-9:45 Dimension Reduction Through Gamma Convergence in Thin Elastic Sheets with Thermal Strain, with Consequences for the Design of Controllable Sheets
David Padilla Garza, New York University, U.S.

9:50-10:05 A Comparison of Mean Field Games and the Best Reply Strategy: The Stationary Case
Matthew Barker and Pierre Degond, Imperial College London, United Kingdom; Marie-Therese Wolfram, University of Warwick, United Kingdom

Friday, December 13

CP10

Equations of Mathematical Physics and Other Applications III

8:30 a.m.-10:30 a.m.

Room: Santa Rosa

Chair: Scott Little, California Polytechnic State University, Pomona, U.S.

8:30-8:45 Barriers of the McKean-Vlasov Energy via a Mountain Pass Theorem in the Space of Probability Measures
Rishabh S. Gvalani, Imperial College London, United Kingdom; André Schlichting, Universitaet Bonn, Germany

8:50-9:05 On the Euler Equations with Helical Symmetry
Anne Bronzi, Universidade Estadual de Campinas, Brazil; Helena Nussenzveig Lopes, Universidade Federal de Rio de Janeiro, Brazil; Milton Lopes Filho, Universidade Federal do Rio De Janeiro, Brazil

9:10-9:25 Multicomponent Coagulation Equation for Aerosol Dynamics
Marina A. Ferreira and Jani Lukkarinen, University of Helsinki, Finland; Alessia Nota and Juan Velazquez, University of Bonn, Germany

9:30-9:45 Stochastic Helmholtz Finite Volume Method for DBI String-Brane Theory Simulations
Scott Little, California Polytechnic State University, Pomona, U.S.; Dan Cervo, Yavapai College, U.S.

9:50-10:05 Globally Convergent Methods for Inverse Scattering Problems: Theory and Testing Against Experimental Data
Thanh Nguyen, Rowan University, U.S.

10:10-10:25 Exact Soliton, Periodic and Superposition Solutions to the Extended Korteweg-De Vries (KdV2) Equation
Piotr Rozmej, University of Zielona Góra, Poland

Friday, December 13

Coffee Break

10:30 a.m.-10:55 a.m.

Room: Flores 4

Announcements

10:55 a.m.-11:00 a.m.

Room: Flores 5

Friday, December 13

IP5

Crowd Motion and the Muskat Problem via Optimal Transport

11:00 a.m.-11:45 a.m.

Room: Flores 5

Chair: Theodore Kolokolnikov, Dalhousie University, Canada

In this talk we will talk about single and multi-phase models that describe transport of densities under incompressibility constraint. These models hold importance in crowd motion and fluid dynamics. A particular focus will be on the Muskat problem, modeling dynamics of interface between two incompressible fluids. Our goal is to establish global-time existence of solutions past potential singularities, based on its gradient flow structure in Wasserstein spaces. This perspective allows us to construct weak solutions via a minimizing movements scheme. We will survey relevant results in the literature, and then report a recent result obtained in joint work with Matthew Jacobs and Alpar Meszaros.

Inwon Kim
University of California, Los Angeles, U.S.

Friday, December 13

IP6

An Application of the Sharp Caffarelli-Kohn-Nirenberg Inequalities

11:45 a.m.-12:30 p.m.

Room: Flores 5

Chair: Maria Gualdani, The University of Texas at Austin, U.S.

This talk is centered around the symmetry properties of optimizers for the Caffarelli-Kohn-Nirenberg (CKN) inequalities, a two parameter family of inequalities. After a general overview I will explain some of the ideas on how to obtain the optimal symmetry region in the parameter space and will present an application to non-linear functionals of Aharonov-Bohm type, i.e., to problems that include a magnetic flux concentrated at one point. These functionals are rotationally invariant and, as I will discuss, depending on the magnitude of the flux, the optimizers are radially symmetric or not.

Michael Loss
Georgia Institute of Technology, U.S.

Lunch Break

12:30 p.m.-2:00 p.m.

Attendees on own

Friday, December 13

SP1

SIAG/Analysis of Partial Differential Equations Prize Lecture

2:00 p.m.-2:45 p.m.

Room: Flores 5

Chair: Irene Fonseca, Carnegie Mellon University, U.S.

In 1907, Orr first observed that solutions to the 2D incompressible Euler equations linearized around a linear shear flow (known as planar Couette flow) converge to equilibrium as t ⇒±∞. This convergence happens weakly at the level of the vorticity, and strongly in L^2 at an algebraic rate at the level of the velocity. It is a time-reversible effect associated with the continuous spectrum and a loss of compactness by low-to-high frequency cascade. In this way, it shares a variety of similarities with Landau damping in kinetic theory. This mixing effect is now sometimes referred to as "inviscid damping" and is now known to play an important role for understanding the stability of shear flows and vortices in incompressible fluids at high Reynolds number. In our work, Nader Masmoudi and I demonstrated that Orr's prediction holds also in the (nonlinear) 2D Euler equations near the Couette flow in the idealized domain T x R, provided one starts with at least Gevrey-2 regularity. In order to propagate the predicted low-to-high frequency cascade in a stable and controlled manner until $t \to \pm \infty$, a deep understanding and careful quantification of the weakly nonlinear effects is required. Gevrey-2 regularity was demonstrated to be sharp in a certain sense by Yu Deng and Nader Masmoudi in 2018. I will discuss the original work as well as a few of the works that have followed it by other authors and by ourselves and our collaborators.

Speaker:
Jacob Bedrossian
University of Maryland, U.S.

Nader Masmoudi
Courant Institute of Mathematical Sciences, New York University, U.S.

Coffee Break

2:45 p.m.-3:15 p.m.

Room: Flores 4

Friday, December 13

MS38

Mean Field Games: Theory and Applications - Part I of III

3:15 p.m.-5:15 p.m.

Room: Flores B/C

For Part 2 see MS52

Mean field game theory is a mathematical framework established recently by Lasry-Lions and Caines-Huang-Malhame in order to describe a contiuum of rational agents in Nash equilibrium. In this minisymposium we will discuss a range of theoretical aspects of mean field games, such as Hamilton-Jacobi equations on infinite dimensional spaces, the master equation, forward-backward systems of PDE, optimal transport, the calculus of variations, a priori estimates and fixed point theorems. In addition, we will address applications, including, but not limited to, economics, finance, pedestrian crowd modeling, flocking, and traffic flow.

Organizer: Jameson Graber
Baylor University, U.S.

Organizer: Alpar Meszaros
University of California, Los Angeles, U.S.

3:15-3:40 Weak Solutions for a Class of Potential Mean Field Games of Controls
Alan Mullenix, Baylor University, U.S.; Frédéric Bonnans, Inria Saclay and CMAP Ecole Polytechnique, France; Jameson Graber, Baylor University, U.S.; Laurent Pfeiffer, Inria Saclay and CMAP Ecole Polytechnique, France

3:45-4:10 Asymptotics for Mean Field Games of Market Competition
Marcus Laurel, Baylor University, U.S.

4:15-4:40 Existence Theory for a Mean Field Games Model of Household Wealth
David Ambrose, Drexel University, U.S.

4:45-5:10 Variational Mean Field Games: On Estimates for the Density and the Pressure and their Consequences for the Lagrangian Point of View
Hugo Lavenant, Universite de Paris-Sud, France

Friday, December 13

MS67

Recent Developments in Numerical Analysis of PDEs and Their Applications - Part I of III

3:15 p.m.-5:15 p.m.

Room: Flores 5

For Part 2 see MS80

Numerical analysis of partial differential equations and their applications have played a crucial role in applied and computational mathematics. This minisymposium focuses on recent developments in numerical analysis and aims to bring together the leading researchers in the fields of applied and computational mathematics to discuss and disseminate the latest advances and envisage future challenges in both the traditional and new areas of scientific and engineering computing. The topics of this minisymposium will cover a broad range of numerical methods including but not limited to weak Galerkin finite element methods, discontinuous Galerkin finite element methods and finite volume methods for various PDEs, such as nonlinear parabolic problems, Helmholtz equations, time fractional equations, rheological fluid flow, quasilinear elliptic PDE, Maxwell's equations, etc., their analysis and applications.

Organizer: Chunmei Wang
Texas Tech University, U.S.

Organizer: Jun Zou
The Chinese University of Hong Kong, Hong Kong

3:15-3:40 Modeling Rheological Fluid Flow
Ridgway Scott, University of Chicago, U.S.

3:45-4:10 High Order Explicit Local Time-Stepping Methods For Hyperbolic Conservation Laws
Thi-Thao-Phuong Hoang, Auburn University, U.S.; *Lili Ju*, University of South Carolina, U.S.; Wei Leng, Chinese Academy of Sciences, China; Zhu Wang, University of South Carolina, U.S.

4:15-4:40 Computational Study of Lateral Phase Separation in Biological Membranes
Vladimir Yushutin, *Annalisa Quaini*, Sheereen Majd, and Maxim A. Olshanskii, University of Houston, U.S.

continued on next page

Friday, December 13

MS67

Recent Developments in Numerical Analysis of PDEs and Their Applications - Part I of III

continued

4:45-5:10 Long Time Stability and Polynomial Decay Rate of Numerical Solutions for Time Fractional Equations
Dongling Wang, Northwest University of China, China

Friday, December 13

MS68

PDEs in Machine Learning - Part I of II

3:15 p.m.-5:15 p.m.

Room: Flores 1

For Part 2 see MS81

Machine learning (ML) has been a fast growing area of research since the beginning of the 21st century due to the advent of computing resources and availability of data. Recently interesting connections between the theory of partial differential equations (PDEs) and ML have been discovered that provide deep insights into the behavior of ML algorithms and problems in certain asymptotic regimes and also lead to improvements or entirely new algorithms. The goal of this minisymposium is to bring together experts at the intersectsion of PDEs and ML to discuss recent advances in this interdisciplinary field of research.

Organizer: Bamdad Hosseini
California Institute of Technology, U.S.

Organizer: Andrew Stuart
California Institute of Technology, U.S.

3:15-3:40 Rates of Convergence for Graph Total Variation Based Optimziation Problems: Cheeger Cuts and Trend Filtering
Nicolas Garcia Trillos, University of Wisconsin, Madison, U.S.; Ryan Murray, North Carolina State University, U.S.; Matthew Thorpe, University of Cambridge, United Kingdom

3:45-4:10 Nonlinear PDEs in Machine Learning
Jeff Calder, University of Minnesota, U.S.

4:15-4:40 From the Graph Laplacian to PDE's in Semi-Supervised Learning
Matthew Thorpe, University of Cambridge, United Kingdom; Dejan Slepcev, Carnegie Mellon University, U.S.; Jeff Calder, University of Minnesota, U.S.

4:45-5:10 Applying the Eikonal Equation for Graph Based Semi-Supervised Learning
Kevin Miller, University of California, Los Angeles, U.S.

Friday, December 13

MS69

Traveling Waves: Selection Principles and Stability - Part II of II

3:15 p.m.-5:15 p.m.

Room: Flores 2

For Part 1 see MS56

Traveling waves arise in a variety of physical systems from combustion and chemical reactions to population dynamics and invasion processes. Since traveling waves determine the speed of propagation for information in a system, they can be seen as organizing the dynamics. Dating back to the Fisher-KPP equation, there is a rich intersection of traveling wave analysis and techniques from dynamical systems and functional analysis. This minisymposium brings together experts who develop and employ these techniques to determine the speed, profile, and stability of traveling waves in a range of physical systems and model PDEs.

Organizer: Jasper Weinburd
Harvey Mudd College, U.S.

Organizer: Paul Carter
University of Arizona, U.S.

3:15-3:40 Asymptotic Stability of Pulled Fronts
Gregory Faye, CNRS, Institut de Mathématiques de Toulouse. France; *Matt Holzer*, George Mason University, U.S.

3:45-4:10 Long Time Dynamics of Waves in Stochastic Bistable RDEs
Christian Hamster and Hermen Jan Hupkes, Leiden University, Netherlands

4:15-4:40 Stability of Spiral Wave Patterns in Models of Excitable and Oscillatory Media
Stephanie Dodson, Brown University, U.S.

4:45-5:10 Fronts of Foraging Locusts
Jasper Weinburd and Andrew J. Bernoff, Harvey Mudd College, U.S.; Maryann Hohn, University of California, Santa Barbara, U.S.; Michael Culshaw-Maurer, University of California, Davis, U.S.; Christopher Strickland, University of Tennessee, Knoxville, U.S.; Rebecca Everett, Haverford College, U.S.

Friday, December 13

MS70

Gauge Theory and Partial Differential Equations - Part II of IV

3:15 p.m.-5:15 p.m.

Room: Flores 3

For Part 1 see MS57
For Part 3 see MS83

Almost all of the speakers are experts on the Yang-Mills or coupled Yang-Mills equations. Yang-Mills gauge theory seeks to describe the behavior of elementary particles using non-Abelian Lie groups and is at the core of the unification of the electromagnetic force and weak forces (i.e., U(1) x SU(2)) as well as quantum chromodynamics, the theory of the strong force (based on SU(3)). Thus, it forms the basis of our understanding of the Standard Model of particle physics. Coupled Yang-Mills equations arise when one considers Euler-Lagrange equations for an energy function that intertwines a connection A and one more sections of vector bundles associated with P and this has is a very active area of research, due to their roles in theoretical physics and applications to differential geometry, representation theory, symplectic geometry, and low-dimensional topology. Examples include the Hitchin-Simpson equations (1987, 1988), Kapustin-Witten equations, SO(3) monopole equations, Seiberg-Witten monopole equations, Vafa-Witten equations, as well as other coupled Yang-Mills equations arising in particle physics. Many of our speakers will describe their work on such coupled Yang-Mills equations, including central questions of compactness and geometry of the moduli spaces of solutions and applications to the definition of invariants.

Organizer: Paul Feehan
Rutgers University, U.S.

Organizer: Duong Phong
Columbia University, U.S.

3:15-3:40 Singular Ricci-Flat Metrics on Quasi-Projective Varieties
Freid Tong, Columbia University, U.S.

3:45-4:10 An Index Estimate for Yang-Mills in Connections and an Application to Einstein Metrics
Matt Gursky, University of Notre Dame, U.S.; Casey Kelleher, Princeton University, U.S.

4:15-4:40 The Kapustin-Witten Equations with the Nahm Pole Boundary Condition
Siqi He, Stony Brook University, U.S.

4:45-5:10 Adiabatic Limits of Yang-Mills Connections on Collapsing K3 Surfaces
Adam Jacob, University of California, Davis, U.S.

continued in next column

Friday, December 13

MS71

Recent Developments on Analysis and Computations in Fluid Dynamics - Part I of III

3:15 p.m.-5:15 p.m.

Room: Flores 6

For Part 2 see MS84

Over the past decades, there have been made active interactions between the analysis and numerical computations in fluid mechanics. In this minisymposium, we bring together the leading experts and aim to discuss recent developments in this research direction including, e.g., the existence, regularity, and asymptotic behavior of solutions to fluid equations as well as the implementation and convergence analysis of some effective numerical methods.

Organizer: YoungJoon Hong
San Diego State University, U.S.

Organizer: Gung-Min Gie
University of Louisville, U.S.

Organizer: Bongsuk Kwon
Ulsan National Institute of Science and Technology, South Korea

3:15-3:40 Mathematical Analysis of the Jin-Neelin Model of El Nino-Southern-Oscillation
Roger M. Temam, Indiana University, U.S.

3:45-4:10 A Sharp Embedding Result Arising from a Fluid-Structure Interaction Problem
Anna Mazzucato, Pennsylvania State University, U.S.; Nikolai Chemetov, Universidade de Lisboa, Portugal

4:15-4:40 On the Well-Posedness of the Inviscid Quasi-Geostrophic Equations for Large-Scale Geophysical Flows
Qingshan Chen, Clemson University, U.S.

4:45-5:10 Refined Approaches for Energy Minimization
Arthur Bousquet, Indiana University, U.S.

Friday, December 13

MS72

Recent Results in Incompressible Fluid Mechanics - Part I of III

3:15 p.m.-5:15 p.m.

Room: Flores 7

For Part 2 see MS85

Fluid mechanics is an important branch of physics that studies the laws governing the motion of fluids depending on properties such as fluid density, viscosity and compressibility. Mathematically, the theoretical understanding is far from complete even for incompressible fluids. Analytic techniques have been used, and many times developed, to successfully prove results about the behavior of incompressible fluids as described by various models. These models include the Euler equations, Navier-Stokes equations, Darcy's law for fluid flow in porous media, the surface quasi-geostrophic models for atmospheric flows, etc. Beside the fundamental question of existence and uniqueness of solutions, recent research on these incompressible fluid models have yielded results regarding stability of solutions, long-time asymptotic behavior, regularity, finite time singularities and more. The purpose of this minisymposium is to bring together both senior researchers and young mathematicians to discuss the current state of this subject and the mathematical methods that have been successful. Particular interest may be paid to the analysis of free boundary problems, but the scope of the symposium is not limited to it.

Organizer: Neel Patel
University of Michigan, U.S.

Organizer: Eduardo Garcia-Juarez
University of Pennsylvania, U.S.

Organizer: Annalaura Stingo
University of California, Davis, U.S.

3:15-3:40 Validity of Steady Prandtl Layer Expansions
Sameer Iyer, Princeton University, U.S.

3:45-4:10 Angled Crested Type Water Waves
Siddhant Agrawal, University of Massachusetts, Amherst, U.S.

continued in next column

4:15-4:40 On Well-Posedness and Global Solutions for the Muskat Problem
Huy Nguyen, Brown University, U.S.

4:45-5:10 Justification of the Peregrine Soliton from Full Water Waves
Qingtang Su, University of Michigan, U.S.

Friday, December 13

MS73

Recent Progress in Incompressible Fluid Dynamics - Part I of III

3:15 p.m.-5:15 p.m.

Room: Flores 8

For Part 2 see MS86

A plethora of physical phenomena are well-described by the equations of incompressible fluids, the Euler and Navier-Stokes equations, along with the many variations incorporating additional physical phenomena. In this minisymposium, the speakers will address several of the fundamental issues surrounding these equations. Themes include well-posedness, high- as well as low-regularity solutions, blow-up of solutions, numerical approximations, fluid flow on manifolds, low-viscosity solutions, and flows through porous media.

Organizer: James P. Kelliher
University of California, Riverside, U.S.

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

3:15-3:40 Ill-Posedness for the Generalized SQG Equations with Singular Velocity
In-Jee Jeong, Korea Institute for Advanced Study, Korea

3:45-4:10 Blowup Condition of the Incompressible Navier-Stokes Equations in Terms of One Velocity Component
Hantaek Bae, Ulsan National Institute of Science and Technology, South Korea

4:15-4:40 Special Solutions to the 2D Euler Equation
Tarek Elgindi, University of California, San Diego, U.S.

4:45-5:10 Navier-Stokes Equations and Onsager's Conjecture
Alexey Cheskidov and Xiaoyutao Luo, University of Illinois, Chicago, U.S.

Friday, December 13

MS74

Analysis and Modeling of PDEs in Materials Science and Biological Systems - Part I of III

3:15 p.m.-5:15 p.m.

Room: Capra A

For Part 2 see MS87

This minisymposium focuses on the mathematical modeling, analysis, and numerical simulations of PDEs for diverse phenomena in materials science and biological systems. The research is related to the PDE-based models arising in variational descriptions of the systems and their analysis and simulation. The speakers will talk about their recent work on a range of interesting problems including but not limited to the defects structures in solids, phase-field models in complex fluids, and morphological evolution in biological systems.

Organizer: Tao Luo
Purdue University, U.S.

Organizer: Chaozhen Wei
Worcester Polytechnic Institute, U.S.

3:15-3:40 From Atomistic Model to the Peierls–Nabarro Model with Gamma-Surface for Dislocations
Yang Xiang, Hong Kong University of Science and Technology, Hong Kong

3:45-4:10 Dynamics of Grain Boundaries with Evolving Lattice Orientations and Triple Junctions
Masashi Mizuno, Nihon University, Japan; Chun Liu, Illinois Institute of Technology, U.S.; Yekaterina Epshteyn, University of Utah, U.S.

4:15-4:40 Energy and Dynamics of Grain Boundaries Based on Underlying Microstructure
Luchan Zhang, National University of Singapore, Singapore

4:45-5:10 A Unified Disconnection Model for the Grain Boundary and Triple Junction Dynamics
Chaozhen Wei, Worcester Polytechnic Institute, U.S.; David J. Srolovitz, University of Pennsylvania, U.S.; Yang Xiang, Hong Kong University of Science and Technology, Hong Kong

Friday, December 13

MS75

Recent Development in Analysis and Computation of Hyperbolic and Kinetic Problems - Part I of III

3:15 p.m.-5:15 p.m.

Room: Capra B

For Part 2 see MS88

Hyperbolic and kinetic models arise from a broad range of application problems such as gas and fluid dynamics, plasma physics, magnetohydrodynamic and so on. Advanced computational techniques for these model problems have been under great development in the past few decades, yet many open challenges remain. In this mini symposium, we bring together researchers to discuss PDE/numerical analysis, computation, and model techniques for solving hyperbolic, kinetic and multi scale models. Presentations on modern computational methodology development such as multi-resolution, adaptivity, reduced order modeling, and on numerical analysis such as structure preserving, asymptotic preserving, asymptotic stable and accurate will be featured in our mini symposium.

Organizer: Yingda Cheng
Michigan State University, U.S.

Organizer: Fengyan Li
Rensselaer Polytechnic Institute, U.S.

Organizer: Jingmei Qiu
University of Delaware, U.S.

3:15-3:40 Asymptotic and Positivity Preserving Methods for Kerr-Debye Model with Lorentz Dispersion in One Dimension
Zhichao Peng, Rensselaer Polytechnic Institute, U.S.

3:45-4:10 Arbitrary Order Hermite Methods for Time Dependent Problems
Daniel Appelo, University of Colorado Boulder, U.S.

4:15-4:40 Fast Fourier Spectral Method for the Boltzmann Collision Operator with Non-Cutoff Kernels
Jingwei Hu, Purdue University, U.S.

4:45-5:10 Semi-Lagrangian Discontinuous Galerkin Method for the Bgk Model: Formulation and Accuracy Analysis in the Fluid Limit
Ruiwen Shu, University of Maryland, College Park, U.S.

Friday, December 13

MS76

Inviscid Fluid Dynamics - Part II of II

3:15 p.m.-5:15 p.m.

Room: Capra C

For Part 1 see MS63

One of the fundamental systems in fluid mechanics is the Euler system describing flows of inviscid fluids. Although the system was formulated in the eighteenth century, only now we are observing incredible progress both in the well-posedness (or rather ill-posedness) theory and in the observation of various fundamental properties of solutions. The minisymposium addresses recent progress not only for Euler system, but more generally for inviscid fluid dynamics. The most emerging topics in this field include the resolution of the famous Onsager's conjecture, existence and uniqueness of different notions of solutions or the phenomenon of weak-strong uniqueness among many other questions.

Organizer: Agnieszka Swierczewska-Gwiazda
University of Warsaw, Poland

Organizer: Emil Wiedemann
Leibniz University Hannover, Germany

3:15-3:40 The Navier-Stokes-End-Functionalized Polymer System
Theodore D. Drivas, Princeton University, U.S.

3:45-4:10 On a Model Arising in Fluid Mechanics and Collective Behaviors
Angel Castro, ICMAT, Spain

4:15-4:40 Relative Entropy Method for Measure-Valued Solutions of Fluid Equations
Tomasz Debiec, University of Warsaw, Poland

4:45-5:10 Pushing Forward the Theory of Well-Posedness for Systems of Conservation Laws Verifying a Single Entropy Condition
Sam G. Krupa, University of Texas at Austin, U.S.; Alexis F. Vasseur, University of Texas, Austin, U.S.

Friday, December 13

MS77

Singular Solutions to Geometric Problems in Continuum and Discrete Mechanics - Part II of II

3:15 p.m.-4:45 p.m.

Room: Capra D

For Part 1 see MS64

Geometric ideas play a key role in the analysis of PDEs, including, but not limited to, an understanding of PDEs as in terms of rigidity/flexibility through an investigation of geometric structures in solutions, and the quest for methods that respect/exploit the natural geometric features that are intrinsic to the PDE. In our minisymposium, we plan to bring together scientists studying multi-scale solutions to various (geometric, variational, integrable, etc) PDEs using geometrical ideas. The goal is to encourage interactions among different mathematical communities, to organize a forum for investigating connections between problems and techniques and to discuss advances and challenges from different perspectives. We will give particular attention to "singular" and "discrete" constructions and methods that inform and enrich the descriptions available via "continuum" theories. The minisymposium will be organized around the following interrelated topics: (1) Discrete geometry and "structure-preserving" methods for PDEs; (2) Rough solutions and convex integration constructions for elasticity, fluids and transport equations; (3) Variational problems and the geometry of defects.

Organizer: Marta Lewicka
University of Pittsburgh, U.S.

Organizer: Shankar C. Venkataramani
University of Arizona, U.S.

3:15-3:40 An Integrable, Hamiltonian Structure for the Gross-Pitaevskii Hierarchy

Natasa Pavlovic, University of Texas at Austin, U.S.

3:45-4:10 On the First Critical Field of a 3D Anisotropic Superconductivity Model

Andres A. Contreras, New Mexico State University, U.S.; *Guanying Peng*, University of Arizona, U.S.

continued in next column

4:15-4:40 Extreme Vortex Concentration Phenomena in Ginzburg-Landau Problems

Andres A. Contreras, New Mexico State University, U.S.

Friday, December 13

MS78

Patterns in Fluids and Materials: Analytical and Numerical Perspectives - Part II of III

3:15 p.m.-5:15 p.m.

Room: Capra E

For Part 1 see MS65
For Part 3 see MS91

The purpose of this minisymposium is to bring senior and junior researchers in the field of pattern formation, in a rather broad sense. Recent breakthroughs in the field from diverse applications inspires the search for recurring and perhaps unifying themes. The goal of the minisymposium is to exchange new ideas on the study of mathematical models arising as descriptions of patterns in complex physical and biological systems; examples include swarming, complex fluids and solids. Such systems form patterns and defects, undergo phase transitions, and are often sensitive to external forces. Mathematical models and numerical simulations can help understanding, predicting and controlling these phenomena better. The speakers of this minisymposium will present recent advances on the modeling, mathematical and numerical analysis of defect dynamics, instabilities and phase transitions in applications such as convection, swarming and complex materials. The minisymposium will highlight the role of partial differential equations in these application areas, serve as a forum for the dissemination of new scientific ideas and discoveries and will enhance scientific communication.

Organizer: Franziska Weber
Carnegie Mellon University, U.S.

Organizer: Raghav Venkatraman
Carnegie Mellon University, U.S.

3:15-3:40 A Homogenization Result in the Gradient Theory of Phase Transitions

Irene Fonseca, Carnegie Mellon University, U.S.

3:45-4:10 Minimizers and Splitting in TFDW Type Models

Lorena Aguirre Salazar, McMaster University, Canada

4:15-4:40 Optimal Design of Wall-Bounded Heat Transport

Ian Tobasco, University of Illinois at Chicago, U.S.

continued on next page

4:45-5:10 Existence and Stability of Liquid-Solid Phases in a Simple Swarming Model
Ihsan Topaloglu, Virginia Commonwealth University, U.S.

Friday, December 13

MS79

Kinetic Modeling: Analysis and Applications Part I of III

3:15 p.m.-5:15 p.m.

Room: The Studios

For Part 2 see MS92

This minisymposium will focus on new mathematical methods to rigorously understand the emergence of kinetic equations associated to particle interactions in the modeling of bridging quantum to hydrodynamics systems. Such kinetic models can be viewed as statistical flow descriptions. We will discuss different analytical issues of interacting particle models of Boltzmann or Landau type, ranging from classical gas dynamics interactions in neutral and plasma regimes, aggregation and breakage, gas mixture systems and the connection of quantum to kinetic systems though mean field theory approaches as much as bio and social interactions. Applications range from modeling systems for plasma and kinetic chemistry, of sprays and shear flows, population dynamics in biological systems and the formation and evolution of condensed gases in quantum kinetic regimes, among many possible applications.

Organizer: Irene M. Gamba
University of Texas, Austin, U.S.

Organizer: Alessia Nota
University of Bonn, Germany

Organizer: Maja Taskovic
Emory University, U.S.

3:15-3:40 Swarming Models with Local Alignment Effects: Phase Transitions and Hydrodynamics
José A. Carrillo, Imperial College London, United Kingdom

3:45-4:10 Uniqueness of Solutions to a Gas-Solid Interacting System
Weiran Sun, Simon Fraser University, Canada

4:15-4:40 Multicomponent Coagulation Equation for Aerosol Dynamics
Marina A. Ferreira, University of Helsinki, Finland

4:45-5:10 Global Mild Solutions of the Landau and Non-Cutoff Boltzmann Equation
Robert M. Strain, University of Pennsylvania, U.S.

Friday, December 13

CP11

Numerical Analysis and Methods I

3:15 p.m.-4:55 p.m.

Room: Fiesta 8

Chair: Jolene Britton, University of California, Riverside, U.S.

3:15-3:30 Generalized Multiscale Finite Element Method for a Strain-Limiting Nonlinear Elasticity Model
Shubin Fu and Eric Chung, Chinese University of Hong Kong, Hong Kong; *Tina Mai*, Duy Tan University, Vietnam

3:35-3:50 An Overlapping Local Projection Stabilized Finite Element Methods for Darcy Flow
Deepika Garg and Sashikumaar Ganesan, Indian Institute of Science, Bangalore, India

3:55-4:10 An Entropy-Adjoint Order-Adaptive Discontinuous Galerkin Method for the Simulation of Chaotic Flows
Matteo Franciolini, NASA Ames Research Center, U.S.; Francesco Bassi and Alessandro Colombo, University of Bergamo, Italy; Andrea Crivellini, Università Politecnica delle Marche, Italy; Krzysztof Fidkowski, University of Michigan, U.S.; Antonio Ghidoni and Gianmaria Noventa, University of Brescia, Italy

4:15-4:30 A Numerical Algorithm Based on Finite Element Method for Simulation of Some Parabolic Problems
Ram Jiwari, Indian Institute of Technology Roorkee, India

4:35-4:50 High Order Moving-Water Equilibria Preserving Discontinuous Galerkin Methods for the Ripa Model
Jolene Britton and Yulong Xing, University of California, Riverside, U.S.

Friday, December 13

CP12

Hyperbolic and Kinetic PDE I

3:15 p.m.-4:55 p.m.

Room: Santa Rosa

Chair: Yunbai Cao, University of Wisconsin, Madison, U.S.

3:15-3:30 Spectral Stability of Ideal-Gas Shock Layers in the Strong Shock Limit
Bryn N. Balls-Barker, Brigham Young University, U.S.

3:35-3:50 On Convergence of Nonlocal Conservation Laws to Local Conservation Laws
Alexander Keimer, University of California, Berkeley, U.S.; Lukas Pflug, Friedrich-Alexander Universitaet Erlangen-Nuernberg, Germany

3:55-4:10 One-Dimensional Cylindrical Shock Waves in Non-Ideal Magnetogasdynamics
Mayank Singh, Indian Institute of Technology Roorkee, India

4:15-4:30 On Boundary Layers for the Burgers Equations in a Circle Domain
Junho Choi, Ulsan National Institute of Science and Technology, South Korea

4:35-4:50 The Vlasov-Poisson-Boltzmann System in Bounded Domains
Yunbai Cao, University of Wisconsin, Madison, U.S.

Saturday, December 14

Registration

8:00 a.m.-3:00 p.m.

Room: Flores Foyer

Saturday, December 14

MS52

Mean Field Games: Theory and Applications - Part II of III

8:30 a.m.-10:30 a.m.

Room: Flores B/C

For Part 1 see MS38
For Part 3 see MS62

Mean field game theory is a mathematical framework established recently by Lasry-Lions and Caines-Huang-Malhame in order to describe a contiuum of rational agents in Nash equilibrium. In this minisymposium we will discuss a range of theoretical aspects of mean field games, such as Hamilton-Jacobi equations on infinite dimensional spaces, the master equation, forward-backward systems of PDE, optimal transport, the calculus of variations, a priori estimates and fixed point theorems. In addition, we will address applications, including, but not limited to, economics, finance, pedestrian crowd modeling, flocking, and traffic flow.

Organizer: Jameson Graber
Baylor University, U.S.

Organizer: Alpar Meszaros
University of California, Los Angeles, U.S.

8:30-8:55 Homogenization of a Stationary Mean-Field Game via Two-Scale Convergence
Rita Ferreira, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

9:00-9:25 Forward-Forward Mean Field Games and Conservation Laws
Levon Nurbekyan, University of California, Los Angeles, U.S.

9:30-9:55 Derivation of Smooth, Short-Time Solutions to a 1st Order MFG Master Equation
Sergio Mayorga, Baylor University, U.S.

10:00-10:25 An Optimal Transport Approach for the Planning Problem
Carlo Orrieri, University of Trento, Italy

Saturday, December 14

MS80

Recent Developments in Numerical Analysis of PDEs and Their Applications - Part II of III

8:30 a.m.-10:30 a.m.

Room: Flores 5

For Part 1 see MS67
For Part 3 see MS93

Numerical analysis of partial differential equations and their applications have played a crucial role in applied and computational mathematics. This minisymposium focuses on recent developments in numerical analysis and aims to bring together the leading researchers in the fields of applied and computational mathematics to discuss and disseminate the latest advances and envisage future challenges in both the traditional and new areas of scientific and engineering computing. The topics of this minisymposium will cover a broad range of numerical methods including but not limited to weak Galerkin finite element methods, discontinuous Galerkin finite element methods and finite volume methods for various PDEs, such as nonlinear parabolic problems, Helmholtz equations, time fractional equations, rheological fluid flow, quasilinear elliptic PDE, Maxwell's equations, etc., their analysis and applications.

Organizer: Chunmei Wang
Texas Tech University, U.S.

Organizer: Jun Zou
The Chinese University of Hong Kong, Hong Kong

8:30-8:55 Finite Volume Weno Schemes for Nonlinear Parabolic Problems with Degenerate Diffusion on Non-Uniform Meshes
Todd Arbogast, University of Texas at Austin, U.S.; Chieh-Sen Huang, National Sun Yat-Sen University, Taiwan; Xikai Zhao, University of Texas at Austin, U.S.

9:00-9:25 An Pure Source Transfer Domain Decomposition Method for Helmholtz Equations in Unbounded Domain
Haijun Wu, Nanjing University, China

9:30-9:55 Fast Algorithms for Deep Learning based PDE Solvers
Haizhao Yang, Purdue University, U.S.

10:00-10:25 Anderson Acceleration for Nonlinear PDE
Sara Pollock, University of Florida, U.S.

Saturday, December 14

MS81

PDEs in Machine Learning - Part II of II

8:30 a.m.-10:30 a.m.

Room: Flores 1

For Part 1 see MS68

Machine learning (ML) has been a fast growing area of research since the beginning of the 21st century due to the advent of computing resources and availability of data. Recently interesting connections between the theory of partial differential equations (PDEs) and ML have been discovered that provide deep insights into the behavior of ML algorithms and problems in certain asymptotic regimes and also lead to improvements or entirely new algorithms. The goal of this minisymposium is to bring together experts at the intersectsion of PDEs and ML to discuss recent advances in this interdisciplinary field of research.

Organizer: Bamdad Hosseini
California Institute of Technology, U.S.

Organizer: Andrew Stuart
California Institute of Technology, U.S.

8:30-8:55 Consistency of Graph Total Variation Below the Connectivity Threshold
Andrea Braides, University of Rome II, Rome, Italy; Nicolas Garcia Trillos, University of Wisconsin, Madison, U.S.; Andrey Piatnitski, Narvik Institute of Technology, Norway; *Dejan Slepcev*, Carnegie Mellon University, U.S.

9:00-9:25 Wasserstein Information Geometric Learning
Wuchen Li, University of California, Los Angeles, U.S.

9:30-9:55 Consistency of Probit Semi-Supervised Learning in the Continuum Limit
Bamdad Hosseini, California Institute of Technology, U.S.

10:00-10:25 Variational and Statistical Approaches to Deep Learning: Robustness and Confidence using Modified Losses
Adam M. Oberman, McGill University, Canada

Saturday, December 14

MS82

Mathematical Exploration of Particle Systems: PDEs, Competitive Games and Data Science - Part I of II

8:30 a.m.-10:30 a.m.

Room: Flores 2

For Part 2 see MS95

Particle systems are successfully applied in simulations of many biological systems, including migrations of schools of fish in the ocean. One can consider the continuum limit of these particle systems, and, when comparing the solutions to the PDEs, the resulting densities can be compared directly to scientific observations. For accurate predictions, it is important to include environmental information; it is also imperative to include the correct form of the noise for each environment. This addition of noise implies that the systems can be formulated as competitive games and leads to new mathematics where equations involving derivatives with respect to densities appear. It is also of interest to compare the predictions of the dynamics to the predictions made by data science. This minisymposium will explore all of these issues both from a mathematical and biological perspective.

Organizer: Alethea Barbaro
Case Western Reserve University, U.S.

Organizer: Bjorn Birnir
University of California, Santa Barbara, U.S.

8:30-8:55 An Interacting Particle Model for Fish in a Changing Environment
Alethea Barbaro, Case Western Reserve University, U.S.; Bjorn Birnir, University of California, Santa Barbara, U.S.; Sam Subbey, Institute of Marine Research, Bergen, Norway

9:00-9:25 The Canary in the Coalmine: Capelin as a Probe for Climate Change
Bjorn Birnir, University of California, Santa Barbara, U.S.

9:30-9:55 Deep Learning Seismic Substructure Detection using the Frozen Gaussian Approximation
Jay Roberts, University of California, Santa Barbara, U.S.

10:00-10:25 A Particle Model for Territorial Development and its Continuum Limit
Abdulaziz Alsenafi, Kuwait University, Kuwait

Saturday, December 14

MS83

Gauge Theory and Partial Differential Equations - Part III of IV

8:30 a.m.-10:30 a.m.

Room: Flores 3

For Part 2 see MS70
For Part 4 see MS96

Almost all of the speakers are experts on the Yang-Mills or coupled Yang-Mills equations. Yang-Mills gauge theory seeks to describe the behavior of elementary particles using non-Abelian Lie groups and is at the core of the unification of the electromagnetic force and weak forces (i.e., U(1) x SU(2)) as well as quantum chromodynamics, the theory of the strong force (based on SU(3)). Thus, it forms the basis of our understanding of the Standard Model of particle physics. Coupled Yang-Mills equations arise when one considers Euler-Lagrange equations for an energy function that intertwines a connection A and one more sections of vector bundles associated with P and this has is a very active area of research, due to their roles in theoretical physics and applications to differential geometry, representation theory, symplectic geometry, and low-dimensional topology. Examples include the Hitchin-Simpson equations (1987, 1988), Kapustin-Witten equations, SO(3) monopole equations, Seiberg-Witten monopole equations, Vafa-Witten equations, as well as other coupled Yang-Mills equations arising in particle physics. Many of our speakers will describe their work on such coupled Yang-Mills equations, including central questions of compactness and geometry of the moduli spaces of solutions and applications to the definition of invariants.

Organizer: Paul Feehan
Rutgers University, U.S.

Organizer: Duong Phong

8:30-8:55 The Anomaly Flow and Calabi-Yau Manifolds with Torsion
Sebastian Picard, Harvard University, U.S.

9:00-9:25 On Monopoles with Nonmaximal Symmetry Breaking
Akos Nagy, Duke University, U.S.

9:30-9:55 Kapustin-Witten Monopole Equations
Goncalo Oliveira, Universidade Federal Fluminense, Brazil

continued in next column

10:00-10:25 On Orientations for Gauge-Theoretic Moduli Spaces
Yuuji Tanaka, University of Oxford, United Kingdom

Saturday, December 14

MS84

Recent Developments on Analysis and Computations in Fluid Dynamics - Part II of III

8:30 a.m.-10:30 a.m.

Room: Flores 6

For Part 1 see MS71
For Part 3 see MS97

Over the past decades, there have been made active interactions between the analysis and numerical computations in fluid mechanics. In this minisymposium, we bring together the leading experts and aim to discuss recent developments in this research direction including, e.g., the existence, regularity, and asymptotic behavior of solutions to fluid equations as well as the implementation and convergence analysis of some effective numerical methods.

Organizer: YoungJoon Hong
San Diego State University, U.S.

Organizer: Gung-Min Gie
University of Louisville, U.S.

Organizer: Bongsuk Kwon
Ulsan National Institute of Science and Technology, South Korea

8:30-8:55 Ill-Posedness Results for Certain Nonlinear Wave Equations in Smooth Function Classes
Jerry Bona, University of Illinois, Chicago, U.S.; David Ambrose, Drexel University, U.S.; David P. Nicholls, University of Illinois, Chicago, U.S.; Timur Milgrom, Drexel University, U.S.

9:00-9:25 Boundary Layers for Incompressible Fluids: The Annoyance of Characteristic Points
James P. Kelliher, University of California, Riverside, U.S.; Gung-Min Gie, University of Louisville, U.S.

9:30-9:55 Variational Reduction Formulas for Predicting High-Order Critical and Stochastic Transitions
Mickael Chekroun, University of California, Los Angeles, U.S.

10:00-10:25 Convective Stability with an Additional Stochastic Heat Source
Jared P. Whitehead, Brigham Young University, U.S.

Saturday, December 14

MS85

Recent Results in Incompressible Fluid Mechanics - Part II of III

8:30 a.m.-10:30 a.m.

Room: Flores 7

For Part 1 see MS72
For Part 3 see MS98

Fluid mechanics is an important branch of physics that studies the laws governing the motion of fluids depending on properties such as fluid density, viscosity and compressibility. Mathematically, the theoretical understanding is far from complete even for incompressible fluids. Analytic techniques have been used, and many times developed, to successfully prove results about the behavior of incompressible fluids as described by various models. These models include the Euler equations, Navier-Stokes equations, Darcy's law for fluid flow in porous media, the surface quasi-geostrophic models for atmospheric flows, etc. Beside the fundamental question of existence and uniqueness of solutions, recent research on these incompressible fluid models have yielded results regarding stability of solutions, long-time asymptotic behavior, regularity, finite time singularities and more. The purpose of this minisymposium is to bring together both senior researchers and young mathematicians to discuss the current state of this subject and the mathematical methods that have been successful. Particular interest may be paid to the analysis of free boundary problems, but the scope of the symposium is not limited to it.

Organizer: Neel Patel
University of Michigan, U.S.

Organizer: Eduardo Garcia-Juarez
University of Pennsylvania, U.S.

Organizer: Annalaura Stingo
University of California, Davis, U.S.

8:30-8:55 Sharp Fronts for the Sqg Equation
Jingyang Shu, University of California, Davis, U.S.

9:00-9:25 On the Relativistic Landau Equation
Robert M. Strain, University of Pennsylvania, U.S.

continued in next column

9:30-9:55 Dispersive Solutions for the Kdv Flow
Mihaela Ifrim, University of California, Berkeley, U.S.

10:00-10:25 Water Waves with Time-Dependent and Deformable Angled Crests (or Corners)
Steve Shkoller, University of California, Davis, U.S.

Saturday, December 14

MS86

Recent Progress in Incompressible Fluid Dynamics - Part II of III

8:30 a.m.-10:30 a.m.

Room: Flores 8

For Part 1 see MS73
For Part 3 see MS99

A plethora of physical phenomena are well-described by the equations of incompressible fluids, the Euler and Navier-Stokes equations, along with the many variations incorporating additional physical phenomena. In this minisymposium, the speakers will address several of the fundamental issues surrounding these equations. Themes include well-posedness, high- as well as low-regularity solutions, blow-up of solutions, numerical approximations, fluid flow on manifolds, low-viscosity solutions, and flows through porous media.

Organizer: James P. Kelliher
University of California, Riverside, U.S.

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

8:30-8:55 Vorticity Measures and Vanishing Viscosity
Milton Lopes Filho, Federal University of Rio de Janeiro, Brazil; Peter Constantin, Princeton University, U.S.; Helena Nussenzveig Lopes, Universidade Federal de Rio de Janeiro, Brazil; Vlad C. Vicol, Princeton University, U.S.

9:00-9:25 Well-Posedness of the 2D Euler Equations when Velocity Grows at Infinity
Elaine Cozzi, Oregon State University, U.S.; James P. Kelliher, University of California, Riverside, U.S.

9:30-9:55 On the Vanishing Viscosity Problem for the Navier-Stokes Equations
Igor Kukavica, University of Southern California, U.S.; Vlad C. Vicol, Princeton University, U.S.

10:00-10:25 The Stokes Equation and its Fundamental Solution on the Hyperbolic Space
Magdalena Czubak, University of Colorado Boulder, U.S.; Chi Hin Chan, National Chiao Tung University, Taiwan

Saturday, December 14

MS87

Analysis and Modeling of PDEs in Materials Science and Biological Systems - Part II of III

8:30 a.m.-10:30 a.m.

Room: Capra A

For Part 1 see MS74
For Part 3 see MS100

This minisymposium focuses on the mathematical modeling, analysis, and numerical simulations of PDEs for diverse phenomena in materials science and biological systems. The research is related to the PDE-based models arising in variational descriptions of the systems and their analysis and simulation. The speakers will talk about their recent work on a range of interesting problems including but not limited to the defects structures in solids, phase-field models in complex fluids, and morphological evolution in biological systems.

Organizer: Tao Luo
Purdue University, U.S.

Organizer: Chaozhen Wei
Worcester Polytechnic Institute, U.S.

8:30-8:55 Multiscale Continuum Elastic Model of Solid Tumor Growth
John Lowengrub, University of California, Irvine, U.S.

9:00-9:25 Modeling Cell Wall Morphology and Elongation at the Root Tip
Min Wu, Dianjenis Abreu, Danush Chelladurai, and Luis Vidali, Worcester Polytechnic Institute, U.S.

9:30-9:55 Uncertainty Quantification for Linear Transport Equation with Random Inputs: Analysis and Numerics
Zheng Ma, Purdue University, U.S.

10:00-10:25 Numerical Solutions to the Free Boundary Problem for a Void in a Solid with Anisotropic Surface Energy
Weiqi Wang, State University of New York at Buffalo, U.S.

Saturday, December 14

MS88

Recent Development in Analysis and Computation of Hyperbolic and Kinetic Problems - Part II of III

8:30 a.m.-10:30 a.m.

Room: Capra B

For Part 1 see MS75
For Part 3 see MS101

Hyperbolic and kinetic models arise from a broad range of application problems such as gas and fluid dynamics, plasma physics, magnetohydrodynamic and so on. Advanced computational techniques for these model problems have been under great development in the past few decades, yet many open challenges remain. In this mini symposium, we bring together researchers to discuss PDE/ numerical analysis, computation, and model techniques for solving hyperbolic, kinetic and multi scale models. Presentations on modern computational methodology development such as multi-resolution, adaptivity, reduced order modeling, and on numerical analysis such as structure preserving, asymptotic preserving, asymptotic stable and accurate will be featured in our mini symposium.

Organizer: Yingda Cheng
Michigan State University, U.S.

Organizer: Fengyan Li
Rensselaer Polytechnic Institute, U.S.

Organizer: Jingmei Qiu
University of Delaware, U.S.

8:30-8:55 Energy and Hamiltonian-Preserving Local Discontinuous Galerkin Methods for the Klein-Gordon-Schrodinger Equations
Yang He, Augusta University, U.S.

9:00-9:25 An Implicit Finite Element Method for Reduced Resistive Mhd
Qi Tang, Los Alamos National Laboratory, U.S.

9:30-9:55 Galerkin Method for Stationary Radiative Transfer Equations with Uncertain Coefficients
Xinghui Zhong, Zhejiang University, China

10:00-10:25 An Adaptive Multiresolution Discontinuous Galerkin Method with Artificial Viscosity for Scalar Conservation Laws in Multi-Dimensions
Juntao Huang, Michigan State University, U.S.

Saturday, December 14

MS89

Long Time Behaviour and Fine Asymptotics of Gradient Flows - Part I of II

8:30 a.m.-10:30 a.m.

Room: Capra C

For Part 2 see MS102

PDEs of gradient flow type are ubiquitous in mathematics and its applications since they describe the transition of a physical system from a state of high to a state of low energy. An interesting question that arises within the study of such equations is whether they converge to an equilibrium state (as time goes to infinity) and if so how fast. Here the story splits up: often the equilibrium itself is of high physical interest and one wants to prove a rate of convergence. In this case, one typically measures the distance to the stationary state using a relative entropy functional. In other scenarios, like pure diffusion, the equilibrium and convergence rates are well-known and rather uninteresting. In these cases, one would rather like to understand the fine asymptotics of the solution by rescaling with its convergence rate in order to prevent it from reaching the equilibrium state. These rescaled solutions then typically converge to an eigenfunction of the operator that defines the gradient flow which gives interesting insides into nonlinear spectral theory and has applications, for instance, in spectral graph clustering. In this two-part minisymposium researchers will present their latest results and discuss future trends in the field.

Organizer: Jan-Frederik Pietschmann
Technische Universität, Chemnitz, Germany

Organizer: Leon Bungert
Friedrich-Alexander Universitaet Erlangen-Nuernberg, Germany

8:30-8:55 Gradient Flow Approach to the Boltzmann and Landau Equations
Matthias Erbar, Universitaet Bonn, Germany

continued on next page

9:00-9:25 Interacting Particle Systems and Asymptotic Gradient Flows Structures
Marie-Therese Wolfram, University of Warwick, United Kingdom; Maria Bruna, University of Oxford, United Kingdom; Martin Burger, Universität Erlangen, Germany; Helene Ranetbauer, University of Vienna, Austria

9:30-9:55 Some Remarks on a System of Cross-Diffusion Equations with Formal Gradient Flow Structure
Jan-Frederik Pietschmann, Technische Universität, Chemnitz, Germany

10:00-10:25 Dislocations Dynamics: From Microscopic Models to Macroscopic Crystal Plasticity
Stefania Patrizi, University of Texas at Austin, U.S.

Saturday, December 14

MS90

Asymptotics of PDEs with Random Coefficients - Part I of II

8:30 a.m.-10:00 a.m.

Room: Capra D

For Part 2 see MS103

This session will review recent progress in the field of PDEs with random coefficients in the broad sense, with an emphasis on asymptotic theory. The scope of the minisymposium includes, but is not limited to, Homogenization, Waves in Random Media and Imaging, Stochastic PDEs, Reaction-Diffusion equations.

Organizer: Olivier Pinaud
Colorado State University, U.S.

Organizer: Alexei Novikov
Pennsylvania State University, U.S.

8:30-8:55 Wave Propagation in Moving Random Media and Applications to Imaging
Liliana Borcea, University of Michigan, U.S.

9:00-9:25 Multiscale Analysis of Wave Propagation and Imaging in Random Media
Knut Solna, University of California, Irvine, U.S.; Josselin Garnier, Ecole Polytechnique, France

9:30-9:55 Title Not Available
Lenya Ryzhik, Stanford University, U.S.

Saturday, December 14

MS91

Patterns in Fluids and Materials: Analytical and Numerical Perspectives - Part III of III

8:30 a.m.-10:30 a.m.

Room: Capra E

For Part 2 see MS78

The purpose of this minisymposium is to bring senior and junior researchers in the field of pattern formation, in a rather broad sense. Recent breakthroughs in the field from diverse applications inspires the search for recurring and perhaps unifying themes. The goal of the minisymposium is to exchange new ideas on the study of mathematical models arising as descriptions of patterns in complex physical and biological systems; examples include swarming, complex fluids and solids. Such systems form patterns and defects, undergo phase transitions, and are often sensitive to external forces. Mathematical models and numerical simulations can help understanding, predicting and controlling these phenomena better. The speakers of this minisymposium will present recent advances on the modeling, mathematical and numerical analysis of defect dynamics, instabilities and phase transitions in applications such as convection, swarming and complex materials. The minisymposium will highlight the role of partial differential equations in these application areas, serve as a forum for the dissemination of new scientific ideas and discoveries and will enhance scientific communication.

Organizer: Franziska Weber
Carnegie Mellon University, U.S.

Organizer: Raghav Venkatraman
Carnegie Mellon University, U.S.

8:30-8:55 A Nonlinear Fluid-Mesh-Shell Interaction Problem
Suncica Canic, University of California, Berkeley, U.S.; Marija Galic and B. Muha, University of Zagreb, Croatia

9:00-9:25 A Finite Element Method for the Q-Tensor Model of Nematic Liquid Crystals
Wujun Zhang, Rutgers University, U.S.; Shawn Walker, Louisiana State University at Shreveport, U.S.

continued on next page

Saturday, December 14

MS91

Patterns in Fluids and Materials: Analytical and Numerical Perspectives - Part III of III

continued

9:30-9:55 On the Dynamics of Ferrofluids: A Relaxation Limit from the Rosensweig Model Towards Equilibrium

Franziska Weber, Carnegie Mellon University, U.S.; Konstantina Trivisa, University of Maryland, U.S.; Ricardo H. Nochetto, University of Maryland, U.S.

10:00-10:25 Attractors for Internal Waves in Stratified Fluids: A Numerical Analysis Viewpoint

Nilima Nigam, Simon Fraser University, Canada

Saturday, December 14

MS92

Kinetic Modeling: Analysis and Applications Part II of III

8:30 a.m.-10:30 a.m.

Room: The Studios

For Part 1 see MS79
For Part 3 see MS105

This minisymposium will focus on new mathematical methods to rigorously understand the emergence of kinetic equations associated to particle interactions in the modeling of bridging quantum to hydrodynamics systems. Such kinetic models can be viewed as statistical flow descriptions. We will discuss different analytical issues of interacting particle models of Boltzmann or Landau type, ranging from classical gas dynamics interactions in neutral and plasma regimes, aggregation and breakage, gas mixture systems and the connection of quantum to kinetic systems though mean field theory approaches as much as bio and social interactions. Applications range from modeling systems for plasma and kinetic chemistry, of sprays and shear flows, population dynamics in biological systems and the formation and evolution of condensed gases in quantum kinetic regimes, among many possible applications.

Organizer: Irene M. Gamba
University of Texas, Austin, U.S.

Organizer: Alessia Nota
University of Bonn, Germany

Organizer: Maja Taskovic
Emory University, U.S.

8:30-8:55 On the Large-Data Cauchy Theory of the Landau and Non-Cutoff Boltzmann Equations

Stanley Snelson, Florida Institute of Technology, U.S.

9:00-9:25 Semiclassical Limit from Hartree to Vlasov Poisson Equation

Laurent Lefleche, University of Paris IX-Dauphine, France and University of Texas at Austin, U.S.

9:30-9:55 Polynomial and Exponential Weighted Lpk Solutions of the System of Boltzmann Equations for Monatomic Gas Mixtures

Erica de la Canal, University of Texas at Austin, U.S.; Irene M. Gamba, University of Texas, Austin, U.S.; Milana Pavic-Colic, University of Novi Sad, Serbia

continued in next column

10:00-10:25 Long-Time Asymptotics for Homoenergetic Solutions of the Boltzmann Equation

Alessia Nota, University of Bonn, Germany; Richard James, University of Minnesota, U.S.; J.J.L. Velazquez, Universidad de Complutense de Madrid, Spain

Saturday, December 14

CP13

Numerical Analysis and Methods II

8:30 a.m.-10:10 a.m.

Room: Fiesta 8

Chair: Harish Kumar Kotapally, Indian Institute of Technology Roorkee, India

8:30-8:45 Wavelet Algorithms for a High-Resolution Image Reconstruction in Magnetic Induction Tomography
Ahmed Kaffel, Marquette University, U.S.

8:50-9:05 Legendre Wavelet Based Numerical Solution for 1D, 2D and 3D Benjamin–Bona–Mahony–Burgers Equation
Harish Kumar Kotapally and Ram Jiwari, Indian Institute of Technology Roorkee, India

9:10-9:25 Arbitrary High-Order Time-Stepping Methods for Reaction Diffusion Equations via Deferred Correction
Saint-Cyr E. Koyaguerebo-Imé and Yves Bourgault, University of Ottawa, Canada

9:30-9:45 Time Domain Finite Element Method for Nonlinear Maxwell's Equations
Asad Anees and Lutz Angermann, Techniche Universität Clausthal, Germany

9:50-10:05 The Application of Lagrange Operational Matrix Method for Two-Dimensional Hyperbolic Telegraph Equation
Vinita Devi, Rahul Kumar Maurya, and Vineet Kumar Singh, Indian Institute of Technology (Banaras Hindu University), India

Saturday, December 14

CP14

Hyperbolic and Kinetic PDE II

8:30 a.m.-10:10 a.m.

Room: Santa Rosa

Chair: Aekta Aggarwal, Indian Institute of Management, Indore, India

8:30-8:45 Delta Shock Waves for a Hyperbolic System of Conservation Laws
Richard De La Cruz, Universidad Pedagógica y Tecnológica de Colombia, Columbia; Marcelo Santos, IMECC-UNICAMP, Brazil; Eduardo Abreu, University of Campinas, Brazil

8:50-9:05 Characteristic Decompositions for the Unsteady Transonic Small Disturbance Equation
Katarina Jegdic, University of Houston-Downtown, U.S.

9:10-9:25 Group Classification, Similarity Solutions and Evolution of Weak Discontinuity for Ripa System
Pabitra K. Pradhan and Manoj Pandey, BITS Pilani, India

9:30-9:45 Delta Shocks in Systems of Conservation Laws of Keyfitz-Kranzer Type
Ralph Saxton, University of New Orleans, U.S.; Katarzyna Saxton, Loyola University, New Orleans, U.S.

9:50-10:05 Godunov Type Solvers for Euler System with Friction Terms
Aekta Aggarwal, Indian Institute of Management, Indore, India

Coffee Break

10:30 a.m.-10:55 a.m.

Room: Flores 4

Announcements

10:55 a.m.-11:00 a.m.

Room: Flores 5

Saturday, December 14

IP7

Collisional Kinetics of Multi-Component System Models

11:00 a.m.-11:45 a.m.

Room: Flores 5

Chair: Jingwei Hu, Purdue University, U.S.

We study the mathematical properties of complex particle systems modeling the `binary mixing of gas mixtures'. More precisely, we focus on the interaction of monoatomic and polyatomic gases with different masses. The model is realized by a Boltzmann system of equations for the evolution of vector valued probability distribution densities describing the random interacting particles through non-local bilinear forms, corresponding to the dynamics of binary mixing of identical shape particles with internal energy exchange but different masses. The corresponding Cauchy problem takes place in Banach spaces naturally associated to the solution observables, yielding global existence and uniqueness of vector valued solutions systems in L^p_k spaces, for $1 \le p \le \infty$, with clearly distinguished initial data depending on their diverse mass parameters. We also discuss numerical approximating conservative schemes that can be shown to converge thanks to the regularity properties associated to the underlying system.

Irene M. Gamba
University of Texas, Austin, U.S.

Saturday, December 14

IP8

Kalman-Wasserstein Gradient Flows

11:45 a.m.-12:30 p.m.

Room: Flores 5

Chair: Shi Jin, Shanghai Jiaotong University, China

We study an interesting class of interacting particle systems that may be used for optimization. By considering the mean-field limit, we obtain a nonlinear Fokker-Planck equation. This equation exhibits a novel gradient structure in probability space, based on a modified Wasserstein distance which reflects particle correlations: the Kalman-Wasserstein metric. We demonstrate how the setting gives rise to a methodology for calibrating, and quantifying uncertainty in, parameters appearing in complex computer models; the methodology arises from connecting the interacting particle system to ensemble Kalman methods for inverse problems.

Andrew Stuart
California Institute of Technology, U.S.

Lunch Break

12:30 p.m.-2:30 p.m.

Attendees on own

Saturday, December 14

MS62

Mean Field Games: Theory and Applications - Part III of III

2:30 p.m.-4:00 p.m.

Room: Flores B/C

For Part 2 see MS52

Mean field game theory is a mathematical framework established recently by Lasry-Lions and Caines-Huang-Malhame in order to describe a contiuum of rational agents in Nash equilibrium. In this minisymposium we will discuss a range of theoretical aspects of mean field games, such as Hamilton-Jacobi equations on infinite dimensional spaces, the master equation, forward-backward systems of PDE, optimal transport, the calculus of variations, a priori estimates and fixed point theorems. In addition, we will address applications, including, but not limited to, economics, finance, pedestrian crowd modeling, flocking, and traffic flow.

Organizer: Jameson Graber
Baylor University, U.S.

Organizer: Alpar Meszaros
University of California, Los Angeles, U.S.

2:30-2:55 Weak Solutions of Mean Field Game Master Equations
Chenchen Mou, University of California, Los Angeles, U.S.; Jianfeng Zhang, University of Southern California, U.S.

3:00-3:25 On Differentiability in the Wasserstein Space and Well-Posedness for Hamilton–Jacobi Equations
Adrian Tudorascu, West Virginia University, U.S.

3:30-3:55 A Partial Laplacian as an Infinitesimal Generator on the Wasserstein Space
Yat Tin Chow, University of California, Riverside, U.S.

Saturday, December 14

MS93

Recent Developments in Numerical Analysis of PDEs and Their Applications - Part III of III

2:30 p.m.-4:30 p.m.

Room: Flores 5

For Part 2 see MS80

Numerical analysis of partial differential equations and their applications have played a crucial role in applied and computational mathematics. This minisymposium focuses on recent developments in numerical analysis and aims to bring together the leading researchers in the fields of applied and computational mathematics to discuss and disseminate the latest advances and envisage future challenges in both the traditional and new areas of scientific and engineering computing. The topics of this minisymposium will cover a broad range of numerical methods including but not limited to weak Galerkin finite element methods, discontinuous Galerkin finite element methods and finite volume methods for various PDEs, such as nonlinear parabolic problems, Helmholtz equations, time fractional equations, rheological fluid flow, quasilinear elliptic PDE, Maxwell's equations, etc., their analysis and applications.

Organizer: Chunmei Wang
Texas Tech University, U.S.

Organizer: Jun Zou
The Chinese University of Hong Kong, Hong Kong

2:30-2:55 Analysis and Approximations of Dirichlet Boundary Control of Stokes Flows in Energy Space
Yangwen Zhang, University of Delaware, U.S.

3:00-3:25 Stability Analysis of An Ap Imex-Dg Scheme for a Linear Kinetic Transport Model
Fengyan Li, Rensselaer Polytechnic Institute, U.S.

3:30-3:55 Numerical Study of a Flux Ratio for Permanent Charge Effects on Ionic Flow
Weishi Liu, University of Kansas, U.S.

4:00-4:25 Direct Sampling Methods for Coefficient Determination Inverse Problems
Yat Tin Chow, University of California, Riverside, U.S.

Saturday, December 14

MS94

Nonlinear and Nonlocal PDE Models in Social and Life Sciences

2:30 p.m.-4:30 p.m.

Room: Flores 1

In recent years, PDE (partial differential equation) models have found countless applications in life and social sciences. The main objective of this minisymposium is to bring together experts working in diverse areas of PDE modeling, focusing on applications in pedestrian dynamics, crowded transport phenomena, interacting particle systems, cell movement and biological network formation. The PDE models are typically derived by first principles, as mean-field-limits of interacting particles, particles obeying certain rules in a lattice structure or discrete network structures. Moreover, they may exhibit various non-standard features, implying the need to develop novel mathematical techniques in order to tackle them both in a theoretical framework as well as in a numerical one. The presentations of the minisymposium speakers will include analytical aspects, modeling problems and numerical results. More specifically, they will range from applications of gradient flow theory on the micro- and macroscopic level, optimal transportation theory, dynamics on discrete networks, derivation of mean-field limits to the derivation of efficient numerical methods. The speakers will report on the latest progress in their fields, exchange ideas and highlight novel mathematical problems.

Organizer: Jan Haskovec
King Abdullah University of Science & Technology (KAUST), Saudi Arabia

2:30-2:55 Rigorous Continuum Limit for the Discrete Network Formation Problem
Jan Haskovec, King Abdullah University of Science & Technology (KAUST), Saudi Arabia; Lisa Maria Kreusser, University of Cambridge, United Kingdom; Peter Markowich, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

3:00-3:25 An Anisotropic Interaction Model for Simulating Fingerprints
Lisa Maria Kreusser, University of Cambridge, United Kingdom

continued in next column

3:30-3:55 Hydrodynamic Limits for Kinetic Flocking Models of Cucker-Smale Type
Pedro Aceves Sanchez, North Carolina State University, U.S.

4:00-4:25 Mean Field Games with State Constraints
Rossana Capuani, North Carolina State University, U.S.

Saturday, December 14

MS95

Mathematical Exploration of Particle Systems: PDEs, Competitive Games and Data Science - Part II of II

2:30 p.m.-4:00 p.m.

Room: Flores 2

For Part 1 see MS82

Particle systems are successfully applied in simulations of many biological systems, including migrations of schools of fish in the ocean. One can consider the continuum limit of these particle systems, and, when comparing the solutions to the PDEs, the resulting densities can be compared directly to scientific observations. For accurate predictions, it is important to include environmental information; it is also imperative to include the correct form of the noise for each environment. This addition of noise implies that the systems can be formulated as competitive games and leads to new mathematics where equations involving derivatives with respect to densities appear. It is also of interest to compare the predictions of the dynamics to the predictions made by data science. This minisymposium will explore all of these issues both from a mathematical and biological perspective.

Organizer: Alethea Barbaro
Case Western Reserve University, U.S.

Organizer: Bjorn Birnir
University of California, Santa Barbara, U.S.

2:30-2:55 A Particle Method for Nonlocal Equations with Reaction
Katy Craig, University of California, Santa Barbara, U.S.

3:00-3:25 A Stable Manifold of Distributional Solutions for the Radially Symmetric Aggregation Equation
Robert Volkin, Case Western Reserve University, U.S.

3:30-3:55 Stochastic Graphon Games
Rene Carmona, Princeton University, U.S.

Saturday, December 14

MS96

Gauge Theory and Partial Differential Equations - Part IV of IV

2:30 p.m.-4:30 p.m.

Room: Flores 3

For Part 3 see MS83

Almost all of the speakers are experts on the Yang-Mills or coupled Yang-Mills equations. Yang-Mills gauge theory seeks to describe the behavior of elementary particles using non-Abelian Lie groups and is at the core of the unification of the electromagnetic force and weak forces (i.e., U(1) x SU(2)) as well as quantum chromodynamics, the theory of the strong force (based on SU(3)). Thus, it forms the basis of our understanding of the Standard Model of particle physics. Coupled Yang-Mills equations arise when one considers Euler-Lagrange equations for an energy function that intertwines a connection A and one more sections of vector bundles associated with P and this has is a very active area of research, due to their roles in theoretical physics and applications to differential geometry, representation theory, symplectic geometry, and low-dimensional topology. Examples include the Hitchin-Simpson equations (1987, 1988), Kapustin-Witten equations, SO(3) monopole equations, Seiberg-Witten monopole equations, Vafa-Witten equations, as well as other coupled Yang-Mills equations arising in particle physics. Many of our speakers will describe their work on such coupled Yang-Mills equations, including central questions of compactness and geometry of the moduli spaces of solutions and applications to the definition of invariants.

Organizer: Paul Feehan
Rutgers University, U.S.

Organizer: Duong Phong
Columbia University, U.S.

2:30-2:55 A Lower Bound for the Hausdorff Measure of Blow Up Sets of the Seiberg-Witten Equation with Two Spinors
Andriy Haydys, Universität Freiburg, Germany

3:00-3:25 Singular Instanton Floer Homology for Sutured Manifolds
Boyu Zhang, Princeton University, U.S.; Yi Xie, Stony Brook University, U.S.

continued in next column

3:30-3:55 Canonical Metrics on Hopf Surfaces
Jeffrey Streets, University of California, Irvine, U.S.

4:00-4:25 Recent Progress on the Kapustin-Witten Equations
Rafe Mazzeo, Stanford University, U.S.

Saturday, December 14

MS97

Recent Developments on Analysis and Computations in Fluid Dynamics - Part III of III

2:30 p.m.-4:30 p.m.

Room: Flores 6

For Part 2 see MS84

Over the past decades, there have been made active interactions between the analysis and numerical computations in fluid mechanics. In this minisymposium, we bring together the leading experts and aim to discuss recent developments in this research direction including, e.g., the existence, regularity, and asymptotic behavior of solutions to fluid equations as well as the implementation and convergence analysis of some effective numerical methods.

Organizer: YoungJoon Hong
San Diego State University, U.S.

Organizer: Gung-Min Gie
University of Louisville, U.S.

Organizer: Bongsuk Kwon
Ulsan National Institute of Science and Technology, South Korea

2:30-2:55 On Boundary Layers in the Limit of Euler-α, as α → 0, with Dirichlet Boundary Conditions
Helena Nussenzveig Lopes, Universidade Federal de Rio de Janeiro, Brazil

3:00-3:25 Co-existence of Both Stable and Unstable Solitary Waves in One System
Hongqiu Chen, University of Memphis, U.S.

3:30-3:55 Title Not Available
Alexey Cheskidov, University of Illinois, Chicago, U.S.

4:00-4:25 Reduction of Optimal Control Problems in Infinite Dimension based on Parameterization
Honghu Liu, Virginia Tech, U.S.

Saturday, December 14

MS98

Recent Results in Incompressible Fluid Mechanics - Part III of III

2:30 p.m.-4:30 p.m.

Room: Flores 7

For Part 2 see MS85

Fluid mechanics is an important branch of physics that studies the laws governing the motion of fluids depending on properties such as fluid density, viscosity and compressibility. Mathematically, the theoretical understanding is far from complete even for incompressible fluids. Analytic techniques have been used, and many times developed, to successfully prove results about the behavior of incompressible fluids as described by various models. These models include the Euler equations, Navier-Stokes equations, Darcy's law for fluid flow in porous media, the surface quasi-geostrophic models for atmospheric flows, etc. Beside the fundamental question of existence and uniqueness of solutions, recent research on these incompressible fluid models have yielded results regarding stability of solutions, long-time asymptotic behavior, regularity, finite time singularities and more. The purpose of this minisymposium is to bring together both senior researchers and young mathematicians to discuss the current state of this subject and the mathematical methods that have been successful. Particular interest may be paid to the analysis of free boundary problems, but the scope of the symposium is not limited to it.

Organizer: Neel Patel
University of Michigan, U.S.

Organizer: Eduardo Garcia-Juarez
University of Pennsylvania, U.S.

Organizer: Annalaura Stingo
University of California, Davis, U.S.

2:30-2:55 On the Asymptotic Stability of Stratified Solutions for the 2D Boussinesq Equations with a Velocity Damping Term
Angel Castro, ICMAT, Spain

3:00-3:25 Gravity Water Waves and Emerging Bottom
Thibault De Poyferré, University of California, Berkeley, U.S.

3:30-3:55 Analyticity Results for the Navier-Stokes Equations
Guher Camliyurt, Institute for Advanced Studies, U.S.

4:00-4:25 Euler Equations in Domains with Rough Boundaries
Andrej Zlatos, University of California, San Diego, U.S.

Saturday, December 14

MS99

Recent Progress in Incompressible Fluid Dynamics - Part III of III

2:30 p.m.-4:30 p.m.

Room: Flores 8

For Part 2 see MS86

A plethora of physical phenomena are well-described by the equations of incompressible fluids, the Euler and Navier-Stokes equations, along with the many variations incorporating additional physical phenomena. In this minisymposium, the speakers will address several of the fundamental issues surrounding these equations. Themes include well-posedness, high- as well as low-regularity solutions, blow-up of solutions, numerical approximations, fluid flow on manifolds, low-viscosity solutions, and flows through porous media.

Organizer: James P. Kelliher
University of California, Riverside, U.S.

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

2:30-2:55 Numerical Approximation for Invariant Measures of the 2D Navier-Stokes Equations
Cecilia F. Mondaini and Nathan Glatt-Holtz, Tulane University, U.S.

3:00-3:25 On the Convergence of Numerical Approximations of the Incompressible Euler Equations
Samuel Lanthaler, ETH Zürich, Switzerland

3:30-3:55 Optimal Bounds on the Heat Transfer in the Marangoni-Bénard Convection
Camilla Nobili, Universitat Hamburg, Germany; Giovanni Fantuzzi and Andrew Wynn, Imperial College London, United Kingdom

4:00-4:25 Incompressible Fluids Through a Porous Medium
Christophe Lacave, Université de Grenoble Alpes, France; Matthieu Hillairet, Université Paris Dauphine, France; Nader Masmoudi, Courant Institute of Mathematical Sciences, New York University, U.S.

continued in next column

Saturday, December 14

MS100

Analysis and Modeling of PDEs in Materials Science and Biological Systems - Part III of III

2:30 p.m.-4:30 p.m.

Room: Capra A

For Part 2 see MS87

This minisymposium focuses on the mathematical modeling, analysis, and numerical simulations of PDEs for diverse phenomena in materials science and biological systems. The research is related to the PDE-based models arising in variational descriptions of the systems and their analysis and simulation. The speakers will talk about their recent work on a range of interesting problems including but not limited to the defects structures in solids, phase-field models in complex fluids, and morphological evolution in biological systems.

Organizer: Tao Luo
Purdue University, U.S.

Organizer: Chaozhen Wei
Worcester Polytechnic Institute, U.S.

2:30-2:55 Predictions of Molecular Binding/Unbinding Kinetics: Geometrical Flows, Transition Paths, and Multi-State Brownian Dynamics
Bo Li, University of California, San Diego, U.S.

3:00-3:25 Numerical Homogenization of Levy-Type Nonlocal Problems with Oscillating Coefficients
Yating Wang, Purdue University, U.S.

3:30-3:55 Cauchy-Born Rule and Stability of Crystalline Solids at Finite Temperature
Tao Luo, Purdue University, U.S.; Yang Xiang, Hong Kong University of Science and Technology, Hong Kong; Jerry Zhijian Yang and Cheng Yuan, Wuhan University, China

4:00-4:25 Modeling and Analysis on Distribution of Oxygen Partial Pressure in Electrolytes with Different Structures: Explaining Degradation of Solid Oxide Electrolyzer Cells
Qian Zhang, Beom-Kyeong Park, Scott Barnett, and Peter Voorhees, Northwestern University, U.S.

Saturday, December 14

MS101

Recent Development in Analysis and Computation of Hyperbolic and Kinetic Problems - Part III of III

2:30 p.m.-4:30 p.m.

Room: Capra B

For Part 2 see MS88

Hyperbolic and kinetic models arise from a broad range of application problems such as gas and fluid dynamics, plasma physics, magnetohydrodynamic and so on. Advanced computational techniques for these model problems have been under great development in the past few decades, yet many open challenges remain. In this minisymposium, we bring together researchers to discuss PDE/numerical analysis, computation, and model techniques for solving hyperbolic, kinetic and multi scale models. Presentations on modern computational methodology development such as multi-resolution, adaptivity, reduced order modeling, and on numerical analysis such as structure preserving, asymptotic preserving, asymptotic stable and accurate will be featured in our mini symposium.

Organizer: Yingda Cheng
Michigan State University, U.S.

Organizer: Fengyan Li
Rensselaer Polytechnic Institute, U.S.

Organizer: Jingmei Qiu
University of Delaware, U.S.

2:30-2:55 A Kernel Based High Order Explicit Unconditionally Stable Scheme for Hamilton-Jacobi Equations
Hyoseon Yang, Michigan State University, U.S.

3:00-3:25 A Bi-Fidelity Method for the Boltzmann Equation with Random Parameters and Multiple Scales
Liu Liu, University of Texas, Austin, U.S.

3:30-3:55 Bifidelity Data-Assisted Neural Networks in Nonintrusive Reduced-Order Modeling
Xueyu Zhu, University of Iowa, U.S.

4:00-4:25 A Sparse Grid Discontinuous Galerkin Method for the High-Dimensional Helmholtz Equation with Variable Coefficients
Wei Guo, Texas Tech University, U.S.

Saturday, December 14

MS102

Long Time Behaviour and Fine Asymptotics of Gradient Flows - Part II of II

2:30 p.m.-4:00 p.m.

Room: Capra C

For Part 1 see MS89

PDEs of gradient flow type are ubiquitous in mathematics and its applications since they describe the transition of a physical system from a state of high to a state of low energy. An interesting question that arises within the study of such equations is whether they converge to an equilibrium state (as time goes to infinity) and if so how fast. Here the story splits up: often the equilibrium itself is of high physical interest and one wants to prove a rate of convergence. In this case, one typically measures the distance to the stationary state using a relative entropy functional. In other scenarios, like pure diffusion, the equilibrium and convergence rates are well-known and rather uninteresting. In these cases, one would rather like to understand the fine asymptotics of the solution by rescaling with its convergence rate in order to prevent it from reaching the equilibrium state. These rescaled solutions then typically converge to an eigenfunction of the operator that defines the gradient flow which gives interesting insides into nonlinear spectral theory and has applications, for instance, in spectral graph clustering. In this two-part minisymposium researchers will present their latest results and discuss future trends in the field.

Organizer: Leon Bungert
Friedrich-Alexander Universitaet Erlangen-Nuernberg, Germany

Organizer: Jan-Frederik Pietschmann
Technische Universität, Chemnitz, Germany

2:30-2:55 Asymptotic Profiles of Homogeneous Gradient Flows
Leon Bungert, Friedrich-Alexander Universitaet Erlangen-Nuernberg, Germany; Martin Burger, Universität Erlangen, Germany

3:00-3:25 Kurdyka-Lojasiewicz-Simon Inequality for Gradient Flows in Metric Spaces
Jose M. Mazon, Universitat de Valencia, Spain

continued on next page

3:30-3:55 Gradient Flows for the Stochastic Amari Neural Field Model
Christian Kuehn, Technische Universität München, Germany; *Jonas M. Tölle*, Universitaet Augsburg, Germany

Saturday, December 14

MS103

Asymptotics of PDEs with Random Coefficients - Part II of II

2:30 p.m.-4:00 p.m.

Room: Capra D

For Part 1 see MS90

This session will review recent progress in the field of PDEs with random coefficients in the broad sense, with an emphasis on asymptotic theory. The scope of the minisymposium includes, but is not limited to, Homogenization, Waves in Random Media and Imaging, Stochastic PDEs, Reaction-Diffusion equations.

Organizer: Olivier Pinaud
Colorado State University, U.S.

Organizer: Alexei Novikov
Pennsylvania State University, U.S.

2:30-2:55 Feeble Fish in Turbulent Waters and Stochastic Homogenization of the G-Equation
Alexei Novikov, Pennsylvania State University, U.S.

3:00-3:25 Fractional White-Noise Limit and Paraxial Approximation for Waves in Random Media
Olivier Pinaud, Colorado State University, U.S.

3:30-3:55 Wave Propagation in Random Waveguide with Long-Range Correlations
Christophe Gomez, Aix-Marseille Université, France

Saturday, December 14

MS105

Kinetic Modeling: Analysis and Applications Part III of III

2:30 p.m.-4:30 p.m.

Room: The Studios

For Part 2 see MS92

This minisymposium will focus on new mathematical methods to rigorously understand the emergence of kinetic equations associated to particle interactions in the modeling of bridging quantum to hydrodynamics systems. Such kinetic models can be viewed as statistical flow descriptions. We will discuss different analytical issues of interacting particle models of Boltzmann or Landau type, ranging from classical gas dynamics interactions in neutral and plasma regimes, aggregation and breakage, gas mixture systems and the connection of quantum to kinetic systems though mean field theory approaches as much as bio and social interactions. Applications range from modeling systems for plasma and kinetic chemistry, of sprays and shear flows, population dynamics in biological systems and the formation and evolution of condensed gases in quantum kinetic regimes, among many possible applications.

Organizer: Irene M. Gamba
University of Texas, Austin, U.S.

Organizer: Alessia Nota
University of Bonn, Germany

Organizer: Maja Taskovic
Emory University, U.S.

2:30-2:55 Partial Regularity in Time for the Landau Equation (with Coulomb Interaction)
Alexis F. Vasseur, University of Texas, Austin, U.S.; Maria Gualdani, The University of Texas at Austin, U.S.; Francois Golse, Universite Paris 7-Denis Diderot, France ; Cyril Imbert, CNRS and École Normale Supérieure, Paris, France

3:00-3:25 On the Relativistic Landau Equation
Maja Taskovic, Emory University, U.S.; Robert M. Strain, University of Pennsylvania, U.S.

3:30-3:55 Kinetic Description of a Boltzmann-Rayleigh Gas with Annihilation
Raphael Winter, Ecole Normale Superieure de Lyon, France

continued on next page

Saturday, December 14

MS105

Kinetic Modeling: Analysis and Applications Part III of III

continued

4:00-4:25 A Rigorous Derivation of a Ternary Boltzmann Equation for a Classical System of Particles
Iaokeim Ampatzoglou, University of Texas at Austin, U.S.

Saturday, December 14

MS106

Layered 2D Materials and Edge States - Part II of II

2:30 p.m.-4:00 p.m.

Room: Capra E

For Part 1 see MS58

In recent years 2d materials such as graphene have generated intense interest for engineering applications. One feature of such materials is that they may host "edge states": electronic states localized at the physical edge of, or along interfaces between, 2d materials. Such states (and their counterparts in photonic analogs of such materials) have potential for robust wave-guiding applications.
This minisymposium will bring together mathematicians working on edge states with those working on layered 2d materials (novel materials created by stacking 2d materials on top of each other) in the hope of catalyzing interaction between these exciting areas.

Organizer: Alexander Watson
Duke University, U.S.

2:30-2:55 Transport at Interfaces Between Topological Insulators
Alexis Drouot, Columbia University, U.S.

3:00-3:25 Topological Insulators Beyond Periodic Structures
Alexander Watson, Duke University, U.S.

3:30-3:55 Spectral Bands, Tight Binding Limits, Topological Band Gaps and Bifurcations in Periodic Schrödinger Operators
Jeremy L. Marzuola, University of North Carolina, Chapel Hill, U.S.

Saturday, December 14

CP15

Simulations and Modeling

2:30 p.m.-4:30 p.m.

Room: Fiesta 8

Chair: Cordula Reisch, Technical University Braunschweig, Germany

2:30-2:45 Magnetohydrodynamic Flow Through Channels with Asymmetric Wall Distortion and Cross-Channel Pressure Interaction
Monalisa Munsi, Saint Louis University, U.S.; Alric P. Rothmayer and Paul Sacks, Iowa State University, U.S.

2:50-3:05 On a System Posed by R. Aris
Alejandro Omon Arancibia, Universidad de La Frontera, Chile

3:10-3:25 Mathematical Modelling and Computational Simulations of Diffusion in Cardiac Tissue
Jan N. Rose and Jerome Garnier-Brun, Imperial College London, United Kingdom; Andrew D Scott, Royal Brompton Hospital, United Kingdom; Denis J Doorly, Imperial College London, United Kingdom

3:30-3:45 A Rigorous Error Bound for the Slender Body Approximation of a Thin, Rigid Fiber in Stokes Flow
Laurel Ohm and Yoichiro Mori, University of Minnesota, U.S.

3:50-4:05 Hierarchical Model Family of Reaction-Diffusion Equations for Liver Infections
Cordula Reisch, Technical University Braunschweig, Germany

4:10-4:25 On Stochastic Korteweg - De Vries-Type Equations
Anna Karczewska, University of Zielona Góra, Poland

Saturday, December 14

CP16

Hyperbolic and Mean Field PDE

2:30 p.m.-3:50 p.m.

Room: Santa Rosa

Chair: Farshad Shirani, Georgetown University, U.S.

2:30-2:45 On Local Boundedness and Divergence-Free Drifts
Dallas Albritton, University of Minnesota, U.S.

2:50-3:05 Strong Shock Waves in Non-Ideal Gas of Variable Density under Magnetic Field
Antim Chauhan, Indian Institute of Technology Roorkee, India

3:10-3:25 Quantifying the Reduction in Damage by a Nuclear Blast Wave by the Addition of Dust.
Meera Chadha, Netaji Subhas Institute of Technology, India

3:30-3:45 Well-Posedness, Regularity, and Global Dynamics of a Mean Field Model of Electroencephalographic Activity in the Neocortex
Farshad Shirani, Georgetown University, U.S.; Rafael de la Llave, Georgia Institute of Technology, U.S.

SIAM Conference on

Analysis of Partial Differential Equations

December 11-14, 2019

La Quinta Resort & Club
La Quinta, California, U.S.

IP1

Non Exchangeability and Synchronization Mechanisms in Multi-Agent Systems

The aim of this talk is to investigate the behavior of large networks of interacting but non identical agents. Because agents are not indistinguishable, the possible interactions between agents are described through a connectivity graph which may be fixed or evolve in time through some feedback or learning mechanisms between pairs of agents. Correlations between agents are reinforced through the connectivities so that this type of models and its variants are often studied where synchronization between agents is expected or desired and they encompasses a broad set of applications from synchronized oscillators, to neuron networks (biological or artificial). Mean-field limits remain an attractive approach due to the large size of the systems but the usual concept of propagation of chaos cannot be applied which requires a new framework.

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IP2

Scalable Block Preconditioning of Implicit / IMEX FE Continuum Plasma Physics Models

Continuum plasma physics models are used to study important phenomena in astrophysics and in technology applications such as magnetic confinement (e.g. tokamak), and pulsed inertial confinement (e.g. NIF, Z-pinch) fusion devices. The computational simulation of these systems, requires solution of the governing PDEs for conservation of mass, momentum, and energy, along with various approximations to Maxwell's equations. The resulting systems are characterized by strong nonlinear coupling of fluid and electromagnetic phenomena, as well as the significant range of time- and length-scales that these interactions produce. To enable accurate, and stable approximation of these systems, a wide-range of spatial discretizations that include mixed integration, stabilized, and structure-preserving approaches are employed. For effective long-time-scale integration some implicitness is required. In this context, fully-implicit, and implicit-explicit methods have shown considerable promise. These characteristics make scalable and efficient iterative solution, of the resulting poorly-conditioned discrete systems, extremely difficult. Our approach to overcome these challenges has been the development of efficient fully-coupled multilevel preconditioned Newton-Krylov methods. This talk considers the structure of these algorithms, demonstrates the flexibility of this approach, and presents results on scaling of the methods on up to 1M cores.

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IP3

Singularity Formation in Critical Parabolic Problems

Singularity formation in evolution problems is a central issue in many mathematical models. It usually arises as the blow-up of a quantity reflecting regularity of the solution on some lower-dimensional set. We deal with construction and stability analysis of blow-up of solutions for a class of parabolic equations, classical in the PDE literature, that involve bubbling phenomena, corresponding to gradient flows of variational energies. The term bubbling refers to the presence of families of solutions which at main order look like scalings of a single stationary solution which in the limit become singular but at the same time have an approximately constant energy level. This phenomenon arises in various problems where critical loss of compactness for the underlying energy appears. Specifically, we present construction of threshold-dynamic solutions with infinite time blow-up in the Sobolev critical semilinear heat equation in $\mathbb{R}^n$, and finite time blow up for the harmonic map flow from a two-dimensional domain into S^2. This is done by "gluing methods" matching inner regimes (close to the singular set) and outer regimes, that are naturally considered at different scales.

Manuel del Pino
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IP4

Bound-Preserving High Order Schemes for Hyperbolic Equations: Survey and Recent Developments

Solutions to many hyperbolic equations have convex invariant regions, for example solutions to scalar conservation laws satisfy maximum principle, solutions to compressible Euler equations satisfy positivity-preserving property for density and internal energy, etc. It is however a challenge to design schemes whose solutions also honor such invariant regions. This is especially the case for high order accurate schemes. In this talk we will first survey strategies in the literature to design high order bound-preserving schemes, including the general framework in constructing high order bound-preserving finite volume and discontinuous Galerkin schemes for scalar and systems of hyperbolic equations through a simple scaling limiter and a convex combination argument based on first order bound-preserving building blocks, and various flux limiters to design high order bound-preserving finite difference schemes. We will then discuss a few recent developments, including high order bound-preserving schemes for relativistic hydrodynamics, high order discontinuous Galerkin Lagrangian schemes, high order discontinuous Galerkin methods for radiative transfer equations, high order discontinuous Galerkin methods for MHD, and implicit bound-preserving schemes. Numerical tests demonstrating the good performance of these schemes will be reported.

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IP5

Crowd Motion and the Muskat Problem via Optimal Transport

In this talk we will talk about single and multi-phase models that describe transport of densities under incompressibility constraint. These models hold importance in crowd motion and fluid dynamics. A particular focus will be on the Muskat problem, modeling dynamics of interface between two incompressible fluids. Our goal is to establish global-time existence of solutions past potential singularities, based on its gradient flow structure in Wasserstein spaces. This perspective allows us to construct weak solutions via a minimizing movements scheme. We will survey

relevant results in the literature, and then report a recent result obtained in joint work with Matthew Jacobs and Alpar Meszaros.

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IP6

An Application of the Sharp Caffarelli-Kohn-Nirenberg Inequalities

This talk is centered around the symmetry properties of optimizers for the Caffarelli-Kohn-Nirenberg (CKN) inequalities, a two parameter family of inequalities. After a general overview I will explain some of the ideas on how to obtain the optimal symmetry region in the parameter space and will present an application to non-linear functionals of Aharonov-Bohm type, i.e., to problems that include a magnetic flux concentrated at one point. These functionals are rotationally invariant and, as I will discuss, depending on the magnitude of the flux, the optimizers are radially symmetric or not.

Michael Loss
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IP7

Collisional Kinetics of Multi-Component System Models

We study the mathematical properties of complex particle systems modeling the 'binary mixing of gas mixtures'. More precisely, we focus on the interaction of monoatomic and polyatomic gases with different masses. The model is realized by a Boltzmann system of equations for the evolution of vector valued probability distribution densities describing the random interacting particles through non-local bilinear forms, corresponding to the dynamics of binary mixing of identical shape particles with internal energy exchange but different masses. The corresponding Cauchy problem takes place in Banach spaces naturally associated to the solution observables, yielding global existence and uniqueness of vector valued solutions systems in L^p_k-spaces, for $1 \leq p \leq \infty$, with clearly distinguished initial data depending on their diverse mass parameters. We also discuss numerical approximating conservative schemes that can be shown to converge thanks to the regularity properties associated to the underlying system.

Irene M. Gamba
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IP8

Kalman-Wasserstein Gradient Flows

We study an interesting class of interacting particle systems that may be used for optimization. By considering the mean-field limit, we obtain a nonlinear Fokker-Planck equation. This equation exhibits a novel gradient structure in probability space, based on a modified Wasserstein distance which reflects particle correlations: the Kalman-Wasserstein metric. We demonstrate how the setting gives rise to a methodology for calibrating, and quantifying uncertainty in, parameters appearing in complex computer models; the methodology arises from connecting the interacting particle system to ensemble Kalman methods for inverse problems.

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SP1

Inviscid Damping and the Asymptotic Stability of Planar Shear Flows in the 2D Euler Equations

In 1907, Orr first observed that solutions to the 2D incompressible Euler equations linearized around a linear shear flow (known as planar Couette flow) converge to equilibrium as $t \to \pm\infty$. This convergence happens weakly at the level of the vorticity, and strongly in L^2 at an algebraic rate at the level of the velocity. It is a time-reversible effect associated with the continuous spectrum and a loss of compactness by low-to-high frequency cascade. In this way, it shares a variety of similarities with Landau damping in kinetic theory. This mixing effect is now sometimes referred to as "inviscid damping" and is now known to play an important role for understanding the stability of shear flows and vortices in incompressible fluids at high Reynolds number. In our work, Nader Masmoudi and I demonstrated that Orr's prediction holds also in the (nonlinear) 2D Euler equations near the Couette flow in the idealized domain $T \times R$, provided one starts with at least Gevrey-2 regularity. In order to propagate the predicted low-to-high frequency cascade in a stable and controlled manner until $t \to \pm\infty$, a deep understanding and careful quantification of the weakly nonlinear effects is required. Gevrey-2 regularity was demonstrated to be sharp in a certain sense by Yu Deng and Nader Masmoudi in 2018. I will discuss the original work as well as a few of the works that have followed it by other authors and by ourselves and our collaborators.

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Nader Masmoudi
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CP1

Numerical Solution of Fractional Initial Boundary Value Problem

In this paper, the finite difference scheme is used to find the solution of fractional diffusion equation. The stability as well as convergence is discussed for the scheme. Moreover, the test problem is given along with its graphical representation of solution. Error analysis is carried out for the same.

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CP1

Geometric Properties of Eigenfunctions on Annuli

and Applications

We study some geometric properties, like monotonicity and foliated Schwarz symmetry of the first eigenfunction of Laplcian on annuli with mixed boundary conditions. As a consequence, we prove the strict monotonicity of the corresponding eigenvalue, using shape derivative techniques.

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CP1

Finite Difference Scheme for Electromagnetic Waves Model Arising from Dielectric Media

In this work, we developed a finite difference scheme for solving two dimensional (2D) fractional differential models of electromagnetic waves (FDMEWs) arising from dielectric media. The Caputo's fractional derivative in time is discretized by a difference scheme of $\mathcal{O}(t^{3-\alpha})$, $1 < \alpha < 2$, and the Laplacian operator is approximated by central difference discretization. Unconditional stability for the proposed scheme is established and convergence analysis is done through optimal error bounds. For 2D FDMEWs, accuracy of $\mathcal{O}(\tau^{2-\alpha} + \tau^{2-\beta} + h_1^2 + h_2^2)$ are proved for the discrete numerical scheme, where $1 < \beta < \alpha < 2$. Several examples are included to verify the reliability and computational efficiency of the proposed scheme which support our theoretical findings.

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CP1

Convergence and Error Analysis of HPM Solution for Nonlinear Partial Differential Equations

In this work our main goal is to study the convergence and error analysis of the solution of some nonlinear partial differential equations obtained with the help of homotopy perturbation sumudu transform method (HPSTM). The nonlinear terms are handled with Hes polynomial, the condition of convergence and uniqueness of the solution is derived. The results obtained are verified with the help of two examples.

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CP1

Multistep Finite Difference Scheme for Fractional Partial Differential Equation with Dirichlet Boundary Conditions

In this work, we developed multistep finite difference scheme for solving two dimensional (2D) fractional differential models (FDMs) arising from dielectric media which contain both initial and Dirichlet boundary conditions. The Caputo's fractional derivative in time is discretized by a difference scheme of order $\mathcal{O}(\tau^{3-\alpha})$, $1 < \alpha < 2$, and the Laplacian operator is approximated by central difference discretization. Unconditional stability, convergence analysis and error bounds are investigated. For the proposed fractional differential model the accuracy of order $\mathcal{O}(\tau^{3-\alpha}+\tau^{3-\beta}+h_1^2+h_2^2)$ are proved, where $1 < \beta < \alpha < 2$. Test functions are included to verify the reliability and computational efficiency of the proposed scheme which support our theoretical results.

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CP1

A Composite Algorithm for Computational Modeling of Two-Dimensional Coupled Burgers Equations

In this work, a new composite algorithm with the help of finite difference and modified cubic trigonometric B-spline DQ method is developed for computational modeling of two-dimensional coupled Burgers equation with initial and Dirichlet boundary conditions. The developed algorithm is better than the DQ algorithms proposed in literature due to more smoothness of cubic trigonometric B-spline functions. In the development of the algorithm, the first step is semi-discretization in time with forward finite difference and then obtained system is fully discretized by modified cubic trigonometric B-spline DQ method. Finally, the author obtain coupled Lyapunov systems of linear equations which are analyzed by MATLAB solver for the system. The results obtained by MATLAB solver are compared with the exact solutions as well as with the numerical solutions appearing in the literature. It is found that there is a quite good agreement between the exact solutions and the numerical solutions obtained by the method introduced in this paper. The technique can be extended for multidimensional problems after some modifications.

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CP2

Recent Developments on Nonlocal Fractional Problems Involving Variable Exponents

The talk is based on very recent results regarding nonlocal fractional problems involving variable exponents. In particular, we study the qualitative aspects of fractional Sobolev spaces with variable exponents and discuss existence and multiplicity of weak solutions of the corresponding fractional $p(x)-$ Laplacian equations.

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CP2

Volume Preserving Mean Curvature Flow for Star-Shaped Sets

Mean curvature flows appear in many physical applications such as material science and image processing. The evolution of convex sets for motion by mean curvature including anisotropic or crystalline one has been well-studied. In this talk, we present the evolution of star-shaped sets in volume preserving mean curvature flow. Constructed by mean curvature flows with forcing and their minimizing movements, our solution preserves a strong version of star-shapedness for all time. We use the gradient flow structure of the problem and show that the solutions converges to a ball as time goes to infinity. We also discuss how we can generalize this result to crystalline and anisotropic mean curvature flows.

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CP2

A Study of the Concentration Compactness Type Principle for Fractional Sobolev Spaces and Applications

We establish a concentration compactness type principle for fractional order Sobolev spaces, $W_0^{s,q}(\Omega)$, in a bounded domain $\Omega \subset \mathbb{R}^N$ to study PDEs involving the fractional q-Laplacian and power nonlinearities with two critical exponents. As an application to this principle we discuss the following Dirichlet problem.

$$\begin{aligned}(-\Delta_{p(\cdot)})^s u + (-\Delta_{p^+})^s u &= |u|^{(p^+)^*-2}u + |u|^{p_s^*(x)-2}u + \lambda|u|^{\beta(x)-2}u \text{ in } \Omega,\\ u &= 0 \text{ in } \mathbb{R}^N \setminus \Omega,\end{aligned}$$

where $s \in (0,1)$, $\lambda > 0$, $p(\cdot,\cdot)$ is a continuous symmetric bounded function in $\mathbb{R}^N \times \mathbb{R}^N$, $p^+ = \sup_{(x,y)\in\mathbb{R}^N\times\mathbb{R}^N} p(x,y)$, $N > sp^+$, $p_s^*(x) = \frac{Np(x,x)}{N-sp(x,x)}$, $(p^+)^* = \frac{Np^+}{N-sp^+}$ and the function β appears with a subcritical growth. Further, we assume the critical set $\{x \in \Omega : p_s^*(x) = (p^+)^*\} \neq \emptyset$.

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CP2

On a Class of Generalized Monge-Ampere Type Equations

In this paper we consider generalized solutions to the Dirichlet problem for a class of generalized Monge-Ampère equations. For such generalized solutions, we give a complete proof for the so-called comparison principle.

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CP2

Existence Result for Fractional Kirchhoff Equations Involving Choquard Exponential Nonlinearity

This talk deals with the existence of a non-negative solution of fractional-Kirchhoff equation with exponential nonlinearity of choquard type

$$-M\left(\int\int_{R^{2n}} \frac{|u(x)-u(y)|^{\frac{n}{s}}}{|x-y|^{2n}}\right)(-\Delta)^s_{n/s}u = \left(\int_\Omega \frac{G(y,u)}{|x-y|^\mu}\right) g(x,u) \text{ in } \Omega,$$

where $(-\Delta)^s_{n/s}$ is the n/s-fractional Laplace operator, $n \geq 1$, $s \in (0,1)$ $\Omega \subset \mathbb{R}^n$ is a bounded domain with Lipschitz boundary, $M : \mathbb{R}^+ \to \mathbb{R}^+$ and $g : \Omega\times\mathbb{R} \to \mathbb{R}$ are continuous functions, where g behaves like $e^{|u|^{\frac{n}{n-s}}}$ as $|u| \to \infty$ and G is primitive of g with respect to the second variable.

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CP3

Homogenization of a Phase Transition Problem with Prescribed Normal Velocity

Phase transition processes (e.g., *water/ice* or different *phases in steel*) are typical examples of problems where the geometry is allowed to evolve and where microscopic effects (growing *nucleation cells*) determine the macroscopic properties of the system. In this talk, we present and analyze a thermoelasticity model describing such phase transition processes. Starting with the *prescribed* normal velocity of the interface separating the competing phases, a specific transformation of coordinates, the so-called Hanzawa transformation, is constructed. This is achieved by (i) solving a non-linear system of ODEs characterizing the motion of the interface (ii) using the Implicit Function Theorem to arrive at the height function characterizing this motion. Based on uniform estimates for the functions related to the transformation of coordinates, the strong two-scale convergence of these functions is shown. Finally, these results are used to establish the corresponding effective model.

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CP3

Coron Problem for Nonlocal Equations Involving

Choquard Nonlinearity

We consider the following Choquard equation

$$-\Delta u = \left(\int_\Omega \frac{|u(y)|^{2^*_\mu}}{|x-y|^\mu} dy \right) |u|^{2^*_\mu - 2} u, \text{ in } \Omega, \quad u = 0 \text{ on } \partial\Omega,$$

where Ω is a smooth bounded domain in $\mathbb{R}^N$ $(N \geq 3)$, $2^*_\mu = (2N-\mu)/(N-2)$. This paper is concerned with the existence of a positive high-energy solution of the above problem in an annular-type domain when the inner hole is sufficiently small.

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CP3

Concentration Phenomena in the Critical Exponent Problems on Hyperbolic Space

This article deals with the study of the following critical exponent problem

$$(P_{\lambda,\mu}) \begin{cases} -\Delta_{\mathbb{H}^n} u + (\mu g(x) - \lambda) u = |u|^{p-2} u \text{ in } \mathbb{H}^n, \\ u > 0 \text{ in } \mathbb{H}^n, \ u \in H^1(\mathbb{H}^n) \end{cases}$$

where $\mathbb{H}^n$ is n-dimensional hyperbolic space, $n \geq 4$, $p = \frac{2n}{n-2}$ is the critical exponent, $\lambda, \mu > 0$ is a real parameter, $\Delta_{\mathbb{H}^n}$ denotes the Laplace-Beltrami operator on $\mathbb{H}^n$ and $g(x)$ is a real valued potential function on $\mathbb{H}^n$. Using variational methods, we establish the existence of ground state solution to $(P_{\lambda,\mu})$ and studied the convergence of solutions when μ approaches $+\infty$.

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CP3

Stochastic Heat Equation with Variable Thermal Conductivity

We consider a stochastic heat equation with variable thermal conductivity, on infinite domain, with both deterministic and stochastic source and with stochastic initial data. The stochastic source appears in the form of multiplicative generalized stochastic process. The generalized stochastic process appearing in the equation could be a generalized smoothed white noise process or any other generalized stochastic process of a certain growth. In our solving procedure we use regularized derivatives and the theory of generalized uniformly continuous semigroups of operators. We establish and prove the result concerning the existence and uniqueness of solution within certain generalized function space. At the end, we justify our procedure by proving that, under certain growth conditions, the solutions of non-regularized and the corresponding regularized problems are associated, supposing that the first one exists.

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CP4

Using Multiple Scales for Obtaining Asymptotic Solutions of the Quadratic and Cubic Nonlinear Klein-Gordon Equations

The general nonlinear Klein-Gordon equation (NKGE) is important in the area of nonlinear evolution equations. In particular, the quadratic and cubic versions of the Klein-Gordon equation arise in theoretical physics and in the area of relativistic quantum mechanics. When using the ansatz method, the quadratic nonlinear Klein-Gordon equation provides a sech squared 1-soliton solution, while the cubic nonlinear Klein-Gordon equation provides a simple 1-soliton sech solution, and if the nonlinear term in these partial differential equations is omitted, the resulting traveling wave pulse becomes a Fourier represented superposition of existing sine and cosine traveling wave components. To that extent, we have obtained the asymptotic solution of both the quadratic and cubic nonlinear Klein Gordon equations for weak nonlinearity. With this asymptotic approximation when using multiple scales, we have determined the results occurring from the on-set of nonlinear wave behavior in the solutions, where, in these cases, the waves amplitudes are velocity depend, i.e, larger amplitude waves travel at higher speeds than smaller amplitude waves. Moreover, the use of multiple scales provides the elimination of generated secular terms, thus allowing consistent solutions to be obtained. Additionally, we have extended the calculations to determining second order correction asymptotic terms.

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CP4

Mathematical Modeling and Analysis of Viscoelastic Waves within Fractional Framework

We are concerned with the wave equation for infinite one-dimensional viscoelastic media described by fractional constitutive models. For that purpose we propose, analyze and solve a system of three equations - equation of motion of one-dimensional deformable body, constitutive equation of fractional type for the mechanical properties of the linear viscoelastic body, and the strain measure for small local deformations, together with prescribed initial and boundary conditions. Such models originate from the basic equations of the continuum mechanics, where the equation of motion and strain are preserved, since they hold true for any type of deformable body, and only the constitutive equation, which is the Hooke law for an elastic body, is changed and adapted for viscoelastic type media. A novelty in our approach is the use of complex order fractional derivatives in the Zener constitutive relation, which extends capabilities of real order fractional differential operators and provides a better qualitative analysis of solutions. Several questions will be discussed: real valued compatibility constraints, thermodynamical restrictions on parameters, solvability of

the generalized Cauchy problem, calculation of the fundamental solution, numerical simulations, etc. The talk is based on collaboration with T. M. Atanackovic, M. Janev and S. Pilipovic.

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CP4

Wave Propagation in Viscoelastic Media and Energy Dissipation

Wave propagation in viscoelastic media is described by a fractional wave equation. In the system of three equations, equivalent to wave equation, consisting of equation of motion as a consequence of the second Newton's law, a strain measure, and Hooke's law for elastic body, latter is replaced with fractional type of constitutive law for viscoelastic body. For the constitutive law giving relation between the stress and the strain it is required to satisfy thermodynamical restrictions imposing certain constrains on the model parameters. It is shown that exactly those restrictions on coefficients and orders of fractional differentiations are necessary in order to prove existence and uniqueness of the solution to generalised Cauchy problem corresponding to given fractional wave equation and initial data. In this work, dissipation of energy, the main feature that waves in viscoelastic media display, is proved for the whole class of fractional wave equations obtained when distributed-order constitutive law, which includes all linear constitutive equations of fractional and integer order, grouped into four class of thermodynamically acceptable models, is used. For the proof of energy inequality thermodynamical restrictions are shown to be of crucial importance. Spatial profiles of analytically calculated solutions are presented and also show energy dissipation behaviour.

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CP4

Space-Time Discontinuous Galerkin Method for the One-Dimensional Wave Equation

The discontinuous Galerkin finite element method is a very attractive numerical method for partial differential equations due to its flexibility and efficiency in terms of mesh and shape functions, and a new higher order of convergence can be achieved without many iterations. In this paper, we develop and analyze a space-time discontinuous Galerkin (DG) finite element method for the second-order wave equation in one space dimension. The space-time DG discretization is presented in detail, including the definition of the numerical fluxes, which are necessary to maintain stable and non-oscillatory solutions. The scheme can be made arbitrarily high-order accurate in both space and time. We prove several optimal a priori error estimates in space-time norms for the proposed scheme. Several numerical examples are provided to verify the theoretical estimates.

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CP4

Analysis of Hydrodynamic Mixture Models

This talk is based on recent studies of the qualitative properties of classical solutions to the Cahn-Hilliard-Brinkman and Cahn-Hilliard-Navier-Stokes-Boussinesq equations arising in the modeling of multi-phase fluid flows. In particular, the global well-posed in energy critical space and long-time behavior of large-data classical solutions to the models will be reported. This is a joint work with Dong Li.

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CP5

Controllability of Stochastic Second-Order Neutral Differential Systems with State Dependent and Infinite Delay

In this paper controllability of damped second-order stochastic impulsive functional differential system with state dependent delay is studied. Sufficient conditions for controllability results are derived using the theory of cosine families of operators and fixed point technique. A class of damped system modeled below is studied

$$\begin{aligned} d[x'(t) - p(t, x_t, \int_0^t g(t,s,x_s)ds)] &= [Ax(t) + f(t, x_{\rho(t,x_t)}) + Bu(t) + Gx \\ + \int_{-\infty}^t \sigma(t,s,x_s)dw(s), &\qquad t \in [0,b],\ t \neq t_i,\ i = 0,...,n \\ x_0 &= \phi \in \mathfrak{B}, \\ x'(0) &= \xi \in X, \\ \Delta x(t_i) &= I_i^1(x_{t_i}),\ i = 1,2,...,n \\ \Delta x'(t_i) &= I_i^2(x_{t_i}),\ i = 1,2,...,n \end{aligned}$$

Here $0 = t_0 < t_1 \leq t_2, ..., < t_n \leq t_{n+1} = b$ are prefixed numbers. Refer [1], for related information. Generally the literature related to delay differential equations deal with differential equations in which the state actually belonged to a finite dimensional space. As a result, partial functional differential equations involving state dependent delay were mostly abandoned. This is one of the motivations of my work.

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CP5

Existence and Uniqueness of Magnetic Field for a Superconductor in the Presence of Electric Field

To account for the Meissner Effect, property that characterizes the superconducting state, responsible of magnet

levitation above or below a superconductor. The brothers Fritz and Heinz London establish two equations to govern electrodynamic properties. The second equation for the magnetic field is given by taking into account the hypothesis that all of super-electrons were due only to magnetic field and there does not exist the variation of electric field according to time $\frac{\partial E}{\partial t} = 0$. In this work, varying this electric field E in terms of time $\frac{\partial E}{\partial t} \neq 0$, we obtain an extension of the second equation of London which is nothing but the Klein-Gordon equation. We study the question of existence and uniqueness by a transcription in the frame of semi-groups theory. Moreover, we determine the explicit field magnetic B using the wave equations.

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CP5

Effect of Internal Heat Source on Magneto-Stationary Convection of Couple Stress Fluid under Magnetic Field Modulation

The present article provides an analytical solution of nonlinear heat transfer of an electrically conducting Couple stress liquid under a magnetic field modulation with an internal heat source. A weakly nonlinear theory is used to obtain the rate of heat transfer concerning the Nusselt number. A cubic Landau equation is derived in terms of amplitude of convection and solved by using Mathematica 8 software. The effect of various system parameters are obtained on nonlinear heat transfer which is discussed in detail by graphically. The Prandtl number, internal Rayleigh number, Couple stress parameter and magnetic Prandtl number destabilize the system while Chandrasekhar number has stabilizing effect. Hence, Couple stress parameter and internal Rayleigh number increase the rate of heat transfer.

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CP5

Lie Symmetry Analysis of Short Pulse Type Equation

Lie symmetry analysis is performed for the short plus type equation which describe the propagation of ultra-short optical pulses in nonlinear media. The short pulse type equation represents an alternative approach in contrast with the slowly varying envelope approximation which leads to the nonlinear Schrdinger equation. As the pulse duration shortens, the nonlinear Schrdinger equation becomes less accurate. With the rapid progress of ultra-short optical pulse techniques, it is expected that the short pulse equation and its multi-component generalization will play more important roles. The infinitesimals of the group of transformations which leaves this equation invariant are furnished. The optimal systems of one-dimensional subalgebras of the Lie symmetry algebras are determined with the adjoint action of the symmetry group.

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CP5

A Integrable Hierarchy, a Bi-Hamiltonian Reduction, and Some Explicit Solutions

We begin with a definition of a Lax pair and an example. We will see how led to the zero curvature equation and, ultimately, an entire hierarchy of Lax pairs and their corresponding spectral problems that produce evolution equations. We will discuss some precious results. Then, a new integrable generalization to the D-Kaup-Newell soliton hierarchy is presented along with a bi-Hamiltonian reduction. Lastly, a Darboux transformation is taken on the hierarchy to present explicit solutions.

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CP5

The Impact of Time Delay in a Tumor Model

We consider a free boundary tumor growth model with a time delay in cell proliferation and study how time delay affects the stability and the size of the tumor. The model consists of a coupled system of an elliptic equation, a parabolic equation and an ordinary differential equation to describe the cell location under the presence of time delay, with the tumor boundary as a free boundary. A parameter μ in the model is proportional to the "aggressiveness" of the tumor. It is proved that there exists a unique classical radially symmetric stationary solution (σ_*, p_*, R_*) which is stable for any $\mu > 0$ with respect to all radially symmetric perturbations [S. Xu, Q. Zhou, and M. Bai, Qualitative analysis of a time-delayed free boundary problem for tumor growth under the action of external inhibitors]. However, under non-radially symmetric perturbations, we prove that there exists a critical number μ_* such that if $\mu < \mu_*$ then the stationary solution (σ_*, p_*, R_*) is linearly stable; whereas if $\mu > \mu_*$ then the stationary solution is unstable. It is actually unrealistic to expect the problem to be stable for large tumor aggressiveness parameter, therefore our result is more reasonable. Furthermore, it is also proved by the authors that adding the time delay in the model would result in a larger tumor, and if μ is larger, then the time delay would have a greater impact on the size of the tumor.

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CP6

MHD Carreau-Yasuda Model for Blood Flow and Heat Transfer through a Bifurcated Artery having

Saccular Aneurysm

The study includes an unsteady two-dimensional mathematical modelling of non-Newtonian hemo-dynamics with heat transfer in a bifurcated artery having a saccular aneurysm in the presence of an axial magnetic field. The Carreau-Yasuda model is adopted for blood to mimic non-Newtonian characteristics. To study the influence of vessel geometry on blood flow and heat transfer the transformed equations are solved numerically with appropriate boundary conditions by means of the finite element method based on the variational approach and simulated using the FreeFEM++ code. Blood flow, heat transfer characteristics are examined for the effects of Non-dimensional numbers such as Reynolds, Prandtl numbers and magnetic body force parameter (M) at the aneurysm and throughout the arterial domain. The velocity, pressure and temperature fields are also visualized through instantaneous patterns of contours. An increase in magnetic parameters is found to enhance the pressure, temperature and skin-friction coefficient but decreasing the velocity in the domain. The blood flow shows different characteristic contours by the time variation at aneurysm as well as in the arterial segment.

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CP6

A Class of Upwind Methods based on Generalized Eigenvectors for Weakly Hyperbolic Systems

In this article, a class of upwind schemes is proposed for systems, each of which yields an incomplete set of linearly independent eigenvectors. The theory of Jordan canonical forms is used to complete such sets through the addition of generalized eigenvectors. A modified Burgers system and its extensions generate δ, $\delta^{'}$, $\delta^{'}, \cdot \cdot \cdot, \delta^{n}$ waves as solutions. The performance of flux difference splitting-based numerical schemes is examined by considering various numerical examples. Since the flux Jacobian matrix of pressureless gas dynamics system also produces an incomplete set of linearly independent eigenvectors, a similar framework is adopted to construct a numerical algorithm for a pressureless gas dynamics system.

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CP6

Eulerian Fluid-Structure Interaction Methods for Cardiovascular Modeling

The cardiovascular system has a structure of extreme complexity covering different physical scales in space and time. Although the substantial progress in the fields of mathematics and scientific computing, the simulation of the cardiovascular system as a coupled multiphysics and multiscale problem at the full level of detail remains complex and practically impossible. In this talk, we focus on particular problems of clinical relevance related to the cardiovascular modeling at the macroscopic and microscopic scales. We present mathematical models and efficient computational tools tailored for the simulation of (i) the hemodynamics in both aorta and sinus of Valsalva interacting with thin and highly deformable aortic valve, and (ii) the dynamics of individual red blood cells in microvasculature. These problems lead to coupled systems of highly nonlinear PDEs which are tremendously challenging and entail the resolution of difficult fluid-structure interaction problems evolving highly deformable thin structures. We develop purely Eulerian mathematical framework to circumvent issues related to the large deformations of extremely slender elastic structures in incompressible flows. Appropriate finite element methodologies will be presented. We will report several numerical examples to address the relevance of the mathematical models in terms of physiological meaning and to illustrate the accuracy and efficiency of the numerical methodologies.

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CP6

Oberst-Riquier based Algorithm for Trajectory Generation of Infinite-Dimensional Systems

We propose a generalised approach to solving the trajectory generation problem, which is usually the first step for solving a broader class of control problems known as the motion planning problem or trajectory tracking problem. Such problems arise in many areas of aerodynamics, civil engineering applications, nanotechnology devices, chemical processes etc. The systems concerned here are overdetermined systems defined by linear partial differential equation(s) with boundary condition(s). Our goal is to achieve a target reference trajectory, which we call "output reference" with some precisely calculated open-loop trajectory, which we call the open-loop "input trajectory". The proposed method uses Groebner basis based algebraic analysis for providing an exact solution to such trajectory generation problem. For the solution of PDE(s), we use the Oberst-Riquier algorithm while a Groebner-fan algorithm is used for enumerating all the Groebner bases. Our proposed algorithm does not require the usual procedure of segregating the PDEs into different categories before solving the problem. Moreover, we also examine and provide sufficient conditions for such a problem to be well-posed. Finally, we provide an algorithm that is capable of checking the well-posedness conditions and solving the trajectory generation problem. Our technique of handling the boundary condition(s) enables us to utilize them directly without classifying them into conventional classes of boundary con-

ditions.

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CP6

On Convergent Schemes for a Two-Phase Oldroyd-B Type Model with Variable Polymer Density

In this talk, we are concerned with a diffuse-interface model that describes two-phase flow of dilute polymeric solutions with a variable particle density. The additional stresses, which arise by elongations of the polymers caused by deformations of the fluid, are described by Kramers stress tensor. The evolution of Kramers stress tensor is modeled by an Oldroyd-B type equation that is coupled to a Navier-Stokes type equation, a Cahn-Hilliard type equation and a parabolic equation for the particle density. First, we talk about techniques which are needed to derive an energy estimate for Kramers stress tensor on a formal level. Afterwards, we present a regularized finite element approximation of the model and discuss how to mimic the energy estimate on a discrete level. We can prove with the same techniques as for the discrete energy estimate and a fixed point argument the existence of discrete solutions, which converge to global-in-time weak solutions to the unregularized model as the regularization parameter and the spatial and temporal discretization parameters tend towards zero in two space dimensions. Additionally, we show that our finite element scheme is fully practical and we present numerical simulations.

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CP6

An Analysis of the NLMC Upscaling Method for Elliptic Problems with High Contrast

In this talk we present a new method to solve elliptic problems with high contrast medium. Our methodology is based on the recently developed non-local multicontinuum method (NLMC). The main ingredient of the method is the construction of suitable local basis functions with the capability of capturing multiscale features and non-local effects. In our method, each coarse block is decomposed into various continua according to the contrast ratio, and we require that the contrast ratio should be relatively small within each continua. The analysis shows that the basis functions have decay property, which can also be verified from the numerical simulation. The convergence of the multiscale solution is also proved. Finally, several numerical experiments are carried out to demonstrate the performances of the proposed method. The numerical results indicate that the proposed method can solve problem with high contrast medium efficiently. In particular, if the oversampling size is large enough, then we can achieve the desired error.

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CP7

An Asymptotic Preserving Multilevel Monte Carlo Method for Particle Based Simulation of Kinetic Equations

We consider the particle based simulation of hyperbolic transport equations, in which we introduce a scaling parameter ε (related to the mean free particle path) to characterize the time-scale separation. In the limit where this scaling parameter tends to zero, the hyperbolic transport equation converges to a parabolic diffusion equation. Simulations of the transport equation in the small ε region, however, suffer from extreme time step reduction constraints to maintain stability. Asymptotic-preserving schemes, avoid this issue, but add a linear model error in the time step size, while doing so. In recent work, we reduced this model error in using multilevel Monte Carlo, which uses both coarse and fine time steps to compute a low bias solution at lower cost. We will present this scheme, together with some analysis, demonstrating where it still requires improvement. We will then discuss how to improve upon the existing scheme, both in terms of generality of the scheme and in terms of computation time.

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CP7

Efficient Calculation of Heterogeneous Non-Equilibrium Dynamics in Coupled Network Models

Understanding nervous system function requires careful study of transient (non-equilibrium) neural response to rapidly changing, noisy input from the outside world. Such neural response results from dynamic interactions among multiple, heterogeneous brain regions. Realistic modeling of these large networks requires enormous computational resources, especially when high-dimensional parameter spaces are probed. By assuming quasi-steady-state activity, one can neglect the complex temporal dynamics; however, in many cases the quasi-steady-state assumption fails. Here, we develop a new reduction method of a high-dimensional PDE model, that accurately handles highly non-equilibrium dynamics and interactions of heterogeneous cells. Our method involves solving an efficient set of nonlinear ODEs, rather than time-consuming Monte Carlo simulations or high-dimensional PDEs, and it captures the entire set of first and second order statistics while allowing significant heterogeneity in all model parameters.

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CP7

Weak Approximation Techniques for Mixed-Integer PDE-Constrained Optimization

Applying techniques from mixed-integer optimization to discretizations of PDE-constrained optimal control problems with integer-valued control inputs that are distributed in time or space can be tough as the number of variables in the decision tree grows with the discretization. However, the infinite-dimensional properties of the problem sometimes allow an efficient algorithmic framework. A continuous relaxation of the problem arises from a convexification of the control variable. We present findings on the following two-step procedure: first solve the relaxed problem and second compute integer-valued approximants of the relaxed control in a weaker topology. If the solution operator of the PDE is completely continuous w.r.t the control, the state vector is approximated in norm. Depending on the continuity properties of the objective, the infimum of the original problem is approached or a sub-optimality remains. One may interpret this methodology as a transfer of the bang-bang principle and the Lyapunov convexity theorem to mixed-integer control problems. To obtain implementable controls in practice, we propose an efficient procedure that computes a trade-off between the weak approximation property and the switching costs of the computed control. One has to accept a trade-off here as the number of switches cannot remain bounded when passing to the limit of the approximation if the approximated relaxed control is non-integer-valued on a set of non-zero measure.

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CP7

Inverse Problems for Seismic Exploration Based on Topology Optimization and GPU Processing

In an inverse problem, especially in geophysics exploration, the problem is solved for obtaining images, in order to visualize an image of a specific subsoil based on full-wave equation modeling, where the response generated by a seismic vibrator is measured by geophones, placed on the soil surface. The generated reflections and refractions depend on the wave velocity propagation in the medium and, consequently, on the material properties that composes it. In inverse problems, two challenges arise: a) the solution of a computational model to simulate the wave propagation which, usually, has a high computational cost; and b) the solution of an optimization problem, whereby the computed response is "adjusted" with the measured one, by iteratively updating a distribution of material or properties initially assumed. In the present work, these two aspects are explored based on Graphic Processing Units (GPU) and the Topology Optimization Method (TOM). TOM is a tool used for obtaining optimal and conceptual designs. The GPU-TOM implemented software is based on MATLAB, considering a 2D seismic modelling. The source is modelled by using a Ricker wavelet input and the Absorbing Boundary Conditions are implemented, which mimic an infinite domain. Lastly, the numerical verification is based on Devito platform, which is an open-source Domain-specific Language, based on Phyton programming, for solving differential equations considering Finite Difference Method.

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CP7

A Finite Volume Scheme for Stochastic PDEs

The description of soft matter systems out of equilibrium requires the inclusion of fluctuations in the standard hydrodynamic equations for the average evolution of conserved quantities, such as density or linear momentum. The associated general framework was postulated phenomenologically by Landau et. al., yielding what is known as Landau-Lifshitz fluctuating hydrodynamics (FH). However, the numerical applicability of the fluctuating hydrodynamics entails several challenges which still remain elusive. In particular, conservative fluctuations, i.e. stochastic fluxes under the gradient operator, need to be properly accounted for. Besides, even for the simplest limit of these equations (which corresponds to the stochastic diffusion equation), the presence of a normally-distributed flux in the time-evolution equation for the density involves non-positive solutions, which are clearly unphysical. Hence the need for a robust method capable of handling stochastic fluctuations properly. In this work we present a finite-volume numerical approximation for stochastic gradient flows with nonlinear energy functionals, based on a hybrid upwind-central discretisation of both the deterministic and stochastic fluxes. The positivity of the density is ensured by an innovative time-adapting procedure based on the concept of Brownian trees. We exemplify the applicability and versatility of our method by solving the FH in a wide spectrum of physical settings.

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CP7

Solving Non-Linear PDEs by Training Neural Networks with Augmented Lagrangian Method

Assume the dynamics of a physical system is governed by the nonlinear PDE $\frac{\partial u}{\partial t} = \mathcal{L}u$, where $\mathcal{L}$ is a differential operator and the $n-$dimensional solution u depends on time t and $m-$dimensional space vector x. Neural networks (NN) enable to approximate both the solution u by $\hat{u}(x, t; w)$, where w are the parameters of the NN trained to satisfy $\mathcal{L}u$, as well as the RHS $\mathcal{L}u$ itself. Solving the corresponding initial and boundary value problem (iBVP) relies on the penalty method which converts the constrained error minimization to an unconstrained problem. Its main drawback is that it yields ill-conditioned problems when naively selecting penalty coefficients. The training algorithm appears thus as a main obstacle for the solving of nonlinear PDEs. Instead, we propose to iteratively solve the constrained error minimization problem using the augmented Lagrangian method. The latter adds a term corresponding to an estimate of the Lagrange multiplier in the objective of the unconstrained problem, which helps avoiding its ill-conditioning. The accuracy of the Lagrange multiplier estimation improves at every step. We compare the time complexity (convergence time), spatial complexity (memory bit-size) and model complexity (number of parameters) against the base method to reach a given prediction accuracy for prototypical BVPs, e.g., Burgers and KdV equation.

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CP8

Existence of Solution to a System of Parabolic Partial Differential Equations with Discontinuous Boundary Conditions Modeling Mass Transfer in Heterogeneous Catalysis

We model a slurry reactor with a single catalyst immersed in a viscous fluid through a system of parabolic equations with discontinuous boundary conditions in a moving domain. The catalyst is modeled as a rigid homogeneous solid with an effective diffusivity. The motion of the fluid-catalyst system is described by a velocity field with low regularity in a bounded domain with slip conditions prescribed on the interface. As such, classical methods of rewriting the problem in a cylindrical domain are inapplicable. To show existence of a solution, we solve a sequence of approximate problems in a cylindrical domain: we exploit the rigidity of the catalyst motion to recast the problem in the solid in a fixed domain, while the fluid problem is extended throughout the whole domain, modeled as a diffusion-advection problem with non-constant diffusivity, with appropriate weights applied to regions in the solid domain. Through compactness arguments, we show that, up to a subsequence, the solutions to the approximate problems converge to an appropriate notion of a solution to the original problem.

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CP8

Convergence Rates for the Three-Scale Singular Limit of the Mhd Equations

Convergence rate estimates are obtained for three-scale singular limits of the compressible ideal magnetohydrodynamics equations, in which the Mach and Alfvén numbers tend to zero at different rates. The proofs use and improved version of bounds for three-scale singular limits recently developed by the authors, the time-integration method, and a detailed analysis of exact and approximate fast, intermediate, and slow modes.

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CP8

Analysis of the Bi-Anisotropic Maxwell System in Lipschitz Domains and Free Space

We discuss well-posedness of an initial boundary value problem for the time dependent, bi-anisotropic Maxwell system in a Lipschitz domain. In such a setting there are 8 material parameters, which are allowed to depend on space and time. We in particular taken into account memory effects and impose nonzero Dirichlet boundary data. Similar results in higher order Sobolev spaces are obtained as well, assuming the material parameters satisfy a certain multiplier property. Finally, we discuss the free-space problem which is posed as a quasi-linear symmetric hyperbolic system.

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CP8

Discrete Geometry and PDE-Constrained Optimization for Mechanics of Hyperbolic Elastic Sheets

The edges of growing leaves, blooming flowers, torn plastic sheets, and frilly sea slugs all exhibit intricate wrinkled patterns. Why is this so? We argue that the mechanics of these so-called non-Euclidean elastic sheets are influenced by non-trivial geometric considerations (i.e., non-smooth defects) which may be explored by new methods using discrete differential geometry (DDG). Wrinkled morphologies correspond to energy minimizers of an elastic energy that solves a PDE-constrained variational problem. I will motivate the need for DDG-inspired methods in parametrizing solutions to the constraint PDE and optimizing many topo-

logical/geometric degrees of freedom to study the mechanics of hyperbolic sheets, i.e., soft/thin objects with negative Gauss curvature. And, I will share results obtained from them, including energetic impacts from non-smooth defects, the role of weak external forces, and associated scaling laws. Ultimately, these modeling techniques have the potential to explain rippled shapes in leaves, flowers, etc. and to enable the control/design of slender elastic materials, e.g., for soft robotics.

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CP9

A Comparison of Mean Field Games and the Best Reply Strategy: The Stationary Case

In the first half of this talk I will discuss the Best Reply Strategy (BRS) an instantaneous response to a cost function and how it can be related to a Mean Field Game (MFG) through a short-time rescaling. The second half will focus on stationary solutions to linear-quadratic MFGs and the BRS. I will describe a new proof for existence and uniqueness of such MFGs by transforming the system into a single PDE with unknown parameters. This leads to a nice comparison of the sufficient conditions for existence between the two models. I will highlight some specific examples of MFGs and BRS that highlight the type of differences that can be expected between the two models. Finally, I will explain the importance of these differences, the consequences for modelling mean-field strategic behaviour, and future research questions.

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CP9

Optimal Control Dynamics: Multi-Therapies with Dual Immune Response for Treatment of Dual Delayed HIV-HBV Infections

The growing complexity of dual HIV-HBV infectivity and the scientific ineptitude towards an articulated mathematical model for co-infection dynamics and accompanying methodological application of desired chemotherapies inform this investigation. Therefore, this present study not only ascribed to portrait the quantitative maximization of susceptible state components but opined to an insight into the epidemiological identifiability of dual HIV-HBV infection transmission routes and the methodological application of triple-dual control functions. Using ODEs, the model was formulated as a penultimate 7-Dimensional mathematical dynamic HIV-HBV model,transformed to an optimal control problem following the introduction of multi-therapies in the presence of dual adaptive immune system and time delay lags. Applying classical Pontryagins maximum principle, the system was analyzed, leading to the derivation of the model optimality system and uniqueness of the system. Typically, following the dual role of the adaptive immune system, which culminated into triple-dual application of multi-therapies, dual delayed HIV-HBV virions decays in infected double-lymphocytes in a biphasic manner, accompanied by more complex decay profiles of infectious dual HIV-HBV virions. The result further led to significant triphasic maximization of susceptible double-lymphocytes and dual adaptive immune system achieved under minimal systemic cost. The model is thus an intellectual accomplishment.

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CP9

Dimension Reduction Through Gamma Convergence in Thin Elastic Sheets with Thermal Strain, with Consequences for the Design of Controllable Sheets

In this work, we analyze thin elastic sheets with a wide class of spatially varying prestrains. Using techniques from (Friesecke, G., James, R. D., & Müller, S. (2002). A theorem on geometric rigidity and the derivation of nonlinear plate theory from three-dimensional elasticity), we derive a rigorous Gamma-convergence result for the limiting energy. We borrow from geometric generalizations of the Friesecke-James-Müller theory, work by Bernd Schmidt and later by Marta Lewicka and collaborators, and generalize their results to a wider class of geometric strains and elastic laws. Our main result involves convex integration type techniques found in [Lewicka, M., & Pakzad, M. R. (2017). Convex integration for the MongeAmpre equation in two dimensions]. Our ansatz for the upper bound is qualitatively different from that associated with any classical plate theory; it suggests that in a region where the limiting configuration is locally planar, the presence of prestrain could induce wrinkling (we are grateful to Marta Lewicka for suggesting the use of an ansatz involving wrinkling). Our results provide a systematic framework for modelling and analyzing the design of controllable sheets.

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CP9

Approximate Controllability of Semilinear Impulsive Functional Differential Systems with Non Local Conditions

Many practical systems in physical and engineering sciences are modeled by impulsive differential equations, subject to precipitate changes at certain instants during the evolution process and delay differential equations can be met in various other applications. This paper is concerned with the approximate controllabilty of semilinear impulsive functional differential systems in Hilbert space with nonlocal conditions. We established the sufficient conditions for approximate controllability using Schauder's fixed point theorem. An application involving impulse effect associated with delay is also addressed using non local conditions.

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CP9

External Optimal Control of Fractional Parabolic PDEs

In this talk, we introduce a new notion of optimal control, or source identification in inverse, problems with fractional parabolic PDEs as constraints. This new notion allows a source/control placement outside the domain where the PDE is fulfilled. We tackle the Dirichlet, the Neumann and the Robin cases. The need for these novel optimal control concepts stems from the fact that the classical PDE models only allow placing the source/control either on the boundary or in the interior where the PDE is satisfied. However, the nonlocal behavior of the fractional operator now allows placing the control in the exterior. We introduce the notions of weak and very-weak solutions to the parabolic Dirichlet problem. We present an approach on how to approximate the parabolic Dirichlet solutions by the parabolic Robin solutions (with convergence rates). A complete analysis for the Dirichlet and Robin optimal control problems has been discussed. The numerical examples confirm our theoretical findings and further illustrate the potential benefits of nonlocal models over the local ones.

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CP10

On the Euler Equations with Helical Symmetry

In this talk we will survey some results regarding the global existence of weak solutions of the Euler equations in $\mathbb{R}^3$ with helical symmetry and without swirl for initial vorticity with low regularity.

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CP10

Multicomponent Coagulation Equation for Aerosol Dynamics

In the atmosphere, aerosol particles collide and merge forming bigger particles. To investigate this phenomenon we consider a coagulation equation for the particle size distribution with source at the small particles. We prove existence and non-existence of stationary non-equilibrium solutions for two different classes of coagulation kernels. To account for different types of particles, we then consider a multicomponent coagulation equation. We study the shape of solutions for large times and show that the mass concentrates along straight lines in the size space.

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CP10

Barriers of the McKean-Vlasov Energy via a Mountain Pass Theorem in the Space of Probability Measures

We show that the empirical process associated to a system of weakly interacting diffusion processes exhibits a form of noise-induced metastability. The result is based on an analysis of the associated McKean–Vlasov free energy, which for suitable attractive interaction potentials has at least two distinct global minimisers at the critical parameter value $\beta = \beta_c$. On the torus, one of these states is the spatially homogeneous constant state and the other is a clustered state. We show that a third critical point exists at this value. As a result, we obtain that the probability of transition of the empirical process from the constant state scales like $\exp(-N\Delta)$, with Δ the energy gap at $\beta = \beta_c$. The proof is based on a version of the mountain pass theorem for lower semicontinuous and λ-geodesically convex functionals on the space of probability measures $\mathcal{P}(M)$ equipped with the W_2 Wasserstein metric, where M is a Riemannian manifold or $\mathbf{R}^d$.

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CP10

Stochastic Helmholtz Finite Volume Method for DBI String-Brane Theory Simulations

Recently there has been increased interest in simulation models of cosmic strings and other quantum gravity objects using electromagnetism as a basis analogue for gravitational forces. The research presented here continues from previous years presented at the SIAM Annual Meeting July 8-12, 2013 and SIAM Analysis of Partial Differen-

tial Equations December 7-10, 2015. The Ritz-Galerkin is now a Finite Volume Method (FVM) solving the Stochastic Helmholtz in the context of Transformation Optics to create a simulation of cosmic strings, black holes, and ADS/CFT holographics using metamaterials. Cloaking simulates holographics, gravitational lensing, and singularity compacted dimensions needed in String-Brane Theory. The Helmholtz FVM is incorporated into the Dirac-Born-Infeld (DBI) Action, a String-Brane action in an electromagnetic field. Previously the Chaotic DBI Action was defined on Ising spin glass lattices with a discretized path integral and Wilson Loop equated to triangular Schrdinger Equation Isogeometric Airy shape function nodes. The Airy function is the Schrdinger Equation for a triangular quantum well. This is a realistic method for creating simulations of holographics, singularities and cosmic strings, and as an analytical basis for String-Brane-M Theory that includes data from the Helmholtz wave equations.

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CP10

Globally Convergent Methods for Inverse Scattering Problems: Theory and Testing Against Experimental Data

We consider the multifrequency inverse medium scattering problem. This problem aims to determine the coefficient $c(x)$ in the following Helmholtz equation

$$\Delta u(\mathbf{x}) + k^2 c^2(x) u(\mathbf{x}, t) = f(\mathbf{x}), \quad \mathbf{x} \in \mathbf{R}^n, \ n = 2, 3 \quad (2)$$

where k is the wavenumber, $f(\mathbf{x})$ is the source function describing how the incident wave is generated, and $c(x)$ represents a physical property of the medium. For example, in the case of electromagnetic waves, $c(x)$ is the dielectric constant of the medium. Assume that $0 < c_l \leq c(\mathbf{x}) \leq c_u$, and it is unknown only in a bounded domain D. More precisely, $c(\mathbf{x}) = 1$, $\forall \mathbf{x} \notin D$. We also assume that the support of f is outside of $\bar{D}$. Our goal is to reconstruct $c(\mathbf{x})$, $\mathbf{x} \in D$, from measurements of the wave function $u(\mathbf{x})$ at $\mathbf{x} \in \partial D$ at multiple wavenumbers. Since this inverse problem is ill-posed and nonlinear, conventional iterative methods usually require a good initial guess about the unknown coefficient. In this talk, we discuss a recursive globally method which can provide accurate reconstruction of $c(x)$ but does not require a good initial guess. We will discuss the global convergence of the algorithm and demonstrate its performance in the problem of detection of buried objects with real experimental data.

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CP10

Exact Soliton, Periodic and Superposition Solutions to the Extended Korteweg-De Vries (KdV2) Equation

In the presentation, three kinds of the analytic solutions to the extended Korteweg-de Vries equation (KdV2) are discussed. This equation is obtained in a perturbation approach of second order with respect to small parameters, whereas KdV results from the same perturbation approach but limited to first order. In 2014 we derived the exact soliton solution to KdV2 assuming it in the form $A\,\mathsf{sech}^2[B(x-vt)]$, that is, in the same form as the KdV solution but with different coefficients. The success of this result led us to the conjecture that the other kinds of exact KdV solutions could exist in the same functional form for KdV2. In 2017 we derived the exact periodic (cnoidal) solutions in the form $A\,\mathsf{cn}^2[B(x-vt), m] + D$. In 2018 we found the exact periodic solutions to KdV2 (named superposition solutions) in the forms $\frac{A}{2}\{\mathsf{dn}^2[B(x-vt) \pm \mathsf{cn}[B(x-vt)\mathsf{dn}[B(x-vt)\} + D$. The KdV2 equation supplies one more condition on the coefficients of the solution than KdV. Therefore the ranges of coefficients of solutions to KdV2 are usually narrower than those of KdV. Nevertheless, KdV2 admits, besides "normal" cnoidal solutions, the "inverted" cnoidal waves, too. Recently, we proved that contrary to KdV case, multiple soliton solutions to KdV2 do not exist.

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CP11

High Order Moving-Water Equilibria Preserving Discontinuous Galerkin Methods for the Ripa Model

Shallow water equations with horizontal temperature gradients, also known as the Ripa system, are a system of partial differential equations used to model flows when the temperature fluctuations play an important role. These equations admit steady state solutions where the fluxes and source terms balance each other. We present well-balanced discontinuous Galerkin methods for the Ripa model which can preserve the general moving-water equilibria. The key ideas are the recovery of well-balanced states, separation of the solution into the equilibrium and non-equilibrium components, and appropriate approximations of the numerical fluxes and source terms. Numerical examples are presented to verify the well-balanced property, high order accuracy, and good resolution for both smooth and discontinuous solutions.

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CP11

An Entropy-Adjoint Order-Adaptive Discontinuous Galerkin Method for the Simulation of Chaotic Flows

The work presents an approach to mesh adaptation suitable for scale resolving simulations. The methodology is based on the entropy adjoint approach, which corresponds to a standard output-based adjoint method with output functional targeting areas of spurious generation of entropy. The method shows several advantages over stan-

dard output-based error estimation: i) it is computationally inexpensive, ii) does not require the solution of a fine-space adjoint problem, and iii) is nonlinearly stable with respect to the primal solution for chaotic dynamical systems. In addition, the work reports on the parallel efficiency of the solver, which has been optimized through a multi-constraint domain decomposition algorithm available within the Metis 5.0 library. The reliability, accuracy, and efficiency of the approach are assessed by computing three test cases: the two-dimensional, laminar, chaotic flow around a square at $Re = 3\,000$, the implicit Large Eddy Simulation (LES) of a circular cylinder at $Re = 3\,900$, and the ILES of a square cylinder at $Re = 22\,000$. The results show significant reduction in the number of DoFs with respect to uniform order-refinement, and good agreement with experimental data.

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CP11

An Overlapping Local Projection Stabilized Finite Element Methods for Darcy Flow

Local projection based stabilized methods for the finite element discretization of the solution of Darcy flow offer several advantages as compared to mixed Galerkin methods. In particular, it allows to use equal order interpolation spaces for the velocity and pressure. The article analyzes a generalization of the local projection stabilizations with projection spaces defined on overlapping sets applied to the Darcy flow in the conforming and nonconforming (the CrouzeixRaviart element) finite element spaces. The proposed discrete weak formulation is a combination of the standard Galerkin method, LP stabilization, and weakly imposed boundary condition by using Nitsches technique. The bilinear form corresponding to the proposed stabilization satisfies an inf-sup condition with respect to the $H(div, \Omega)$ norm and the convergence analysis leads to an optimal convergence rate in this norm for the two different finite element spaces, the conforming space and the nonconforming space of finite elements. Numerical results illustrate the theoretical considerations.

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CP11

A Numerical Algorithm Based on Finite Element Method for Simulation of Some Parabolic Problems

In this talk, the author proposed a numerical algorithm based on finite element method for simulation and analysis of some parabolic problems of the types $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + f(x, t, u, u_x)$. Existence and uniqueness of weak solution, a priori error estimates of semi-discrete solution in $L^\infty(0, T; L^2(\Omega))$ norm are proved. Nonlinearity of the problem is handled by lagging it to previous known level. The scheme is found to be convergent. Finally, some numerical examples are considered to check the accuracy and efficiency of the algorithm. The proposed algorithm is found to be fast, easy and accurate.

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CP11

Generalized Multiscale Finite Element Method for a Strain-Limiting Nonlinear Elasticity Model

In this paper, we consider multiscale methods for nonlinear elasticity. More specifically, we study the Generalized Multiscale Finite Element Method (GMsFEM) for a strain-limiting elasticity problem. Being an important case of the implicit constitutive theory of nonlinear elasticity, strain-limiting relation has shown an interesting class of material bodies, for which strains are still bounded while stresses can be arbitrarily high. The nonlinearity and material heterogeneities can create multiscale aspects in the solution, and multiscale methods are hence essential. To handle the nonlinearity in the arising monotone quasilinear elliptic equation, we employ linearization relied on Picard iteration. We examine offline and online basis functions, obeying the general framework of GMsFEM. The offline basis functions depend nonlinearly on the solution. Therefore, an indicator function will be designed and the offline basis functions will be recomputed when the indicator function predicts that the material feature has remarkable change throughout the iterations. On the other hand, we will use the residual based online basis functions to lower the error when updating basis functions is needed. Our numerical results demonstrate that the above combination of offline and online basis functions can produce accurate solutions with only a few basis functions per each coarse domain and adaptive updating basis functions in chosen iterations.

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CP12

Spectral Stability of Ideal-Gas Shock Layers in the Strong Shock Limit

An open question in gas dynamics is the stability of vis-

cous shock layers, or traveling-wave solutions of the compressible Navier-Stokes equations. In general, the Evans function, which is typically computed numerically, plays a key role in determining the stability of these traveling wave solutions. The goal of this research is to analytically describe the spectral stability of ideal-gas shock layers in the strong shock limit using the Evans function. The numerical stability of this system has been previously demonstrated [Humpherys et al, *Spectral stabliity of ideal-gas shock layers*] and we seek to make this stability more rigorous with an analytic proof. We do this by analytically solving for a basis of the unstable and stable manifolds and then by using these solutions to create the Evans function. Due to numerical instability in the Evans system associated with the compressible Navier-Stokes equations, we utilize the compound matrix method and a change of variables to find the bases. With the resulting analytic approximation to the Evans function, we are able to study meaningful bounds on the stability of the shock layers.

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CP12

The Vlasov-Poisson-Boltzmann System in Bounded Domains

In this 15 minutes talk I will discuss some of my recent works on the Vlasov-Poisson-Boltzmann system

$$\partial_t F + v\cdot\nabla_x F - \nabla_x\phi\cdot\nabla_v F = Q(F,F),\ -\Delta\phi(t,x) = \int_{\mathbb{R}^3} F dv - \rho_0$$

in a bounded domain $\Omega \subset \mathbb{R}^3$. I will first give some introduction about the kinetic equation in general, and then the Vlasov-Poisson equation. Then I will briefly talks about the properties of the collision operator $Q(F,F)$. After this I will talk about the boundary condition, first the so-called "incoming set" γ_-, which one should impose boundary condition. Then I will introduce several physical boundary conditions proposed by Maxwell: the inflow, the diffuse reflection, and the specular reflection boundary condition. Then I will briefly go over the history of the development of the Boltzmann equation in bounded domains. Finally I will give some of my recent results on the Vlasov-Poisson-Boltzmann system in bounded domains from [Y. Cao, C.Kim, D.Lee, Global strong solutions of the Vlasov-Poisson-Boltzmann system in bounded domains, online first in Arch. Ration. Mech. Anal.], [Y. Cao, Regularity of Boltzmann equation with external fields in convex domains of diffuse reflection, SIAM J. Math. Anal. (accepted)], [Y. Cao, A note on two species collisional plasma in bounded domains, Kinet. Relat. Models (accepted)].

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CP12

On Boundary Layers for the Burgers Equations in a Circle Domain

As a simplified model derived from the Navier-Stokes equations, we consider the viscous Burgers equations in a circle domain with Dirichlet boundary conditions,

$$\begin{aligned} &u_t^\epsilon - \epsilon\Delta u + \tfrac{(u^\epsilon)^2}{2} = f(x,y,t), && (x,y)\in\Omega\subset\mathbb{R}^2, t\geq 0\\ &u^\epsilon(x,y,0) = u_0(x,y), && (x,y)\in\Omega,\\ &u^\epsilon = g(t), && (x,y)\in\partial\Omega, \quad t\geq 0 \end{aligned}$$

where Ω is a circle. We investigate the singular behaviors of their solutions u^ϵ as the viscosity parameter ϵ gets smaller. Indeed, when ϵ gets smaller, u_x^ϵ has $1/\epsilon$ order slope. So controlling the sharp layer is one of the most important parts in this research. The idea is constructing the asymptotic expansions in the order of the ϵ and validating the convergence of the expansions to the solutions u^ϵ as $\epsilon \to 0$ in $L^2(0,T;H^1(\Omega)))$ space. In this talk, we consider the case where sharp transitions occur at the boundaries, i.e. boundary layers, and we fully analyse the convergence at any order of ϵ using the so-called boundary layer correctors. In the end, we also numerically verify the convergences.

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CP12

On Convergence of Nonlocal Conservation Laws to Local Conservation Laws

In this talk, we will present recent results on the convergence of nonlocal conservation laws to the corresponding local conservation laws. Nonlocal conservation laws are conservation laws where the velocity function depends nonlocally on the solution, i.e. on a spatial integration of the solution over a specified set. We explore results when the area of integration of this nonlocal term tends to zero and show that under specific conditions one obtains the proper weak entropy solution of the corresponding (local) conservation law.

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CP12

One-Dimensional Cylindrical Shock Waves in Non-Ideal Magnetogasdynamics

In the present paper, we analyze the evolutionary behavior of converging strong shock waves propagating through a non-ideal magnetogasdynamics . We considered the presence of infinite electrical conductivity permeated by an axial magnetic field. By using the method based on the kinematics of one dimensional motion of shock waves, we constructed an evolution equation. Here, we have computed the first order truncation approximation for the value of similarity exponents which describes the decay behavior of strong shocks. The calculated approximate value of similarity exponents are compared with the similarity exponents calculated by Whitham's rule and the exact similarity solution at the instant of collapse of the shock wave.

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CP13

Time Domain Finite Element Method for Nonlinear Maxwell's Equations

We discuss a time domain finite element method for the approximate solution of Nonlinear Maxwell's equations. A weak formulation is derived for the electric and magnetic fields with appropriate initial and boundary conditions, and the problem is discretized both in space and time. For this system, we prove an error estimate. In addition, computational experiments are presented to validate the method, the electric and magnetic fields are visualized. The method also allows treating complex geometries of various physical systems coupled to electromagnetic fields in 3D.

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CP13

The Application of Lagrange Operational Matrix Method for Two-Dimensional Hyperbolic Telegraph Equation

In this work, an efficient method is proposed to find the numerical solution of two dimensional hyperbolic telegraph equation. In this method, the roots of Legendre's polynomial are taken as the node points for the Lagrange polynomial. First, we convert the main equation in to partial integro-differential equations(PIDEs) with the help of initial and boundary conditions. The operational matrices of differentiation and integration are then used to transform the PIDEs in to algebraic generalized Sylvester equation. We compared the results obtained by the proposed method with Bernoulli matrix method and B-spline differential quadrature method which shows that the proposed method is accurate for small number of basis functions.

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CP13

Wavelet Algorithms for a High-Resolution Image Reconstruction in Magnetic Induction Tomography

Electrical conductivity (EC) varies considerably throughout the human body. Thus, an ability to image its spatial variability could be useful from a diagnostic standpoint. Various disease states may cause the conductivity to differ from that exhibited in normal tissue. EC imaging in the human body is usually pursued by either electrical impedance tomography or magnetic induction tomography (MIT). Nearly all MIT work uses a multiple coil system. More recently, MIT has explored using a single coil, whose interaction with nearby conductive objects is manifested as an inductive loss. This work has shown that single-coil, scanning MIT is feasible through an analytical 3D convolution integral that relates measured coil loss to an arbitrary conductivity distribution and permits image reconstruction by linear methods. The convolution integral must be discretized over a space that includes the target, a step currently achieved using finite elements. Though feasible, it has major drawbacks, primarily due to the need to know target boundaries precisely. Here, we propose to discretize the convolution integral using wavelets, with a goal of alleviating the problem of unknown boundaries and providing spatial resolving power where it is most needed in the target domain.

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CP13

Legendre Wavelet Based Numerical Solution for 1D, 2D and 3D BenjaminBonaMahonyBurgers Equation

This work proposes a numerical scheme based on Legendre wavelets and quasilinearization for 1D, 2D and 3D Benjamin–Bona–Mahony–Burgers (BBM) equation. Firstly, nonlinear equation is linearized by quasilinearization and later a numerical scheme is developed based on Legendre wavelets without the help of finite difference scheme. In this approach all the domains including time domain is approximated with the help of Legendre wavelets for 3D BBM equation also. The proposed approach extends the application of wavelets to 3D problems. A comparison is made with the other existing numerical methods including other Haar based wavelet methods for 2D BBM equation. Numerical experiments confirms that the proposed method gives much better accuracy with less number of grid points.

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CP13

Arbitrary High-Order Time-Stepping Methods for Reaction Diffusion Equations via Deferred Correction

The space-discretization of time-evolution partial differential equations usually lead to stiff initial value problems (IVP) of large dimension. To avoid overly small time steps, accurate approximate solutions for these IVP are obtained with high-order time-stepping methods with satisfactory stability properties (A-stable method are of great interest). Backward differentiation formulae (BDF) of order 1 and 2 are commonly used according to their A-stability property, but BDF methods of order 3 and higher lack stability properties (e.g. for systems with complex eigenvalues). We propose an approach based on deferred corrections inspired by [Gustafsson and Kress, 2012] for the time discretization of these problems. The method is based on a successive correction (perturbation) of the implicit midpoint rule, increasing the order of accuracy by two per correction step and keeping the A-stable property of the trapezoidal rule for each level of the correction. It results an unconditionally stable methods of arbitrary high order

in time when applied to nonlinear reaction-diffusion equations discretized by finite element methods in space. A complete numerical analysis of the method was done with stability and error estimates using a new Deferred Correction Condition (DCC). A numerical illustration using the bi-stable reaction-diffusion equation with the schemes of order 2, 4, 6, 8 and 10 confirms the order of the method.

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CP14

Godunov Type Solvers for Euler System with Friction Terms

The paper deals with the construction of the numerical schemes for Euler system with the Coulomb-like friction term

$$\begin{aligned} \rho_t + (\rho u)_x &= 0, \\ (\rho u)_t + (\rho u^2 - \epsilon \tfrac{A}{\rho})_x &= \beta \rho, \end{aligned} \tag{3}$$

where ρ and u denote the gas density and velocity with $A, \epsilon > 0$. It represents the lifting force on a wing of an airplane. We are interested in friction, i.e. $\beta \neq 0$. As $\epsilon \to 0$, the system converges to the pressureless gas dynamics model with body force as a source and is used to describe the motion process of free particles sticking under collision in the low temperature. Godunov Solvers for the system based on discontinuous flux for hyoerbolic conservation laws are proposed. The existing theory is limited to non-linear fluxes and does not solutions with concentration. This paper extends the thoery to linear transport equation with the discontnious coefficient admitting $\delta-$shocks. The homogeneous version of pressureless system consists of 2 equations of transport type for which the new Godunov solver will be used equation by equation. For the non homogeneous version, the source term is incorporated in the system through a suitable change of variables so as to convert into a transport equation. The stability properties of ρ and u are established. The scheme is shown to perform better than previous studies, both in location and strength of δ shock.

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CP14

Delta Shock Waves for a Hyperbolic System of Conservation Laws

This talk is concerned with a hyperbolic system of conservation laws of Keyfitz-Kranzer type. We show existence of delta shock wave solution using the vanishing viscosity method. Also, the generalized Rankine-Hugoniot relation and entropy condition are established. Also, a set of numerical experiments are provided, illustrating the theoretical findings numerically.

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CP14

Characteristic Decompositions for the Unsteady Transonic Small Disturbance Equation

We consider a two-dimensional Riemann initial data for the unsteady transonic small disturbance equation. The data is chosen so that the solution results in interacting rarefaction waves. We write the problem in self-similar coordinates and obtain a mixed type system. We resolve the one-dimensional discontinuities in the far field and we formulate the problem in a semi-hyperbolic patch between the hyperbolic and elliptic regions. We prove existence of a smooth local solution in the semi-hyperbolic patch and we obtain various characteristic decompositions.

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CP14

Group Classification, Similarity Solutions and Evolution of Weak Discontinuity for Ripa System

One of the most efficient method for finding exact particular solutions of partial differential equations (PDEs) is based on the symmetry group admitted by the PDEs. Given any subgroup of the symmetry group one can obtain group invariant solution by reducing the PDE to an equivalent PDE with fewer number of variables. In general a Lie algebra contains infinitely many subalgebras and hence can have infinitely many such reduction. It is therefore impossible to construct all such reductions [see, P.J. Olver, Applications of Lie Groups to Differential Equations, vol. 107, Springer Science & Business Media, New York, 2000]. Hence there is a need to classify subalgebras of a given algebra of same dimensions up to an equivalence class. This classification lead to the notion of optimal system of a PDE [see, X. Hu, Y. Li, Y. Chen, A direct algorithm of one-dimensional optimal system for the group invariant solutions, J. Math. Phys. 56 (5) (2015) 053504]. Here we have considered shallow water equation with horizontal temperature gradients called the Ripa system. The Ripa model is used to study ocean current in the shallow region. A complete symmetry group classification of the governing system is obtained. By constructing the one-dimensional optimal system of the Ripa model we have obtained an inequivalent class of group invariant solutions. One of the solutions of the governing system is used to study the evolutionary behaviour of the weak discontinuity wave.

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CP14

Delta Shocks in Systems of Conservation Laws of Keyfitz-Kranzer Type

We examine systems of hyperbolic conservation laws $U_t + (\Phi(U)U)_x = 0$, $U : R_t \times R_x \to R^n$, $n \geq 2$, where

$\Phi(U) = \phi(r, \Theta) : R^n \to R$, $r = |U|$ and $\Theta = U/|U| \in S^{n-1}$ and obtain two broad classes of functions ϕ for which the amplitude of smooth solutions can blow up in finite time. This possibility arises provided $\nabla_\Theta \phi \neq 0$ in regions of phase space where strict hyperbolicity fully fails. Weak solutions to the Riemann problem are found to satisfy the appropriate generalized Rankine-Hugoniot condition admitting delta shocks.

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CP15

On Stochastic Korteweg - De Vries-Type Equations

Korteweg - de Vries-type equations are ubiquitous in physics and applied sciences: for example, they appear in hydrodynamics, nonlinear optics, electric circuits, and plasma physics. Extension of the deterministic theory of KdV-type equations to the case of random forces is a natural next step motivated by the presence of some random fluctuations in the environment. The following class of equations will be considered

$$\begin{cases} du(t,x) &+ \left[Au(t,x)u_x(t,x) + Bu_{xxx}(t,x) - Cu_{xx}(t,x) + Du(t,x)\right]dt \\ &= \Phi\left(u(t,x)\right) dW(t) \\ u(0,x) &= u_0(x), \quad t \geq 0, \quad x \in X, \quad X = \mathbb{R} \quad \text{or} \quad X = [x_1, x_2]. \end{cases} \tag{4}$$

In (1), $W(t)$, $t \geq 0$, is a cylindrical Wiener process, whereas $u_0 \in L^2(X)$ is a deterministic real-valued function. In general, we can consider two cases. In the first, $\Phi(u) = \Phi$ is independent of u. It is a so-called additive case, and the corresponding solution is called a mild one. In the second called multiplicative one, $\Phi(u)$ depends on u, and the corresponding solution is a martingale one. The talk will present a mini survey on the existence results for mild and martingale solutions to the equation (1) for several particular cases of coefficients A, B, C, D.

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CP15

Magnetohydrodynamic Flow Through Channels with Asymmetric Wall Distortion and Cross-Channel Pressure Interaction

The steady flow of an incompressible, electrically charged fluid through a straight channel with asymmetric wall distortions and pressure interaction across the channel [Smith, Upstream Interactions in Channel Flows, JFM 79, 631-655, 1977] is studied in the presence of a transverse magnetic field of finite and sufficiently large strength. An algebraic relation between the stream-wise length scale of the wall distortion and the applied magnetic field strength is obtained. The fundamental nature of the hydrodynamic flow interaction is shown to be preserved on a shorter stream-wise length scale with the gradual increase in the magnetic field strength [Munsi et al., Magnetohydrodynamic Flow In Channels with Cross-Channel Pressure Interaction, Contributions to the Foundations of Multidisciplinary Research in Mechanics 2, 538-539, 2017]. A new flow structure is shown to develop where the stream-wise length is comparable to the channel width when the magnetic field strength is sufficiently large. Linear and non-linear analysis of the flow structures have been shown. Linear studies of the upstream flow character have been done to study the properties of the different flow structures. A major potential application of this work is in the accuracy improvement of MRI-based wall shear stress estimation, widely implicated in the initiation and progression of cardiovascular diseases [Zaromytidou et al., Hellenic Society of Cardiology 57, 389-400, 2016] such as atherosclerosis.

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CP15

A Rigorous Error Bound for the Slender Body Approximation of a Thin, Rigid Fiber in Stokes Flow

We investigate the motion of a thin rigid body in Stokes flow and the corresponding slender body approximation used to model sedimenting fibers. In particular, we derive a rigorous error bound comparing the rigid slender body approximation to the classical PDE for rigid motion in the case of a closed loop with constant radius. Our main tool is the slender body PDE framework previously established by the authors and D. Spirn, which we adapt to the rigid setting.

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CP15

On a System Posed by R. Aris

This note revisits an initial value system posed by Rutherford Aris in the modelling of a chemical reacting system. The interest of the problem, both from the Mathematical and Chemical perspectives, comes from the explicit dependence of the modelling in the temperature through a nonlinear reaction that obeys an Arrhenius law. Important aspects of the steady problem and the influence of the involved parameters in it are studied, for example multiplicity of solution or comparison (in case of multiplicity); then, a natural connection with the proper evolution problem is done, where some ω-limits are studied. In this last context, the corresponding ODE system is also studied. Numerical aspects are also presented for the steady and unsteady problem

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CP15

Hierarchical Model Family of Reaction-Diffusion Equations for Liver Infections

We present a reaction-diffusion system for modeling the interactions of the virus and the cells of the immune system during a liver infection. The reaction functions are based on adapted predator-prey interactions between the virus as a prey and the T cells as a predator. Liver infections like hepatitis B and C are world-wide spread diseases which tend to chronify. Long-lasting inflammations often lead to deathly secondary diseases like liver cirrhosis. The underlying mechanisms of the chronification are not fully understood and therefore mathematical models are used for finding and testing new hypothesis about the development of the disease and the role of the immune system. Depending on the extension of the domain and parameters like the reaction change rate and the diffusion strength, we find solutions tending to zero or solutions tending towards a stationary spatially inhomogeneous state. The first group of solutions is connected to healing infection courses and the second group to chronic courses. I present a hierarchical model family with linear and nonlinear reaction-diffusion models, stationary models and reduced space-independent models. The models of the model family are analyzed by using different mathematical approaches like e.g. Fourier techniques and entropy functionals. We gain insight in the mechanisms leading to a higher chronification tendency by regarding the whole model family and the different information provided by each model.

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CP15

Mathematical Modelling and Computational Simulations of Diffusion in Cardiac Tissue

Diffusion tensor imaging is a powerful tool for inferring microstructure from the magnitude and preferred directions of diffusion measured within biological tissue. This inverse problem is complicated by the inhomogeneous nature of diffusion processes. Computational modelling, commonly by Monte Carlo random walk, has proven useful to study the relation between intrinsic parameters and observed signal. Recently, Rose (2019, MRM, 10.1002/mrm.27561) showed that idealised geometries are insufficient to model diffusion in cardiac tissue over the relevant imaging time scales, necessitating inclusion of the large-scale cellular arrangement in the model. Further, assuming a two-compartment model without exchange (where contributions from intra- and extra-cellular space are analysed separately) fails to match experimental observations, likely because cardiac cells are highly permeable. A large parameter space and computational cost means analytical methods can provide more effective ways of narrowing the search space. In this work we solve the parabolic equations describing diffusion in a domain with complex internal boundary conditions (semi-permeable barriers) in 1D and 2D using semi-analytical methods similar to (Moutal, 2018, arXiv:1807.06336). We obtain time-varying probability distributions of self-diffusing particles and verify our simulations. We inform the parameter choice and simulate 3D diffusion in histology-based microstructures and compare with experimental data.

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CP16

On Local Boundedness and Divergence-Free Drifts

We consider the motion of a scalar θ in a steady, divergence-free velocity field b, for example, as describes the the $2d$ Navier-Stokes equations in vorticity form. The regularity of the corresponding parabolic equation $\partial_t\theta - \Delta\theta + b\cdot\nabla\theta = 0$ has experienced renewed interest in recent years, in light of Caffarelli and Vasseur's proof of regularity for the SQG equation. The De Giorgi-Nash-Moser theory implies that, when the drift b belongs to certain "critical" spaces such as L^n, weak solutions θ are Hölder continuous. When b belongs to certain supercritical spaces, it is known that solutions may be discontinuous, yet they remain bounded. In this talk, we present sharp conditions on the drift b such that weak solutions are locally bounded and satisfy Harnack's inequality. Surprisingly, solutions remain bounded when $b \in L^{\frac{n-1}{2}+}$. The proof relies on a dimension reduction technique of Frehse-Ruzicka and Kontovourkis, who investigated the elliptic case. We present new counterexamples to demonstrate the optimality of our results.

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CP16

Quantifying the Reduction in Damage by a Nuclear Blast Wave by the Addition of Dust.

In this paper, the role of the dust particles in weakening or scaling down the blast wave produced by an atmospheric nuclear explosion is investigated. A near realistic mathematical model has been considered to study the one-dimensional, two-phase unsteady flow of an inviscid non-ideal gas with dust particles. Euler's equations are used for the dusty gas flow, the Rankine-Hugoniot conditions connect the flow ahead and behind the blast waves. The forms of drag force and the heat transfer rate experienced by the particle not in equilibrium with the gas are considered. The non-ideal parameter used is the van der Waals excluded volume. A particular solution is obtained using appropriate assumptions. An estimation of energy released and reduction in the blast radius on varying the various dust parameters like mass fraction of the solid particles in the mixture, ratio of specific heat of the mixture to the specific heat of the gas at constant pressure and ratio of the density of the solid particles to the species density of the gas is obtained. The enhancements in decay caused by varying the quantity of dust is studied. The solution is generalised to all geometries, planar, cylindrical and spherical. It was observed that there is a substantial decrease in the blast wave radius with the increase of dust particles in

the atmosphere however, a reverse trend is seen with the increase in the non-ideal parameter.

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CP16

Strong Shock Waves in Non-Ideal Gas of Variable Density under Magnetic Field

In this article, we analyzed an imploding strong shock wave problem collapsing at the axis of cylindrical piston which is filled with a non-ideal gas of non-uniform density which is decreasing towards the axis of symmetry according to a power law. Also, we considered the presence of axial magnetic field. The perturbation series technique that we applied to system of partial differential equations governing one dimension adiabatic cylindrically symmetric flow provide us the global solution and also recover Guderley's a local solution which holds only in the vicinity of the axis of symmetry. Similarity exponents and their corresponding amplitudes are found by expanding the flow parameters in powers of time. We, also computed similarity exponents by the characteristic method suggested by Chester-Chisnell-Whitham (CCW). Comparison has been made between the computed value of similarity exponents by both the methods and already existed similarity exponents by Hafner and found that results are in good agreement upto two decimal place. All the flow parameters and shock path have been computed in the region extending from the piston to the axis of collapse and analyzed graphically with respect to the variation of different parameters b, delta and C0.

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CP16

Well-Posedness, Regularity, and Global Dynamics of a Mean Field Model of Electroencephalographic Activity in the Neocortex

This talk is focused on analysis of a well-established mean field model of the neocortex, which is comprised of a system of coupled ordinary and partial differential equations in two-dimensional space. The model includes a large set of biophysical parameters which are thoroughly included in the analysis. The entire analysis is constrained by biologically reasonable ranges of values for these parameters to ensure the applicability of the results to neuroscience problems. Analytical results on existence, uniqueness, nonnegativity, and regularity of the solutions of the model are presented. It is shown that semidynamical systems of weak and strong solution operators possess bounded absorbing sets. Moreover, it is shown that for some sets of parameter values the equilibrium sets are not compact in the weak and strong topologies considered in the analysis. This further implies noncompactness of the global attracting set. In this case, some solution components can develop drastic asymptotic discontinuities regardless of the smoothness of initial values and forcing terms. Potential impacts of such discontinuities on numerical solutions of the model are demonstrated. This talk is accompanied by a poster presentation which shows the application of this model in predicting the emergence of spatio-temporal gamma oscillations in the neocortex.

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MS1

Energy-Decaying and Positivity-Preserving Schemes for Kinetic Gradient Flows

We propose fully-discrete, implicit-in-time finite-volume schemes for general non-linear non-local Fokker-Planck equations with a gradient flow structure. The schemes verify the positivity-preserving and energy-decaying properties, done conditionally by the second order scheme and unconditionally by the first order counterpart. Dimensional splitting allow for the construction of these schemes with the same properties and a reduced computational cost in any dimension. We will showcase the handling of complicated phenomena: free boundaries, meta-stability, merging, and phase transitions.

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MS1

A Fully Discrete Positivity-Preserving and Energy-Dissipative Finite Difference Scheme for Poisson-Nernst-Planck Equations

The Poisson-Nernst-Planck (PNP) equations is a macroscopic model widely used to describe the dynamics of ion transport in ion channels. It is a gradient flow with respect to Wasserstein metric. We introduce a semi-implicit finite difference scheme for the PNP equations in a bounded domain. A general boundary condition for the Poisson equation is considered. The fully discrete scheme is shown to satisfy the following properties: mass conservation, unconditional positivity, and energy dissipation (hence preserve the steady state). Solvability of the semi-discrete scheme is proved and a simple fixed point iteration is proposed to solve the fully discrete scheme. Numerical examples in both 1D and 2D and for multiple species are presented to demonstrate the convergence and properties of the proposed scheme. Joint work with Xiaodong Huang.

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MS1

Structure Preserving Schemes for Nonlinear Fokker-Planck Equations with Anisotropic Diffusion

In this talk I will present an extension of a recently proposed structure preserving numerical scheme for non linear Fokker-Planck-type equations with isotropic diffusion [1] to the case of anisotropic diffusion matrices. The introduced schemes preserve fundamental structural properties like non negativity of the solution, entropy dissipation and which guarantees an arbitrarily accurate approximation of the steady state of the problem. All the methods presented are at least second order accurate in the transient regimes and high order for large times. Applications of the schemes

to models for collective phenomena and life sciences are considered, as in these examples anomalous diffusion is often observed and must be taken into account in realistic models.

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MS1

An Entropy Stable High-Order Discontinuous Galerkin Method for Cross-Diffusion Gradient Flow Systems

As an extension of our previous work, we develop a discontinuous Galerkin method for solving cross-diffusion systems with a formal gradient flow structure. These systems are associated with non-increasing entropy functionals. For a class of problems, the positivity (non-negativity) of solutions is also expected, which is implied by the physical model and is crucial to the entropy structure. The semi-discrete numerical scheme we propose is entropy stable. Furthermore, the scheme is also compatible with the positivity-preserving procedure in many scenarios. Hence the resulting fully discrete scheme is able to produce non-negative solutions. The method can be applied to both one-dimensional problems and two-dimensional problems on Cartesian meshes. Numerical examples are given to examine the performance of the method.

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MS2

On the Principal Frequency of the p-Laplacian

For any open, bounded, convex domain $\Omega \subset \mathbb{R}^N$ $(N > 1)$ with smooth boundary for which the maximum of the distance function to the boundary of Ω is sufficiently small, the principal frequency of the p-Laplacian is an increasing function of p on $(1, +\infty)$. This result is sharp, in a sense that will be discussed. The talk is based on joint work with M. Mihailescu ("Simion Stoilow" Institute of Mathematics of the Romanian Academy and University of Craiova, Romania).

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MS3

Uniform Decay Properties of Structural Acoustic PDE Models

In this talk, we discuss the uniform stability problem for a canonical structural acoustics partial differential equation (PDE) model which was originally considered by W. Littman and B. Liu. This structural acoustics model constitutes a coupled PDE interactive system under given boundary dissipation; each component equation of this system evolves within its own distinct geometry, with the coupling between the dynamics occurring across a boundary interface. Since this dissipation is transmitted across the boundary interface to the other non-dissipative (wave) PDE component, a natural question is whether such indirect dissipation suffices to confer uniform stability to all solution variables. By a careful estimation of the associated semigroup resolvent, we establish that classical solutions of this coupled PDE model obey a polynomial rate of decay. Subsequently, we discuss a methodology by which one may show that the obtained rational decay rate is optimal.

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MS3

On the Existence and Stability of Standing Waves in Three Types of NLS Equations

In this talk, we present analytical studies of standing waves in three NLS models. We first consider the spectral stability of ground states of semi-linear Schrödinger and Klein-Gordon equations with fractional dispersion. We use Hamiltonian index counting theory, together with the information from a variational construction to develop sharp conditions for spectral stability for these waves. The second equation we consider is a nonlocal NLS which comes from modeling nonlinear waves in Parity-time symmetric systems. We investigate the spectral stability of standing waves of its $\mathcal{PT}$ symmetric solutions. Finally, the third case is about the existence and the stability of the vortices for the NLS in higher dimensions. We extend the existence and stability results of Mizumachi from two-space dimensions to n space dimensions.

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MS3

Long Time Properties of a Multilayered Structure-Fluid PDE System

We consider a fluid-structure PDE model of longstanding interest within the mathematical and biological sciences. Here, a three dimensional Stokes system and three dimensional vector-valued wave equation comprise the coupled PDE system under study; these respective PDE components come into contact via a boundary interface. For this fluid structure system, our main result is as follows: Under an appropriate geometric assumption which precludes imaginary point spectrum for the associated semigroup generator, then for smooth initial data - i.e., data in the domain of the generator the corresponding solutions decay at a certain polynomial rate.

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MS3

A Note on the Resolvent Estimates of the Damped Wave Equation via Observability Estimate

In this talk, the main object of our study is the following observability estimate

$$(-\Delta - \lambda)u = f \Longrightarrow \|u\|_{L^2(\mathbb{R}^n)} \leq C\left(\langle\lambda\rangle^{\alpha}\|f\|_{L^2(\mathbb{R}^n)} + \|u\|_{L^2(\Omega)}\right), \quad (5)$$

where $\lambda \in \mathbb{R}$, $-1 < \alpha \leq 0$, and $\Omega \in \mathbb{R}^n$ be a nonempty set. I will discuss some methods to prove such estimate on bounded as well as unbounded domains. In one-dimension case, I will show estimate hold for $\alpha = -\frac{1}{2}$ with Ω as 2π periodic set. In higher dimension, the estimate is true for $\alpha = 0$ with Ω as 2π periodic set (which is certainly not optimal). I will also show that using the above observability estimates, we can derive resolvent estimate for damped wave types equations. The resolvent estimate provides the energy decay rate of the underline equation.

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MS4

Regularity and Long-Time Behavior for Hydrodynamic Flocking Models

In this talk, we will discuss wellposedness theory and the long-time behavior for various Euler Alignment models on the 1D torus. We will show that for large times, the deviation from a uniform flock can be controlled by an auxiliary quantity that depends only on the initial data.

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MS4

Anticipation Breeds Alignment

We study the large-time behavior of systems driven by radial potentials, which react to *anticipated* positions, $\mathbf{x}^{\tau}(t) = \mathbf{x}(t) + \tau\mathbf{v}(t)$ with anticipation increment $\tau > 0$. As a special case, such systems yield the celebrated Cucker-Smale model for alignment, coupled with pairwise interactions. Viewed from this perspective, such anticipated-driven systems are expected to emerge into *flocking* due to alignment of velocities, and *spatial concentration* due to confining potentials. We treat both the discrete dynamics and large crowd hydrodynamics, proving the decisive role of anticipation in driving such systems with attractive potentials into velocity alignment and spatial concentration. We also study the concentration effect near equilibrium for anticipated-based dynamics of pair of agents governed by attractive-repulsive potentials.

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MS4

Eulerian Dynamics in Multi-Dimensions with Radial Symmetry

The Eulerian dynamics describes many interesting phenomena in fluid mechanics. In this talk, I will discuss several equations that lie in this category, including the damping Burgers equation, the Euler-Poisson equation and the Euler-Alignment equation. Though a lot of work has been done for the problems in one-dimension, much less is known in multi-dimensions, due to the effect of the "spectral gap". I will explain the main difficulty of controlling the spectral gap, and introduce a new way to handle the term in the case when the solution is radially symmetric.

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MS5

Lax-Wendroff Schemes for Quasi-Exponential Moment-Closure Approximations in Plasma Physics

In many applications the dynamics of gas and plasma can be accurately modeled using kinetic Boltzmann equations. These equations are integro-differential systems posed in a high-dimensional phase space. If the system is sufficiently collisional, the kinetic equations may be replaced by a fluid approximation that is posed in physical space (i.e., a lower dimensional space than the full phase space). The precise form of the fluid approximation depends on the choice of the moment-closure. In general, finding a suitable robust moment-closure is still an open scientific problem. In this work we consider a specific moment-closure based on a nonextensive entropy formulation. In particular, the true distribution is replaced by a Maxwellian distribution multiplied by a quasi-exponential function. We develop a high-order, locally-implicit, discontinuous Galerkin scheme to numerically solve resulting fluid equations. The numerical update is broken into two parts: (1) an update for the background Maxwellian distribution, and (2) an update for the non-Maxwellian corrections. We also develop limiters that guarantee that the inversion problem between moments of the distribution function and the parameters in the quasi-exponential function is well-posed.

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MS5

Quantifying the Uncertainty on Magnetic Equilibrium Computations for Tokamaks

In magnetic confinement fusion devises, the equilibrium configuration of a plasma is determined by the balance between the hydrostatic pressure in the fluid and the magnetic forces generated by an array of external coils and the plasma itself. The location of the plasma is not known *a priori* and must be obtained as the solution to a free boundary problem. The partial differential equation that determines the behavior of the combined magnetic field depends on a set of physical parameters (location of the coils, intensity of the electric currents going through them, mag-

netic permeability, etc.) that are subject to uncertainty and variability. The confinement region is then in turn a function of these stochastic parameters as well. Stochastic collocation and multi level Monte Carlo strategies are used to explore the effect that the stochasticity in the parameters has on relevant features of the plasma boundary such as the location of the x-point, the strike points, and shaping attributes such as triangularity and elongation.

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MS5

Exponential Integration for Stiff Problems in Plasma Physics

Exponential time integration is an alternative approach to solving systems of ordinary differential equations that can offer computational savings for stiff problems compared to explicit and implicit methods. Construction of an efficient exponential scheme is a complex task that involves choosing the appropriate quadrature to approximate the nonlinear forcing in the system as well as a fast algorithm to compute products of exponential-like matrix functions and vectors. In this talk we discuss latest developments in exponential integration and describe recently proposed algorithms that enable significant computational savings. We particularly focus on the efforts in our group to develop efficient time integrators for two types of problems in plasma physics modeling large-scale evolution of plasmas using equations of magnetohydrodynamics and describing particle dynamics in magnetized plasmas.

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MS6

Stability of Growing Stripes in the Complex Ginzburg-Landau Equation

Quenching interfaces have been proposed as a simple way to experimentally and theoretically caricature pattern formation in growing domains. Here a spatial heterogeneity travels through the domain suppressing patterns in one subdomain and exciting them in the complement. In examples such as light-sensitive reaction-diffusion systems, or evaporative chemical deposition, one aims to understand how the speed of the interface can mediate and select patterns in the wake. We consider stability and dynamics of pattern-forming fronts in the Complex Ginzburg-Landau equation with such a quenching mechanism. In the regime where the heterogeneity between domains travels with speed near the natural invasion speed of patterns, the front interface locks far away from the interface, leaving a long plateau state lying near an absolutely unstable homogeneous equilibrium. Technically, this leads to eigenvalues accumulating on weakly unstable absolute spectrum and loss of analyticity in the Evans function. We show how a projective blow-up and Riemann surface reparameterization of the eigenvalue problem can be used to unfold the linear dynamics and study point spectrum.

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MS6

Robustness of Planar Target Patterns

Planar target patterns are radially symmetric time-periodic structures that connect a core region with a spatially periodic traveling wave in the far field. These patterns arise in a number of different applications, including chemical reaction patterns. We are interested in understanding the robustness of these patterns (eg do these patterns select the wave number of the asymptotic wave train or do they come in one-parameter families) and their stability with respect to small perturbations. Existence and robustness of small target patterns was previously studied near degenerate oscillatory instabilities. Here, we study the large-amplitude case and use a combination of spatial dynamical systems and Fredholm techniques to prove that target patterns uniquely select the asymptotic wave number provided the asymptotic wave trains have positive group velocity and are spectrally stable.

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MS6

Temporal Oscillations in Coagulation-Fragmentation Models

We prove that time-periodic solutions arise via Hopf bifurcation in a closed system of coagulation-fragmentation equations. The system we treat is a variant of the Becker-Doering equations, in which clusters grow or shrink by addition or deletion of monomers. To this is added a linear atomization reaction for clusters of maximum size. The structure of the system is motivated by models of bubbling oscillators in physical chemistry which exhibit temporal oscillations under certain input/output conditions.

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MS6

Pattern Selection from Directional Quenching

We study how the growth of a domain influences the formation of striped patterns. We focus on the planar Swift-Hohenberg equation, where stripes are grown in the wake of a moving parameter step. We find stripes perpendicular or oblique relative to the parameter step, and a plethora of defects nucleating at the step. Using amplitude equations, asymptotic methods, algebraic spreading speed calculations, and numerical farfield-core decompositions, we construct a surprisingly complex bifurcation diagram for coherent stripe formation. Solutions form a singular surface, the moduli space, in the three-dimensional parameter space of wavevector of stripes and speed of quenching line. Typical scenarios of stripe formation, observed when increasing the rate of growth, go from oblique stripes to zigzag patterns and perpendicular stripes, then back to zigzag patterns, stripes with amplitude defects, and parallel stripes, before stripe formation detaches.

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MS7

Data Assimilation and Model Bias Estimation During Extreme Events

I will describe a general approach, originally suggested by Baek, Hunt, Ott, *et al.* to handle systematic model bias in an ensemble Kalman filtering data assimilation scheme. Our application is to the operational Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM), when the driving parameters are systematically misspecified, as may occur during a geomagnetic storm event. We consider two simple models for the time evolution of the model bias: a constant-bias model and another with an exponential growth and decay phase. In both cases, the model bias is accommodated in the evaluation of the forward operator during each analysis cycle. Using synthetic data at locations representative of operational ionospheric observing platforms during the geomagnetic storm of 26–27 September 2011, we show that the approaches reduce the root-mean-squared error in 1-hour TIEGCM forecasts of electron density by up to 40 percent compared to an ordinary ensemble Kalman filter. Our results suggest that the approach is a promising way to improve space weather prediction during extreme events.

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MS7

Data Assimilation for PDEs using Adaptive Moving Meshes

We combine techniques for adaptive moving spatial meshes and data assimilation techniques for physical models given by time dependent partial differential equations. We consider ensemble based data assimilation techniques in which each ensemble member evolves independently based upon its own spatial mesh. Our focus is to determine time dependent reference meshes upon which the mean and covariance are calculated, using the metric tensor that defines the spatial mesh of the ensemble mean. We also explore how adaptive moving mesh techniques can control and inform the placement of mesh points to match the location of observations, further reducing errors in the data assimilation process.

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MS8

Many Particle Limit for a System of PDEs with Newtonian Nonlocal Interactions

I will discuss recent results concerning a system of continuity equations driven by Newtonian nonlocal interactions. First, I will talk about the well-posedness for such a system, which depends on the type of the initial datum. Then, I will focus on its deterministic particle approximation, showing that solutions to the system can be obtained as the many particle limit of a set of interacting particles solving the corresponding system of ODEs. The talk is based on joint works with J.A. Carrillo, M. Di Francesco, S. Fagioli, and M. Schmidtchen.

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MS8

Kinetic Model with Thermalization for a Gas with Total Energy Conservation

We consider the thermalization of a gas towards a Maxwellian velocity distribution which depends locally on the temperature of the background. The exchange of kinetic and thermal energy between the gas and the background drives the system towards a global equilibrium with constant temperature. The heat flow is governed by the Fourier's law. Mathematically we consider a coupled system of nonlinear kinetic and heat equations where in both cases we add a term that describes the energy exchange. For this problem we are able to prove existence of the solution in 1D, exponential convergence to the equilibrium through a hypocoercivity technique, macroscopic limit toward a cross-diffusion system. In the last two cases a perturbative approach is taken into account. It's worth noticing that also without heat conductivity we can show the temperature diffusion thanks to the transport of energy. It is also interesting to show that the thermalization is highly influenced by the background temperature. All these aspects have been investigated also from a numerical viewpoint in order to provide simulations in 2D.

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MS8

A Multiscale Derivative-Free Approach to Bayesian Inverse Problems

In large-scale applications of inverse problems, calculating the derivatives or adjoints of the forward model is often undesirable or impossible. In this talk we present a multiparticle multiscale methodology to sample from the Bayesian posterior that does not require the calculation of derivatives and adjoints of the forward model. It also aims to overcome the issue of uncontrolled difference approximations in the Ensemble Kalman Sampler, another recently introduced derivative-free algorithm for inverse problems. We study the method via rigorous asymptotic expansions and we assess its efficacy by means of numerical experiments.

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MS9

Kalman-Wasserstein Gradient Flows

We study a class of interacting particle systems that may be used for optimization. By considering the mean-field limit one obtains a nonlinear Fokker-Planck equation. This equation exhibits a novel gradient structure in probability space, based on a modified Wasserstein distance which reflects particle correlations: the Kalman-Wasserstein metric. This setting gives rise to a methodology for calibrating and quantifying uncertainty for parameters appearing in complex computer models which are expensive to run, and cannot readily be differentiated. This is achieved by connecting the interacting particle system to ensemble Kalman methods for inverse problems.

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MS9

Scaling Limits of Discrete Optimal Transport

We consider dynamical transport metrics for probability measures on discretisations of a bounded convex domain in $\mathbb{R}^d$. These metrics are natural discrete counterparts to the 2-Kantorovich metric, defined using a Benamou-Brenier type formula. However, we show that the discrete transport metrics may fail to converge to the 2-Kantorovich metric, even on certain one-dimensional meshes. We present a homogenisation result that identifies the limiting metric. Under additional isotropy assumptions on the mesh, which are essentially necessary, we show that convergence of the discrete transport metric to the 2-Kantorovich metric holds. This is based on joint work with Peter Gladbach, Eva Kopfer, and Lorenzo Portinale.

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MS9

Evolutionary Artificial Intelligence via Optimal Transport

In this talk, we introduce a new family of transportation costs with applications in exploration algorithms between neural network architectures as gradient descents. These costs are inspired by a new formal Riemannian structure of the probability measures over the product space of $\mathbb{R}^n$ and an abstract graph. We use this family of costs to produce distributional solutions to the gradient flow of the relative entropy in the formal Riemannian structure using a generalized minimizing movement scheme. Additionally, we discuss ongoing work that aims to use the behavior of evolutionary equations in the Wasserstein space to propose

new algorithms and quantify the uncertainty of their global relaxation to equilibrium in the absence of convexity. If time permits, we will summarize how this can be achieved in the particular case of the Kuramoto Sakaguchi equation by using entropy production estimates and the instability of critical points, following the work of L. Desvillettes and C. Villani on the Boltzmann equation. I will discuss past and current joint works with David Poyato, Nicolas Garcia Trillos, and Eitan Tadmor.

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MS9

Nonlocal-Interaction Equations on Graphs and their Continuum Limits

We consider transport equations on graphs, where mass is distributed over vertices and is transported along the edges. The first part of the talk will deal with the graph analogue of the Wasserstein distance, in the particular case where the notion of density along edges is inspired by the upwind numerical schemes. This natural notion of interpolation however leads to the fact that Wasserstein distance is only a quasi-metric. In the second part of the talk we will interpret the nonlocal-interaction equation equations on graphs as gradient flows with respect to the graph-Wasserstain quasi-metric of the nonlocal-interaction energy. We show that for graphs representing data sampled from a manifold, the solutions of the nonlocal-interaction equations on graphs converge to solutions of an integral equation on the manifold. We also show that the limiting equation is a gradient flow of the nonlocal-interaction energy with respect to a nonlocal analogue of the Wasserstein metric.

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MS11

Solitary Water Waves with Discontinuous Vorticity

We investigate the existence of solitary gravity waves traversing a two-dimensional body of water that is bounded below by a flat impenetrable ocean bed and above by a free surface of constant pressure. Under the assumption that the vorticity is only bounded and measurable, we prove that for any upstream velocity field, there exists a continuous curve of large-amplitude solitary wave solutions. This is achieved via a local and global bifurcation construction of weak solutions to the elliptic equations which constitute the steady water wave problem. We also show that such solutions possess a number of qualitative features; most significantly that each of these solitary waves has an axis of even symmetry, and the height of their streamline above the bed decreases monotonically as one moves to the right of the crest.

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MS11

Numerical Bifurcation and Spectral Stability of Wavetrains in Bidirectional Whitham Models

We numerically explore the spectral stability of a class of periodic traveling wave solutions in several bidirectional Whitham models, which incorporate the full two-way dispersion relation of the incompressible Euler equations as well as a canonical shallow water nonlinearity. Via sixth-order pseudospectral methods, we examine the stability spectrum of large-amplitude waves generated by numerically continuing a branch of solutions that bifurcates from zero amplitude.

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MS11

Nonlocal Solitary Waves in Diatomic Fermi-Pasta-Ulam-Tsingou Lattices under the Equal Mass Limit

The diatomic Fermi-Pasta-Ulam-Tsingou (FPUT) lattice is an infinite chain of alternating particles connected by identical nonlinear springs. We prove the existence of nonlocal (or generalized) solitary traveling waves in the diatomic FPUT lattice in the limit as the ratio of the two alternating masses approaches 1, at which point the diatomic lattice reduces to the well-understood monatomic FPUT lattice. These are traveling waves whose profiles asymptote to a small periodic oscillation at infinity, instead of vanishing like the classical solitary wave. Unlike the related long wave and small mass limits for diatomic FPUT traveling waves, this equal mass problem is not singularly perturbed, and so the amplitude of the oscillation is not small beyond all orders. The central challenge of this problem hinges on a hidden solvability condition in the traveling wave equations, which manifests itself in the existence and fine properties of asymptotically sinusoidal solutions to an auxiliary advance-delay differential equation.

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MS11

Nonlinear Stability and Interactions of High-Energy Solitary Waves in Fermi-Pasta-Ulam-Tsingou Chains

The dynamical stability of solitary lattice waves in non-integrable FPUT chains is a long standing open problem and has been solved only in the KdV limit, in which the waves propagate with near sonic speed, have large wave length, and carry low energy. In this talk I explain similar results in a complementary asymptotic regime of fast and strongly localized waves with high energy. The spectrum of the linearized FPUT operator contains asymptotically no unstable eigenvalues except for the neutral ones

that stem from the shift symmetry and the spatial discreteness. Then high-energy waves are linearly stable. Nonlinear stability in some orbital sense is granted by the general, non-asymptotic part of works by Friesecke-Pego and Mizumachi. For the linear stability refined two-scale techniques relate the high-energy wave to a nonlinear asymptotic shape ODE and provide accurate approximation formulas. This yields the existence, local uniqueness, smooth parameter dependence, and exponential localization of fast lattice waves for potentials with algebraic singularity. The eigenvalue problem is studied in exponentially weighted spaces removing unstable essential spectrum. All proper eigenfunctions can asymptotically be linked to unique normalized solutions of the linearized shape ODE, which disproves the existence of unstable eigenfunctions in the symplectic complement of the neutral ones. The linear results are crucial ingredients to understand the interaction of such waves.

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MS12

Poiseuille Flow of Nematic Liquid Crystals via the Full Ericksen-Leslie Model

We study the Cauchy problem of the Poiseuille flow of full Ericksen-Leslie model for nematic liquid crystals. The model is a coupled system of a parabolic equation for the velocity and a quasilinear wave equation for the director. For a particular choice of several physical parameter values, we construct solutions with smooth initial data and finite energy that produce, in finite time, cusp singularities-blowups of gradients. The formation of cusp singularity is due to local interactions of wave-like characteristics of solutions, which is different from the mechanism of finite time singularity formations for the parabolic Ericksen-Leslie system. We are also able to establish the global existence of weak solutions that are Hölder continuous and have bounded energy.

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MS12

Bistable Features of Orthogonal Smectic Bent-Core Liquid Crystals

We consider polarization-modulated orthogonal smectic liquid crystals which exhibits a bistable response to applied electric field. The opposite anchoring at the stripe boundaries and in-polarization form topological singularities. We describe the boundary vortices by obtaining a convergence of minimizers of the Ginzburg-Landau type functional with boundary penalty term in a rectangular domain. Numerical simulations illustrate the boundary vortices formation and switching dynamics of the ferroelectric bistable liquid crystals. This is a joint work with T. Giorgi and C. J. García-Cervera.

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MS12

Two-Dimensional Stokes Immersed Boundary Problem and its Regularizations: Well-Posedness, Singular Limit, and Error Estimates

Studying coupled motion of immersed elastic structures and surrounding fluid is important in science and engineering. In this talk, we first consider 2-D Stokes immersed boundary problem that models a 1-D closed elastic string immersed and moving in a 2-D Stokes flow, and we discuss well-posedness of the string dynamics. Inspired by the numerical immersed boundary method, we then introduce a regularized version of the problem, in which a regularized delta-function is used to mollify the flow field and singular forcing. We prove global well-posedness of the regularized problems, and show that as the regularization parameter diminishes, the string dynamics in the regularized problems converge to that in the un-regularized problem under certain assumptions. Viewing the latter as a benchmark, we derive error estimates for the string dynamics. Our rigorous analysis shows that the regularized problems achieve improved accuracy if the regularized delta-function is suitably chosen. This may imply potential improvement in the numerical immersed boundary method, which is worth further investigation.

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MS12

Suitable Weak Solutions for the Co-Rotational Beris-Edwards System in Dimension Three

In this paper, we establish the global existence of a suitable weak solution to the co-rotational Beris-Edwards Q-tensor system modeling the hydrodynamic motion of nematic liquid crystals with either Landau-De Gennes bulk potential in R^3 or Ball- Majumdar bulk potential in T^3, a system coupling the forced incompressible Navier- Stokes equation with a dissipative, parabolic system of Q-tensor Q in R^3, which is shown to be smooth away from a closed set Σ whose 1-dimensional parabolic Hausdorff measure is zero.

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MS13

Numerical Schemes for Stochastic Navier-Stokes Equations and Related Models

We consider a time discretization scheme of Euler type for

the 2d stochastic Navier-Stokes equations on the torus. We prove a mean square rate of convergence. This refines previous results established with a rate of convergence in probability only. Using exponential moment estimates of the solution of the Navier-Stokes equations and a convergence of a localized scheme, we can prove strong convergence of fully implicit and semi-implicit time Euler discretization and also a splitting scheme. The speed of convergence depends on the diffusion coefficient and the viscosity parameter. If time permits, an introduction to some 3d models will be given with their numerical schemes.

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MS13

Rough Solutions to the Compressible Euler Equations

We establish local well-posedness for the compressible Euler equations with minimal regularity assumptions on the velocity and the density, and an arbitrary equation of state. Our proof relies on a combination of Strichartz estimates for a wave-formulation of the Euler equations, control of the acoustical geometry (i.e., the geometry of sound cones), and elliptic estimates.

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MS13

Boundary Controllability of a Membrane or Plate Enclosing a Potential Fluid

A wave or plate equation is used to model the flexible portion of the boundary of the domain of a three-dimensional linear potential fluid. Exact controllability is proved for sufficiently small fluid density with control applied on a large enough portion of the boundary of the flexible portion. Partial controllability results for a related problem with the potential equation replaced by the wave equation will also be described.

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MS13

On Weak Solutions of 2D Primitive Equations

Due to hydrostaticity of Primitive Equations for incompressible fluids, the nonlinearity of this system in 2D spatial setting appears as strong as that of 3D incompressible Navier-Stokes system, at least at the level of general function space setting. Thus, understanding of the properties of weak solutions to this system remains incomplete even for 2D spatial domain. Some of the basic but important ones in this aspect will be presented and application of them will be discussed as well.

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MS14

Some Extended Mean Field Games with Jumps

Many examples of mean field games arise in economics, where the equilibrium is determined through a market clearing condition. This naturally leads to a mean field game of controls, or extended mean field games. In this talk I will give some new results on existence of classical solutions for such a model, which is of particular interest to exhaustible resource production.

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MS14

Deep Learning Algorithms for Solving High-Dimensional PDEs

High-dimensional PDEs have been a longstanding computational challenge. We propose to solve high-dimensional PDEs by approximating the solution with a deep neural network which is trained to satisfy the differential operator, initial condition, and boundary conditions. Our algorithm is meshfree, which is key since meshes become infeasible in higher dimensions. Instead of forming a mesh, the neural network is trained on batches of randomly sampled time and space points. The algorithm is tested on a class of high-dimensional PDEs in up to 200 dimensions. In addition, we prove a theorem regarding the approximation power of neural networks for a class of quasilinear parabolic PDEs.

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MS14

A Deep Learning Algorithm for Solving Partial Differential Equations

High-dimensional PDEs have been a longstanding computational challenge. We propose to solve high-dimensional PDEs by approximating the solution with a deep neural network which is trained to satisfy the differential operator, initial condition, and boundary conditions. Our algorithm is meshfree, which is key since meshes become infeasible in higher dimensions. Instead of forming a mesh, the neural network is trained on batches of randomly sampled time and space points. The algorithm is tested on a class of high-dimensional free boundary PDEs, which we are able to accurately solve in up to 200 dimensions. The algorithm is also tested on a high-dimensional Hamilton-Jacobi-Bellman PDE and Burgers' equation. The deep learning algorithm approximates the general solution to the Burgers' equation for a continuum of different boundary conditions and physical conditions (which can be viewed as a high-dimensional space). We call the algorithm a "Deep Galerkin Method (DGM)" since it is similar in spirit to Galerkin methods, with the solution approximated by a neural network instead of a linear combination of basis functions. In addition, we prove a theorem regarding the approximation power of neural networks for a class of quasilinear parabolic PDEs.

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MS14

Mean Field Models of Crowd Interactions and Surveillance-Evasion Games

We will examine consistency requirements for mean-field-game-type models of crowd dynamics. Anisotropies in pedestrians' speed profiles might arise due to a non-local dependence on crowd density or due to multi-crowd interactions. In the latter case, there are also additional challenges in proving the uniqueness of Nash equilibrium. We will also discuss the implications for efficiency and accuracy of numerical methods. Similar issues will be also considered for MFG models of evasive path-planning under surveillance uncertainty.

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MS15

Primal Dual Methods for Wasserstein Gradient Flows

Combining the classical theory of optimal transport with modern operator splitting techniques, we develop a new numerical method for nonlinear, nonlocal partial differential equations, arising in models of porous media, materials science, and biological swarming. By leveraging the PDE's underlying variational structure, our method overcomes traditional stability issues arising from the strong nonlinearity and degeneracy. Our method is also naturally positivity preserving and entropy decreasing. We prove that minimizers of the fully discrete problem converge to minimizers of the continuum JKO problem, and in the process, we recover convergence results for existing numerical methods for computing Wasserstein geodesics. We conclude with simulations of nonlinear PDEs and Wasserstein geodesics in one and two dimensions that illustrate the key properties of our numerical method.

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MS15

Dissipative Schemes for Gradient Flows on Riemmanian Manifolds

We give a brief introduction to the discrete gradient methods, developed for solving conservative and dissipative ODEs. We then present the discrete Riemannian gradient (DRG) methods: an extension of the discrete gradient methods to finite-dimensional Riemannian manifolds. Generalizations of the AVF, Gonzalez' midpoint and Itoh–Abe discrete gradients are presented, of which the Itoh–Abe DRG is given most attention, since this yields a derivative-free optimization algorithm. We discuss the application of the methods to gradient flow systems, and present numerical results for manifold valued imaging problems. Joint work with Elena Celledoni, Brynjulf Owren and Torbjrn Ringholm.

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MS15

A Geometric Integration Approach to Nonsmooth, Nonconvex Optimization

Discrete gradient methods are popular numerical methods from geometric integration for solving systems of ODEs. They are known for preserving structures of the continuous system, e.g. energy dissipation, making them interesting for optimisation problems. We consider a derivative-free discrete gradient applied to dissipative ODEs such as gradient flow, thereby obtaining optimisation schemes that are implementable in a black-box setting and retain favourable properties of gradient flow. We give a theoretical analysis in the nonsmooth, nonconvex setting, and conclude with numerical results.

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MS16

Partitioned Numerical Methods for Fluid-Structure Interaction Problems with Large Deformations

Fluid-structure interaction (FSI) problems arise in many applications, such as geomechanics, aerodynamics, and blood flow dynamics (hemodynamics). In hemodynamic applications, mathematical models must capture the nonlinear coupling between blood and the elastic structural dynamics of vessel walls, soft tissue, or cardiac muscles. These structural dynamics create moving domain FSI problems that are challenging to numerically solve and analyze. We propose partitioned numerical methods for the interaction between a fluid and a hyperelastic structure and for the interaction between a fluid and a hyperporoelastic structure. Both methods are developed and analyzed on fully non-linear, moving domain problems. In the first method, the fluid and solid are discretized using the Backward Euler scheme, and the coupling conditions are imposed by introducing novel, generalized Robin boundary conditions. The solid problem is post-processed using time filtering, increasing the accuracy of the approximation. We show that the method is unconditionally stable. The interaction between a fluid and hyperporoelastic structure features different coupling conditions, which are exploited in the design of a partitioned method based on BDF2 time discretization. Performance of both methods is demonstrated by numerical examples.

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MS16

Nonresonance and Global Existence in Isotropic Elastodynamics

We shall discuss a nonresonance condition for isotropic elastic strain energy functions under which the initial value problem for the equations of motion in $\mathbf{R}^3$ have global

smooth solutions with small displacements from the reference configuration.

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MS17

A Construction of Semi-Global Impulsive Gravitational Wave Spacetimes

I will describe a method to construct a semi-global impulsive gravitational wave spacetime, extending previous local constructions of Luk and Rodnianski. This result can be seen as a first step for the construction of global future geodesically complete solutions to the Einstein vacuum equations that arise from the interaction of two impulsive gravitational waves.

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MS17

Asymptotics for the Wave Equations on Curved Spaces

I will present results regarding the late-time asymptotic behavior of the wave equation on curved spacetimes. I will present applications in general relativity and in particular in the black hole dynamics.

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MS17

Initial-Boundary Value Problems for Nonlinear Dispersive PDEs in One and Higher Dimensions

The initial value problem for nonlinear dispersive PDEs like the nonlinear Schrödinger (NLS) and the Korteweg-de Vries (KdV) equations has been studied extensively and from a variety of different perspectives over the last several decades. On the other hand, the analysis of initial-boundary value problems for these equations is rather limited, despite the fact that such problems arise naturally in applications. In this talk, we will study the well-posedness of nonlinear initial-boundary value problems in one as well as in higher dimensions via a new method, which combines the linear solution formulae derived via Fokas's unified transform with suitably adapted harmonic analysis techniques.

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MS17

Existence and Stability of Solitary Waves for the Inhomogeneous NLS - A Complete Classification

We consider the inhomogeneous Schrödinger equation

$$iu_t + \Delta u + |x|^{-b}|u|^{p-1}u = 0, x \in \mathbb{R}^n$$

Depending on the values of the parameters, (n, b, p), we construct its solitary waves and moreover, we establish the sharp regions in which they exist. We also determine the stability of each one of these special solutions. We are able to extend these result to the sub-Laplacian case as well, i.e. where Δ is replaced by $-(-\Delta)^s, 0 < s < 1$.

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MS18

Suppression of Blow-Up in Patlak-Keller-Segel via Fluid Flows

The Patlak-Keller-Segel equations (PKS) are widely applied to model the chemotaxis phenomena in biology. It is well-known that if the total mass of the initial cell density is large enough, the PKS equations exhibit finite time blow-up. In this talk, I present some recent results on applying additional fluid flows to suppress chemotactic blow-up in the PKS equations. These are joint works with Jacob Bedrossian and Eitan Tadmor.

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MS18

Burgers Equation with Some Nonlocal Sources

Consider the Burgers equation with some nonlocal sources

$$u_t + \left(\frac{u^2}{2}\right)_x = \mathbf{K} * u \qquad \text{and} \qquad u(0,\cdot) = u_0$$

which were derived from models of nonlinear wave with constant frequency. This talk will present some recent results on the global existence of entropy weak solutions, priori estimates, and a uniqueness result for both Burgers-Poisson $\left(\mathbf{K} = -\frac{d}{dx}\frac{1}{2}e^{-|x|}\right)$ and Burgers-Hilbert equations ($\mathbf{K} = \frac{1}{\pi x}$). Some open questions will be discussed.

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MS18

Solutions of Generalized SQG Front Problems

We consider a family of patch-like solutions of generalized surface quasi-geostrophic (GSQG) equation, where the patch may be unbounded. We derive the equations of the contour dynamics under different geometrical situations and prove that the initial value problems have unique local smooth solutions. Under a smallness assumption on the initial data, with the help of the dispersive estimate, we are able to prove the global existence of the solutions for SQG front problem. This is a joint work with John Hunter and Jingyang Shu.

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MS19

Generalized Plane Waves and Vector Valued Equations

Modeling for wave propagation in magnetically confined plasma motivates the development of numerical methods for smooth variable coefficient time-harmonic Maxwell's equations. The simplest of these models, the cold plasma model, reads

$$curl\ curlE - \left(\frac{w}{c}\right)^2 \epsilon E = 0,$$

where the 3x3 tensor ϵ is both inhomogeneous and anisotropic. Generalized Plane Waves (GPWs) were introduced in the 2D variable refractive index Helmholtz framework. These functions are constructed to satisfy approximately the PDE, and a set of linearly independent GPWs can easily be constructed for discretization purposes. They were designed as exponential of polynomials, using Taylor expansions. The first extension of the GPW construction to a 3D vector-valued equation is introduced, including a discussion on possible ansatz for the amplitude and phase functions, and emphasizing the challenges related to the construction algorithm. We will also discuss why this first extension is not adapted to Maxwell's equation, and therefore why further investigation is necessary.

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MS19

A Modal, Alias-Free Discontinuous Galerkin Algorithm for Plasma Kinetic Equations

In collisionless and weakly collisional plasmas, the velocity distribution function (VDF) is a rich tapestry of the underlying physics. However, actually leveraging the VDF to understand the dynamics of a collisionless or weakly collisional plasma is challenging because the Vlasov-Maxwell-Fokker-Planck system of equations is a difficult equation system to numerically integrate, and traditional approaches, such as the particle-in-cell method, introduce counting noise. Motivated by the physics contained in the VDF, we have developed a novel algorithm for the numerical solution of the multi-species, non-relativistic, Vlasov-Maxwell-Fokker-Planck (VM-FP) system of equations employing high order discontinuous Galerkin (DG) finite elements to discretize the system on a phase space grid, producing a high fidelity representation of the VDF. The resulting numerical method is robust and retains a number of important properties of the continuous system, such as conservation of mass and energy and a discrete H-theorem. We will discuss a number of mathematical subtleties in discretizing the VM-FP system, most importantly the elimination of aliasing errors in the integration of the discrete weak form common in DG algorithms for fluids equations, and how the use of an orthonormal, modal, basis set, as opposed to the more common nodal bases, allows us to mitigate the curse of dimensionality and reduce tremendously the cost of directly discretizing the VM-FP system.

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MS19

Implicit Energy and Charge-Conserving Particle in Cell Methods on Sparse Grids

The particle-in-cell (PIC) method has been widely used for half a century in the simulation of kinetic plasmas. The last decade has seen two new versions of the method that move toward overcoming long-standing challenges. First, the fully implicit, energy-conserving PIC scheme mitigates the so-called finite grid instability, allowing larger timesteps and, in many cases, coarser spatial resolution while retaining stability. Second, a sparse grid version of PIC was recently introduced that shows the potential to mitigate the curse of dimensionality, thereby dramatically reducing the number of simulated particles needed to achieve satisfactory statistical resolution. In this talk, we present a scheme that marries these two advances. We prove that the energy- and charge-conservation properties of implicit PIC can be carried over to sparse grids. Key here is the appropriate definition of the electrostatic potential. Theoretical results are confirmed via numerical examples using a 2D electrostatic PIC code. *Work performed under the auspices of the U.S. Department of Energy by LLNL and LANL under contracts DE-AC52-07NA27344 and DE-AC52-06NA25396 and supported by the Exascale Computing Project (17-SC-20-SC), a collaborative effort of the U.S. Department of Energy Office of Science and the National Nuclear Security Administration.

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MS19

Topology Optimization of Permanent Magnets for Stellarators to Confine Plasmas

The excessively complex coil is one of the main challenges for stellarators. In recent years, tremendous efforts have been devoted to simplifying stellarator coils. These studies are all concentrating on the current-carrying electromagnet, which is the only type that has been used on stellarators to date. As the most common way to gen-

erate a magnetic field, permanent magnet (PM) has the potential to extremely simplify stellarator coils. Here, we introduce a topology optimization method to design PM for stellarators. We'll start with surface currents solved by conventional coil design codes and provide a relatively good initial guess. Then a nonlinear optimization code is developed to optimize the position, orientation and moment of each magnetic dipole subjected to multiple engineering constraints. Numerical results on quasi-axisymmetric stellarators are shown.

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MS20

Regularized Curve Lengthening within Strongly Functionalized Cahn-Hilliard

Provided with initial background state above equilibrium, we show that level sets of nearly circular bilayer interfaces wrinkle and relax to a circular bilayer with a larger radius until the background states approach equilibrium. The model under our concern is mass-preserving L^2-gradient flow of the strong scaling of the functionalized Cahn-Hilliard gradient flow. In the absence of Maximum Principle, our proof is based on energy estimates and a rigorous center-unstable Galerkin reduction with an asymptotically large number of modes.

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MS20

A New Flow Dynamic Method for Generalized Gradient Flow and Diffusion Problems based on Energetic Variational Approach

We develop a new flow dynamic approach (FDA) for gradient flows based on Energetic Variational Approach(EnVarA), which takes a big advantage of capturing the sharp interface. We derive trajectory equation for Allen-Cahn type equation in combination of flow map and energy dissipative law. Then we devise first and second numerical schemes for trajectory equation in Lagrangian coordinate, and the unique solvability, preserving maximum principle and energy stability of numerical schemes can be proved. We also make robust error estimate for full discretization scheme for Allen-Cahn equation with spectral method in space. Enough numerical simulations are shown to validate the stability and accuracy of the numerical schemes we constructed.

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MS20

Disclinations in 3D Landau-De Gennes Theory

In this talk we will introduce a new bifurcation theory to find multiple solutions of Landau-de Gennes equation. More precisely when subjected to the standard hedgehog boundary condition, we find two axially symmetric solutions beside the hedgehog one. One solution has biaxial torus structure, while another solution has split-core segment structure on z-axis. In the low-temperature limit, the work rigorously confirms various numerical and experimental results on the core-structure of solutions to the Landau-de Gennes equation.

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MS21

An Analysis of Parameter Recovery and Sensitivity in Continuous Data Assimilation of Turbulent Flow, with Applications to Geophysical Models

One of the challenges of the accurate simulation of turbulent flows is that initial data is often incomplete. Data assimilation circumvents this issue by continually incorporating the observed data into the model. Recently a new approach to data assimilation known as the Azouani-Olson-Titi (AOT) algorithm introduced a feedback control term to the 2D incompressible Navier-Stokes equations in order to incorporate sparse measurements. It was proven that the solution to the AOT algorithm for continuous data assimilation converges exponentially to the true solution of 2D incompressible Navier-Stokes equations with respect to the given initial data. In this talk, we analyze how perturbations of viscosity affect the convergence of the AOT algorithm to the 2D incompressible Navier-Stokes equations and provide a viscosity recovery algorithm. Analytical and computational results for this work and corresponding extensions to geophysical models will be presented.

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MS21

Parameter Recovery using Data Assimilation for the Navier-Stokes Equations with Velocity Measurements

We consider the problem of solving the 2D Navier-Stokes equations when the true viscosity and initial condition are unknown, but the force is known and sparse (in space) velocity measurements are provided continuously in time. We develop our approximations using the continuous data assimilation algorithm proposed by Azouani, Olson, and Titi (AOT). We show that the large-time error between the true solution and the assimilated solution is bounded by the discrepancy between the approximate viscosity and the true viscosity. We then develop an algorithm that can be run in tandem with the AOT algorithm to recover both the true solution and the true viscosity using only the velocity measurements.

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MS21

A Comparison of How Measurement Error Affects Two Discrete-in-Time Data Assimilation Algorithms

We compare the numerical performance of two discrete-in-time data-assimilation algorithms: one based on nudging through a time-delayed feedback control and the other based on direct insertion of the observational data into an approximating solution as the latter is integrated forward in time. Both noisy and noiseless measurements are considered. In either case the observational data consists of measurements of the velocity field of the two-dimensional incompressible Navier–Stokes equations obtained by taking local spatial averages near particular points in space. From a physical point of view, these local averages represent the fact that real-world observations never provide the true velocity at a single point. From a mathematical point of view, local averages lead to a regularizing effect which allows for simpler analysis than would otherwise be possible. The observational data is assimilated using a piecewise-constant nearest-neighbor interpolant that has been smoothed by means of a spectral filter. In addition to numerical results, we further present some additional analysis needed for the theoretical framework of our computational setting.

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MS22

Optimal Control for Interacting Agent Systems - From Crowds to Pedestrians

We discuss different optimization problems which are constrained by a dynamic of large interacting particles. The first application is concerned with the steering of sheep with the help of sheperd dogs. Then, we generalize the model by introducing an anisotroy to obtain a model for pedestrians which allows for side-stepping behaviour. Numerical results shall underline the feasibility of the models and highlight features like pattern formation.

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MS23

A Proximal-Gradient Algorithm fora4thOrder PDE with Exponential Mobility fromCrystal Surface Evolution

We discuss a proximal-dual algorithm for solving 4th order degenerate flows with nonlinear mobility functions arising in studies in material science.

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MS23

Gradient Flows in Wasserstein Spaces and the Mean Shift Algorithm

The mean shift algorithm is one of the most basic methods for data clustering in existence. It is based on the intuition that meaningful clusters correspond to regions of high density of data, and for example, if data points $x_1, \ldots, x_n$ are samples from a density in R^d, the algorithm attempts to flow the points towards local maxima of the underlying density. However, how should one adapt the procedure in case data actually lie on an unknown manifold M of much smaller dimension than the ambient space? In this talk I will discuss this question through the lens of gradient flows in Wasserstein spaces on graphs. Our motivation is twofold. On the one hand to formulate theoretically sound approaches for clustering that allow us to define intrinsic flows that adapt to the unknown manifold. On the other hand, to provide a framework that allows us to see several clustering and dimensionality reduction procedures like the mean shift algorithm and spectral based methods as particular cases of a single family of algorithms.

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MS25

Conley-Floer Theory for Waves in Lattices

The focus of this talk is on lattice differential equations. An important class of solutions are so-called travelling waves, which can be formulated as connecting orbits in a differential equation involving both forward and backward delay terms. In this talk I will present a new existence/forcing theorem for monostable waves. This relies on a novel topological invariant which I call the Conley-Floer index of the system.

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MS25

Traveling Waves in Discrete and Continuous Neural Field Equations

In this presentation, I will expose some results on traveling waves in discrete and continuous neural field equations with either monostable or bistable dynamics. Some parts are joint works with J. Fang and Z. Kilpatrick.

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MS25
Dynamics on 2D Lattices

We study dynamical systems posed on planar lattices, with a special focus on the behaviour of basic objects such as travelling corners, expanding spheres and travelling waves. Throughout the talk we will explore the impact that the spatial topology of the lattice has on the dynamical behaviour of solutions. We will discuss lattice impurities, the consequences of anistropy and make connections with the field of crystallography.

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MS25
Moving Defects in Nonlocal Oscillatory Media

In this talk we consider the role of nonlocal coupling in oscillatory media and its effects in the formation of patterns. In particular, we look at the case of patterns that form when a moving defect is introduced into the medium, and model this phenomenon using a nonlocal phase dynamics approximation in the plane. To show the existence of these solutions we model the defect as a perturbation and use the implicit function theorem. As is the case with other spatially extended pattern forming systems, the linearization about the homogeneous state is not a Fredholm operator due to the presence of a zero eigenvalue embedded into the essential spectrum. For our problem we show that when the defect moves with large speeds, and with a judicious choice of a first approximation, the linearization behaves like the Laplacian plus a drift term. We use this information together with anisotropic algebraically-weighted Sobolev spaces to derive Fredholm properties for our operator. As a result we show the existence of patterns with a parabolic profile in the far field.

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MS26
Elliptic Equations Arising from Composite Materials

I will discuss some recent regularity results about elliptic equations arising from composite materials. This is based on joint work with Hong Zhang, Longjuan Xu, and Haigang Li.

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MS26
Bent-Core Ferroelectric SmA Phase in Thin Samples

We formally derive a small thickness limit of a model for the ferroelectric polar Smectic A (SmAP) phase found in bent-core liquid crystals (BCLC), and consider its numerical approximation via gradient flow. Time permitting, we will also present numerical and analytical results for a model illustrating topological ferroelectric bistability in the modulated SmAP phase of BCLC. Both models are characterized by the appearance of boundary singularities.

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MS26
Null Lagrangian Measures

Null Lagrangian measures (denoted $M^{pc}(K)$) arise in the study of certain nonlinear PDEs that are naturally associated to a set K in the space of matrices, and triviality of $M^{pc}(K)$, often leads to nice properties of the PDEs. A particular examples comes from the method of compensated compactness, in which the Young measures can be viewed as Null Lagrangian measures. For general m, n, a necessary and sufficient condition for triviality of $\mathcal{M}^{pc}(\mathcal{K})$ was an open question even in the case where $\mathcal{K}$ is a linear subspace of $M^{m\times n}$. We answer this question and provide a necessary and sufficient condition for any linear subspace $\mathcal{K} \subset M^{m\times n}$. The ideas developed allow us to answer a question raised by Kirchheim, Müller and Sverák on the structure of $M^{pc}(K)$ for some nonlinear submanifold $K \subset \mathbb{R}^{3\times 2}$ that is associated to a well known 2×2 system of conservation laws with one entropy/entropy flux pair. This is joint work with Guanying Peng

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MS26
Quasicrystals: A Paradigm for Almost Periodic Homogenization

We present results on almost periodic homogenization of multiple integral functionals subject to linear partial differential constraints. The problem originates in homogenization questions concerning quasicrystal composites; these materials do not have translational symmetry, and exhibit self-similarity on large scales. This is conveniently modeled via the almost periodicity of the integrand with respect to the fast variable; the partial differential constraints are a stand-in for physical constraints such as mechanical compatibility in linear elasticity or a div/curl constraint such as in Maxwell's equations of magnetostatics. Joint work with Irene Fonseca (CMU) and Rita Ferreira (KAUST).

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MS27

Continuous Data Assimilation with Moving Observers

A major difficulty in accurately simulating turbulent flows is the problem of determining the initial state of the flow. For example, weather prediction models typically require the present state of the weather as input. However, the state of the weather is only measured at certain points, such as at the locations of weather stations or weather satellites. Data assimilation eliminates the need for complete knowledge of the initial state. It incorporates incoming data into the equations, driving the simulation to the correct solution. The objective of this talk is to discuss innovative computational and mathematical methods to test, improve, and extend a promising new class of algorithms for data assimilation in turbulent flows and related systems. We will look at classical and modern approaches, and then examine, via live simulations, a few new ideas which are a little different, but which in many cases give better results with fewer resources.

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MS27

Boundary Stabilization of the Moore-Gibson-Thompson Equation Arising in Nonlinear Acoustics with a Second Sound

Moore-Gibson -Thompson [MGT] equation is a benchmark model describing propagation of nonlinear waves in a heterogenous medium. This is a third order in time dynamics which accounts for a finite speed of propagation of acoustic waves. In fact, by replacing Fourier's law by Cattaneo's law one introduces thermal relaxation parameter whose presence resolves the so called infinite speed of propagation paradox. The model under consideration leads to a quasilinear system of predominantly hyperbolic type. While uniform stability of nonlinear waves has been recently shown under the assumption that diffusive effects of an acoustic medium are sufficiently large, it is of interest to consider the so called *critical case* with small diffusion such that the linearization of the system leads to conservative dynamics only. In such case one obtains *local in time* solutions to the corresponding quasilinear model. The goal of the talk is to present recent results on boundary stabilization of the linearized MGT equation and global solvability of the corresponding quasilinear system also in the *critical case*. Related control problems leading to an optimization of an acoustic pressure will also be discussed.

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MS27

Finite Determining Parameters Feedback Control for Distributed Nonlinear Dissipative Systems - a Computational Study

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 in 2013. 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. In this work 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.

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MS27

Reduced Convergence Rates on Pre-Asymptotic Meshes in Mixed Methods for the Time-Dependent (Navier) Stokes Equations

We consider error analysis of numerical methods for (Navier-)Stokes equations when discretized with (P_k, P_{k-1}) mixed finite elements, in the practical (but rarely studied) case of the spatial mesh with h *not* being sufficiently small or going to zero, i.e. on preasymptotic meshes. We show that although the classical L^2 error estimate of $O(h^{k+1})$ holds for h sufficiently small, on practical meshes with common element choices such as Taylor-Hood, the error behaves instead like $O(h^{k-1})$. If divergence-free elements such as Scott-Vogelius are used, however, then optimal error is still obtained.

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MS28

The Dyson and Coulomb Games

Random matrix statistics emerge in a broad class of strongly correlated systems, with evidence suggesting they can play a universal role comparable to the one Gaussian and Poisson distributions do classically. Indeed, studies

have identified these statistics among heavy nucleii, Riemann zeta zeros, random permutations, and even chicken eyes. But these statistics have also been observed to emerge in decentralized systems, governing the gaps between entrepreneurial buses, parked cars, perched birds, pedestrians, and other forms of traffic. Accordingly, we investigate certain N player dynamic games on the line and in the plane that admit Coulomb gas dynamics as a Nash equilibrium and investigate their basic features, many of which are atypical or even new for the literature on many player games. Most notably, we find that the universal local limit of the equilibrium is sensitive to the chosen model of player information in one dimension but not in two dimensions. We also find that with full information, players can achieve game theoretic symmetry through selfish behavior despite non-exchangeability of states, which allows for strong localized convergence of the N-Nash systems to the mean field master equations against locally optimal player ensembles, i.e., those exhibiting the Nash-optimal local limit.

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MS28

Machine Learning for the Optimal Control of McKean-Vlasov Dynamics and Mean Field Games in Fnite Time Horizon

In this talk, we will present two numerical methods for the optimal control of McKean-Vlasov dynamics in finite time horizon. Both methods are stochastic and based on machine learning tools. In the first method, the loss function stems directly from the objective function of the optimal control problem. The second method tackles a generic forward-backward stochastic differential equation (FBSDE) system of McKean-Vlasov type, and relies on a suitable reformulation as a mean field control problem. This method can also be used to solve mean field games (MFG). We prove a bound on the approximation error and provide several numerical examples.

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MS28

PDE Regularization in Machine Learning

Ill give an overview talk on PDE regularization approaches to robustness and stability in Machine Learning, in particular deep learning, via gradient regularization.

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MS29

Ill-Posedness of Magneto-Hydrodynamics Models

We will talk about certain ill-posedness behavior of the three dimensional magneto-hydrodynamics models. In particular, we will address the non-uniqueness of weak solutions in Leray-Hopf space of a MHD model with Hall effect. We adapt the widely appreciated convex integration framework developed for the Navier-Stokes equation, and with deep roots in a sequence of breakthrough papers for the Euler equation.

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MS29

Stratified Regularity in Fluid Equations and Related PDEs

We say that the regularity of a function in $\mathbb{R}^d$ is striated if it has higher regularity along certain hypersurfaces than it does in directions normal to those hypersurfaces. In the context of active transport equations, we say that striated regularity is propagated if such regularity is maintained as the scalar is transported and the hypersurface is pushed forward by the flow map for the velocity field. We briefly discuss the history of this problem as it relates to the 2D Euler equations, and explain what makes 2D Euler so special as to allow such propagation. We then analyze the situation for a certain class of active scalar equations that include the inviscid aggregation equations, and show how a more limited version of propagation of striated regularity can be obtained, generalizing, using very different techniques, recent work of Bertozzi, Garnett, Laurent, and Verdera on aggregation patches. This is joint work with Hantaek Bae of Ulsan National Institute of Science and Technology (UNIST).

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MS29

On the Free-Boundary Euler Equations

We address the local existence of solutions for the water wave problem, which is modeled by the incompressible Euler equations in a domain with a free boundary evolving with the flow. We are particularly interested in the local existence for the initial velocity, which is rotational and belongs to a low regularity Sobolev space. We will review the available existence and uniqueness results for the problem with surface tension. The results are joint with M. Disconzi and A. Tuffaha.

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MS30

An Algebraic Approach to Elastic Binodal

Nonlinearly elastic materials capable of undergoing martensitic phase transformations typically have non rank one convex energies that can explain the observed twinning instability, whereby two different martensitic phases alternate in layers separated by planar interfaces. Some of the stability conditions of such interfaces are algebraic constraints on the deformation gradient and can be repre-

sented by a surface in phase space that we call the "jump set". Every point on the jump set is either unstable or lies on the elastic binodal - a surface in phase space separating stable homogeneous deformations from unstable ones. In this talk I will describe a method that permits a practical determination of stability of a portion of the jump set, complementing previously developed methods for establishing instability. In some examples our methods permit the explicit determination of the stable part of the jump set, whose knowledge is necessary for understanding more complicated instabilities that involve two or more phases separated by sharp interfaces. This is a joint work with Lev Truskinovsky.

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MS30

Relative Bending Energy for Weakly Prestrained Shells

In this talk, we show the derivation of a dimensionally reduced model for a thin film prestrained with a given incompatible Riemannian metric: $G^h(x', x_3) = I_3 + 2h^\gamma S(x') + 2h^{\gamma/2} x_3 B(x') + h.o.t$, with $\gamma > 2$, where $0 < h << 1$ is the thickness of the film. The problem is studied rigorously by using a variational approach and establishing the Γ-convergence of the non-Euclidean version of the nonlinear elasticity functional. It is shown that the residual nonlinear elastic energy scales as $O(h^{\gamma+2})$ as $h \to 0$.

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MS30

Defect Measures and Elastic Patterns

Defect measures are a familiar tool from nonlinear PDEs to address weak convergence. Oscillations are encoded as the absolutely continuous part, and concentrations as the singular part. In this talk, we discuss the role of defect measures in a recently derived asymptotic model of elastic pattern formation for stamped elastic shells or, more generally, confined non-Euclidean sheets. We think of wrinkles as the absolutely continuous part and folds as the singular part. Optimal defect measures achieve minimal mass subject to an elastic compatibility constraint. A uniqueness theorem identifies the limiting patterns, while a regularity theorem rules out the existence of folds. Such theorems can be proved via the method of characteristics wherein wrinkles (and similarly folds) play the role of characteristic curves. We wonder about the dynamical versions of these results.

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MS30

Homogenization of Thin Shells in Non-Linear Elasticity

We will discuss the derivation of the von Kármán and bending shell model from $3D$ nonlinear elasticity by means of Γ convergence. We will assume that the material oscillates periodically with the period ε and that the thickness of the shell is h. We will derive the effective models by letting both small parameters to zero and show that the obtained models depend on the relation of these two small parameters as well as on the geometry of the shell. In the case of the bending regime we're able to obtain the effective model only under the assumption that the shell is convex. This is a joint work with Peter Hornung (TU Dresden).

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MS31

Bifurcation Analysis of Nonlinear PDEs using Deflated Continuation

Continuation methods are numerical algorithmic procedures for tracing out branches of fixed points/roots to nonlinear equations as one (or more) of the free parameters of the underlying system is varied. Such nonlinear systems of equations originate from the spatial discretization of a Partial Differential Equation (PDE) by using e.g., finite difference and finite element methods, among others. On top of standard continuation techniques such as the sequential and pseudo-arclength continuation, we will present a novel and powerful continuation technique called the Deflated Continuation Method (DCM) which tries to find/construct undiscovered/disconnected branches of solutions by eliminating known branches. In this talk, we will apply the DCM to the one- and two-component Nonlinear Schrödinger (NLS) equations in two spatial dimensions. We will present novel nonlinear steady states that have not been reported before and discuss bifurcations involving such states. Finally, we will discuss about recent developments in the one-component NLS equation in three spatial dimensions by employing the DCM where the landscape of solutions in such a system is far richer.

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MS31

On the Energy Decay Rate of the Fractional Wave Equation with Relatively Dense Damping

We establish upper bounds for the decay rate of the energy of the damped fractional wave equation when the averages of the damping coefficient on all intervals of a fixed length are bounded below. If the power of the fractional Laplacian, s, is between 0 and 2, the decay is polynomial. For $s \geq 2$, the decay is exponential. We also discuss the relationship of our condition on the damping to two well-studied conditions, the Geometric Control Condition and the Relative Density of a measure. We show that whenever i is in the resolvent set of the generator, the damping must be relatively dense.

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MS31

Sharp Relaxation Rates for Plane Waves of Reaction-Diffusion System

It is well-known and classical result that spectrally stable traveling waves of a general reaction-diffusion system in one spatial dimension are asymptotically stable with exponential relaxation rates. In a series of works, the authors have considered plane traveling waves for such systems and they have succeeded in showing asymptotic stability for such objects. Interestingly, the (estimates for the) relaxation rates that they have exhibited, are all algebraic and dimension dependent. It was heuristically argued that as the spectral gap closes in dimensions $n \geq 2$, algebraic rates are the best possible. We revisit this issue, and rigorously calculate the sharp relaxation rates in L^∞ based spaces, both for the asymptotic phase and the radiation terms. These turn out to be indeed algebraic, but about twice better than the best ones obtained in these early works. Finally, we explicitly construct the leading order profiles, both for the phase and the radiation terms. Our approach relies on the method of scaling variables, and in fact provides sharp relaxation rates in a class of weighted L^2 spaces as well.

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MS31

Rogue Waves in the Focusing NLS Equation

We present rogue wave solutions of the focusing nonlinear Schrödinger equation (NLSE) on the background of particular wave patterns. The two background wave patterns of interest are general traveling periodic and double-periodic in space-time wave solutions of the focusing NLSE. The rogue waves are computed by characterizing the Lax spectrum associated with these background waves and then applying the one-fold Darboux transformation. Using an algebraic method we are able to analytically determine certain eigenvalues in terms of the wave parameters. The magnification factor is also computed in closed analytical form. Furthermore, we present the numerical algorithm for computing the Lax spectrum and display some of the interesting figures that arise for different parameter configurations. We also investigate the spectrum further by computing the modulation instability of the periodic background and relating it to the rogue wave.

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MS33

Surrogate Methods for Optimizing Fusion Device Designs

In this talk, we describe our recent work on surrogate-based methods applied to design optimization for stellarators, a class of magnetic confinement geometries for fusion plasmas. After describing why the problem we would like to solve is hard, we tackle some simpler problems using derivative-free global optimization methods based on building a surrogate approximation to the objective(s). We describe both Bayesian optimization methods based on Gaussian process surrogates and alternate algorithms based on radial basis function approximation to the objective, and compare their behavior and performance. We also discuss some computational issues associated with effective asynchronous parallelism for optimization algorithms in cluster and cloud environments.

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MS33

Adjoint-Based Vacuum-Field Stellarator Optimization

A standard approach to stellarator optimization separates design into two stages. The first stage determines a target magnetic field with desired physics quantities of interest, e.g. rotational transform. The second stage optimizes a set of coils such that they reproduce the target magnetic field as accurately as possible. Small errors in the coil optimization stage can lead to errors in the physics quantities of interest of the field generated by the coils. In this talk, we present a combined approach to stellarator optimization whereby we optimize directly the coil geometry to generate a magnetic field with target physics quantities of interest, as well as near-axis quasisymmetry. We define an objective function for which exact gradients are obtained using adjoint methods. Finally, we present a benchmark coil set optimization that demonstrates the performance of our approach.

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MS33

Integral Equation Methods for Computing Stepped Pressure Equilibria in Stellarators

We present a fast high-order numerical solver for computing force-free magnetic fields (Taylor states) in non-axisymmetric toroidal geometries. Our solver can be used to construct ideal magnetohydrodynamic (MHD) equilibria with stepped pressure profile in tokamaks and stellarators. The force-free fields in each constant pressure region is computed using our solver and the position of the interface is updated iteratively to satisfy the force balance. Our method for computing Taylor states is based on the generalized Debye representation for the time-harmonic Maxwell's equations. This formulation results in a well conditioned second-kind boundary integral equation (BIE). Another advantage of the BIE formulation is that we only need to discretize the boundary and this requires significantly fewer unknowns compared to volume discretization based schemes. We use a spectrally accurate Fourier representation for the boundary data and use special high-order quadrature rules to compute the boundary integrals. We have tested our solver for several challenging geometries, and showed that our solver compares favorably with a Galerkin based approach in terms of accuracy and speed.

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MS33

Adjoint Methods for Efficient Shape Optimization and Sensitivity Analysis of Magnetic Confinement Configurations

Stellarators are magnetic confinement devices without continuous symmetry. The design of modern stellarators often employs gradient-based optimization to navigate the high-dimensional spaces used to describe their geometry. However, computing the gradient of a target function with respect to many parameters is expensive. The adjoint method allows these gradients to be computed at reduced cost and without the noise of finite differences. We present the first applications of adjoint solvers to stellarator design. An adjoint method has been implemented for the shape optimization of electromagnetic stellarator coils with a regularized least-squares method. We present a demonstration of adjoint-based coil optimization for coil shapes with minimal field error. An adjoint drift kinetic equation has also been implemented to compute gradients of moments of the distribution function, such as the parallel current, with respect to geometric parameters. Furthermore, we present a continuous adjoint method for obtaining the gradients of functions of magneto-hydrodynamic equilibria, such as the magnetic well, with respect to the shape of the plasma boundary or coils. We demonstrate an order $10^2 - 10^3$ reduction in cost in comparison with finite differences. We also use the derivatives obtained from the adjoint method for local sensitivity analysis by computing the shape gradient. These calculations provide quantification of engineering tolerances and insight into optimization.

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MS34

Mean Field Models for Thin Film Droplet Coarsening

In the late stage of thin liquid films, liquid droplets are connected by an ultra thin residual film. Experimental studies and numerical simulations show that the size distributions of liquid droplets approach a self-similar form. However, theoretical study of the size distributions is lacking because it has been a challenge to retrieve statistical information from the mathematical PDE model of thin films. To facilitate the study of the statistical information, we rigorously derive a mean field model for the Ostwald ripening of thin liquid films through homogenization. This model corresponds to the dilute limit when the droplets are far away from each other and occupy a very small part of the thin film. Our analysis captures the screening effect of the droplets and shows that the mean field spatially varies in a length scale proportional to the screening length.

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MS34

Modeling and Analysis of Patterns in Multi-Constituent Systems

Skin pigmentation, animal coats and block copolymers can be considered as multi-constituent inhibitory systems. Exquisitely structured patterns arise as orderly outcomes of the self-organization principle. Analytically, via the sharp interface model, patterns can be studied as nonlocal geometric variational problems. The free energy functional consists of an interface energy and a long range Coulomb-type interaction energy. The admissible class is a collection of Caccioppoli sets with fixed volumes. To overcome the difficulty that the admissible class is not a Hilbert space, we introduce internal variables. Solving the energy functional for stationary sets is recast as a variational problem on a Hilbert space. We prove the existence of a core-shell assembly and the existence of disc assemblies in ternary systems and also a triple-bubble-like stationary solution in a quaternary system. Numerically, via the diffuse interface model, one open question related to the polarity direction of double bubble assemblies is answered. Moreover, it is shown that the average size of bubbles in a single bubble assembly depends on the sum of the minority constituent volumes and the long range interaction coefficients. One further identifies the ranges for volume fractions and the long range interaction coefficients for double bubble assemblies.

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MS34

End-Cap Structures in the Functionalized Cahn-Hilliard Model

For large-size amphiphiles with its amphiphilicity in favor of a coexistence co-dimension 1 and co-dimension 2 aggregates, a novel network morphology was observed to prevail, characterized by Y-junctions and spherical end-caps. The number of end-caps relative to a connected network appears to decrease with the increasing of the network size. It is then reasonable to speculate that the end-caps are defects and the equilibrium morphology is the hexagonally ordered sheet, admitting Y-junctions as its unit building block. We study the end-cap structures in the setting of functionalized Cahn-hilliard (FCH) free energy with the aspect ratio parameter varying in space. The key observation is that the variance of aspect ratio gives rise to a non-degenerate 1:1 resonance in the normal form of the reduced ODE after the central manifold reduction of the original gradient flow of the FCH free energy.

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MS35

On the Inviscid Limit

I will discuss recent results on the inviscid limit

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MS35

Sufficient Conditions for Turbulence Scaling Laws in 2D and 3D

We provide sufficient conditions for mathematically rigorous proofs of the third order universal laws for both 2d and 3d stochastically forced Navier-Stokes equations. These conditions, which we name weak anomalous dissipation, replace the classical anomalous dissipation condition. For statistically stationary solutions, weak anomalous dissipation appear to be very effective and not too far from being necessary as well.

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MS35

The Batchelor Spectrum in Passive Scalar Turbulence for Stochastic Fluid Models

I will discuss recent results on the turbulence of passive scalars advected by various smooth stochastic fluid models (including the stochastic Navier-Stokes equations at fixed Reynolds number). Specifically, we will see how the chaotic Lagrangian trajectories and corresponding uniform (in diffusivity) almost sure mixing properties of the stochastic velocity fields can be used to prove that statistically stationary solutions to the passive scalar equation when driven by a Gaussian white noise and with finite diffusivity satisfies Batchelor's Law ($1/k$ power spectrum) up to logarithmic corrections over an optimal inertial range. This uniform (in diffusivity) regularity bound (essentially Besov $B^{-\epsilon}_{2,\infty}$) allows one to pass the zero-diffusivity limit in the driven scalar equation to a dissipative stationary weak martingale solution with a pure 1/k power spectrum. This is a joint work with Jacob Bedrossian and Alex Blumenthal.

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MS36

The Ideal Free Distribution, the Allee Effect and Competition: A Story on Good Versus Bad Relocation Strategies

It is well known that relocation strategies in ecology and in economics can make the difference between extinction and persistence. In this talk I present a unifying model for the dynamics of ecological populations and street vendors, an important part of many informal economies. I discuss the effects of chemotactic movement of populations subject to the Allee Effect by discussing the existence of equilibrium solutions subject to various boundary conditions and the evolution problem when the chemotaxis effect is small. On an interesting note, I present numerical simulations, which show that in fact chemotaxis can help overcome the Allee effect as well as some partial analytical results in this direction. I will conclude by making a connection to the Ideal Free Distribution and analyze what happens under competition, showing that the Ideal Free Distribution is locally evolutionarily stable.

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MS37

Nonlinear Aggregation-Diffusion Equations: Stationary States, Functional Inequalities and Stabilization

We analyse under which conditions equilibration between two competing effects, repulsion modelled by nonlinear diffusion and attraction modelled by nonlocal interaction,occurs. I will discuss several regimes that appear in aggregation diffusion problems with homogeneous kernels. I will first concentrate in the fair competition case distinguishing among porous medium like cases and fast diffusion like ones. I will discuss the main qualitative properties in terms of stationary states and minimizers of the free energies. In particular, all the porous medium cases are critical while the fast diffusion are not,and they are characterized by functional inequalites related to Hardy-Littlewood-Sobolev inequalities. In the second part, I will discuss the diffusion dominated case in which this balance leads to continuous compactly supported radially decreasing equilibrium configurations for all masses. All stationary states with suitable regularity are shown to be radially symmetric by means of continuous Steiner symmetrisation

and mass transportation techniques. Consequences for the long time asymptotics with Newtonian attractive interaction in two dimensions are drawn. This talk is based on works in collaboration with V. Calvez, S. Hittmeir, F. Hoffmann, B. Volzone, and Y. Yao.

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MS37

Optimal Control of Conservation Law Models in Biology

Conservation Laws are at the core of a variety of biological models. The present talk overviews recent results devoted to the optimal control of solutions in these models. First, we seek an optimal vaccination policy. We insert in a SIR model the effect of a vaccination campaign and then search for the optimal vaccination policy. As a further example, we deal with the control of a pest population through the introduction of suitable animals that predates on the pest. Again, we target the optimal control strategy. In both cases, basic well posedness results provide the basis for the subsequent approach to optimal control problems. Numerical integrations play a key role in testing the obtained results.

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MS37

Structured Population Equations, from Qualitative Modelling to Experimentally Validated Models

Entropy-based methods, and in particular the so-called "generalised relative entropy" inequalities, have been developed and successfully applied to structured population equations, and in particular to aggregation-fragmentation problems, over the last two decades. In this talk, we study how entropy methods have been recently extended to measure solutions, proving either convergence to a steady state or to a periodic limit. We also investigate the long-time dynamics of a family of nonlinear nucleation-aggregation equations, for which specific entropy functionals may be built.

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MS38

Existence Theory for a Mean Field Games Model of Household Wealth

We study a mean field games model of household wealth. This model consists of a forward-backward coupled pair of transport equations with anisotropic diffusion. Roughly speaking, the households under consideration must decide to allocate their income between consumption and savings, and are maximizing discounted future utility from consumption. The unknowns in the system are the distribution of all households and the utility function that a representative household is seeking to optimize. The problem as stated in the literature comes with an initial distribution of households, a terminal state for the utility function, and a moment constraint on the distribution which amounts to an equilibrium condition. There is also another boundary condition, the state constraint boundary condition, which encodes a maximal possible amount of debt that households may undertake. We relax the moment constraint and prove existence and uniqueness of solutions which are supported away from the debt constraint. We are able to prove in some cases that the full problem has no solution, since a solution of the full problem would solve our relaxation, since solutions of our relaxed problem are unique, and since our solutions (in some cases) do not satisfy the moment constraint.

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MS38

Asymptotics for Mean Field Games of Market Competition

The goal of this presentation is to analyze the limiting behavior of solutions to a system of mean field games developed by Chan and Sircar to model Bertrand and Cournot competition. We first introduce the model first proposed by Chan and Sircar, namely a coupled system of two nonlinear partial differential equations. This model contains a parameter ϵ that measures the degree of interaction between players; we are interested in the regime ϵ goes to 0. We then prove a collection of theorems which give estimates on the limiting behavior of solutions as ϵ goes to 0 and ultimately obtain recursive growth bounds of polynomial approximations to solutions.

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MS38

Variational Mean Field Games: On Estimates for the Density and the Pressure and their Consequences for the Lagrangian Point of View

We will consider first-order Mean Field Games (MFG) with quadratic hamiltonian and local coupling. In this case, the density of agents is the solution of a variational problem where it minimizes its total kinetic energy and a congestion cost. Using time discretization and flow interchange techniques (originally introduced by Matthes, McCann and Savaré for the study of gradient flows), we are able to provide L^∞ bounds on the density of agents. In the case where the density of agents is forced to stay below a given threshold (a model studied by Cardaliaguet, Mészàros and Santambrogio), leading to the apperance of a pressure force, the same techniques lead to a $L^\infty(H^1)$ bound on the pres-

sure, improving known results. With these estimates at our disposal, we are able to give a strong Lagrangian interpretation of the MFG and ensure regularity of the value function.

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MS38

Weak Solutions for a Class of Potential Mean Field Games of Controls

We extend the theory of weak solutions for MFG developed by Cardaliaguet, et al. to a class of mean field games of controls, following the variational formulation proposed by Bonnans, Hadikhanloo, and Pfeiffer.

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MS39

Steklov Representations of Solutions of the Biharmonic Equation

This talk will describe representations of the solutions of the Dirichlet boundary value problem for the biharmonic equation on a bounded Lipschitz domain Ω in R^N. That is, subject to prescribed data $u = g_1$ and $D_\nu u = g_2$ on $\partial\Omega$. A natural Hilbert-Sobolev space $H(\Delta, \Omega)$ of functions on Ω is introduced and Steklov bases of the closed subspaces of harmonic and biharmonic functions on Ω are found. Representations of the solutions of this biharmonic boundary value problem are found that enable the description of necessary and sufficient conditions on the functions g_1, g_2 for the solution to be in $H(\Delta, \Omega)$. The results are illustrated by the construction of specific representations of the geometrical defining function of the region Ω.

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MS39

Critical Regime Homogenisation for the Steklov Problem

In the homogenisation of boundary value problems, there is often a critical regime where a phase transition can be observed in the limiting problem. This phenomenon was dubbed "Strange terms coming from nowhere" by Cioranescu and Murat. For the Steklov problem, we show that that the homogenised limit at the critical regime is a dynamical eigenvalue problem studied by J. von Below and G. François. A distinct feature of this problem is that the eigenvalue appears both in the interior problem, as in traditional eigenvalue problems, and on the boundary, as is the case for the Steklov problem. This will allow us to recover universal bounds for the normalised Neumann eigenvalues in terms of similar bounds for Steklov eigenvalues, through the study of this dynamical problem. Based on joint work with Alexandre Girouard (Laval) and Antoine Henrot (Nancy)

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MS39

The Polya Conjecture for the Steklov Operator

A well-known conjecture due to Pólya and Szegö for the Dirichlet-Laplace eigenvalues is: "Of all n-gons of a fixed area, the regular n-gon minimizes the first Dirichlet eigenvalue." We present some recent approximation-theoretic approaches to a variant of this conjecture, for the Steklov eigenvalues on polygons. We first describe approximation strategies which provide provably computable error bounds on the eigenvalues, and then describe a probabilistic optimization strategy. We compare our results with some standard optimization techniques.

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MS39

Shape-Perturbation of Steklov Eigenvalues in Nearly-Circular and Nearly-Spherical Domains

We will consider the Steklov eigenproblem on nearly-circular (reflection-symmetric) and nearly-spherical domains. The domains of interest are represented as geometric perturbations of circles and spheres respectively, governed by a perturbation function ρ and a "perturbation parameter" ε . We will discuss the analytic dependence of the Steklov eigenvalues on the parameter ε for suitable ρ. Dependence on first-order and second-order terms in ε of the Steklov eigenvalues on the Fourier coefficients of ρ will also be revealed and discussed. Time permitting, we will conclude with applications to local isoperimetric and eigenvalue shape-optimization results.

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MS40

Patterns in Martensites: A Calculus of Variations Prospective

Crumples in a sheet of paper, wrinkles on curtains, cracks in metallic alloys, and defects in superconductors are examples of patterns in materials. In my talk I will address the issue of modelling pattern formation in martenstes via

nonconvex energy minimization problems, regularized by higher order terms. I will also provide some examples qualitative properties of minimizers via sharp energy bounds.

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MS40

The Fractional Porous Medium Equation on Manifolds with Conic Singularities

Due to the need to model long range diffusive interaction, during the last decade there has been a growing interest in considering diffusion equations involving non-local operators, e.g. the fractional powers of differential operators. In this talk, I will report some recent work with Nikolaos Roidos on the fractional porous medium equation on manifolds with cone-like singularities. I will show that most of the properties of the usual (local) porous medium equation, like existence, uniqueness of weak solution, comparison principle, conservation of mass, are inherited by the non-local version

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MS40

Uniqueness and Non-Uniqueness of Steady States of Aggregation-Diffusion Equations

In this talk, I will discuss a nonlocal aggregation equation with degenerate diffusion, which describes the mean-field limit of interacting particles driven by nonlocal interactions and localized repulsion. When the interaction potential is attractive, it is previously known that all stationary solutions must be radially decreasing up to a translation, but uniqueness (for a given mass) within this class was open, except for some special interaction potentials. For general attractive potentials, we show that the uniqueness/non-uniqueness criteria are determined by the power of the degenerate diffusion, with the critical power being m=2. In the case $m \geq 2$, we show the stationary solution for any given mass is unique for any attractive potential, by tracking the associated energy functional along a novel interpolation curve. In the case 1¡m¡2, we construct examples of smooth attractive potentials, such that there are infinitely many radially decreasing stationary solutions of the same mass. This is a joint work with Matias Delgadino and Yao Yao.

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MS40

Energy Stable Semi-Implicit Schemes for Allen-Cahn-Ohta-Kawasaki Model in Binary System

We propose a first order energy stable linear semi-implicit method for solving the Allen-Cahn-Ohta-Kawasaki equation. By introducing a new nonlinear term in the Ohta-Kawasaki free energy functional, all the system forces in the dynamics are localized near the interfaces which results in the desired hyperbolic tangent profile. In our numerical method, the time discretization is done by some stabilization technique in which some extra nonlocal but linear term is introduced and treated explicitly toge with other linear terms, while other nonlinear and n local terms are treated implicitly. The spatial discret tion is performed by the Fourier collocation method v FFT-based fast implementations. The energy stabil are proved for this method in both semi-discretization full discretization levels. Numerical experiments indi the force localization and desire hyperbolic tangent file due to the new nonlinear term. We test the first o temporal convergence rate of the proposed scheme. We present hexagonal bubble assembly as one type of equ rium for the Ohta-Kawasaki model. Additionally, the t third law between the number of bubbles and the strer of long-range interaction is verified which agrees with theoretical studies.

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MS41

On Some Complex Coupled Multi-Physics PDI

Complex coupled problems are mathematical model physical systems (or physically motivated problems) w are governed by partial differential equations and w involve multiple components, complex physics or m physics, as well as complex or coupled domains, or m ple scales. Complex coupled phenomena also often exh nonlinearities and strong interactions between the gov ing equations. As examples of such multi-physics PDE sider poromechanics which has applications in geoscie hydrology, and petroleum exploration, magnetohydro namics (or MHD) which has applications to metallu fusion technology, nuclear reactor technology, and n energy generation, and magnetoelasticity which has ap cations in geophysics as well as various areas of science technology.

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MS41

Immersed Boundary and Immersed Domain Me ods for Fluid-Structure Interaction

The interactions between fluid flows and immersed s structures are nonlinear multi-physics phenomena have applications to a wide range of scientific and e neering disciplines. There are many numerical techni currently available for computing fluid-structure inte tion; among these we will focus on methods of the mersed boundary type in this presentation. Starting f the original immersed boundary method, we will dis several improvements of the method as well as some plications. Following that we will describe an extensio the method to deal with immersed structures that occ a nonzero volume. Such an extension would allow u handle more realistic and more sophisticated structures scribed by detailed constitutive laws. We will demonst the application of these methods through several nontri numerical examples.

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MS41

Well-Posedness of Inextensible Beams with Applications to Flutter

Flutter is a self-excitation instability of an elastic structure in a surrounding fluid flow. Instances of flutter in aerospace applications are of great interest in engineering. Here, motivated by piezoelectric energy harvesting considerations, we consider the large deflections of an elastic cantilever. Mathematically, there is little by way of rigorous analysis of the recent PDE model. For the large deflections of a cantilever (rather than a fully restricted structure), we have nonlinear restoring forces coming through an inextensibility constraint, rather than local stretching. This leads to both nonlinear inertia and stiffness terms, introducing nonlocality and quasilinearity. Existence and uniqueness of strong solutions for the quasilinear problem has recently been worked out through a Galerkin procedure. In this talk, we focus on the complications introduced by the nonlocal inertial terms. The inertial structure precludes a natural weak formulation, and the addition of strong (Kelvin-Voigt) structural damping is necessary to obtain any a priori estimates. Moreover, identifying weak limits requires additional compactness, forcing higher topologies for smooth data. Local existence of strong solutions is obtained for the entire inextensible system, with uniqueness following from a novel decomposition of the dynamics. Time permitting, we show numerical results for flow-cantilever simulations and present the system for an inextensible, cantilevered plate.

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MS41

High Order Symmetric Direct Discontinuous Galerkin Finite Element Method for Elliptic Interface Problems with Body-Fitted Mesh

In this talk I will discuss our recent studies on high order symmetric direct discontinuous Galerkin (DG) finite element method solving elliptic interface problems with zero or none zero solution jump and flux jump interface conditions. We focus on the case the mesh is partitioned along with the curved interface. The two interface jump conditions are naturally and simultaneously built into the numerical flux definitions on the curved triangular elements edges that overlap with the interface. A stable and high order method is obtained regardless of the combination of the two interface conditions that are essentially enforced in the weak sense. Optimal $(k+1)th$ order L^2 norm error estimate is proved for polygonal interfaces. A sequence of numerical examples are carried out to verify the optimal convergence of the symmetric direct DG method with high order P_2, P_3 and P_4 approximations. Uniform convergence orders that are independent of the diffusion coefficient ratio inside and outside of the interface are obtained. The symmetric direct DG method is shown to be capable to handle interface problems with complicated geometries.

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MS42

Viscosity Solutions for Controlled McKeanVlasov Jump-Diffusions

We study a class of nonlinear integro-differential equations on the Wasserstein space related to the optimal control of McKeanVlasov jump-diffusions. We develop an intrinsic notion of viscosity solutions which does not rely on the lifting to an Hilbert space and prove a comparison theorem for these solutions. We also show that the value function is the unique viscosity solution.

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MS42

Many-Player Games of Optimal Consumption and Investment under Relative Performance Criteria

We study a portfolio optimization problem for competitive agents with CRRA utilities and a common finite time horizon. The utility of an agent depends not only on her absolute wealth and consumption but also on her relative wealth and consumption when compared to the averages among the other agents. We derive a closed form solution for the n-player game and the corresponding mean field game. This solution is unique in the class of equilibria with constant investment and continuous time-dependent consumption, both independent of the wealth of the agent. Compared to the classical Merton problem with one agent, the competitive model exhibits a wide range of highly nonlinear and non-monotone dependence on the agents' risk tolerance and competitiveness parameters. Counter-intuitively, competitive agents with high risk tolerance may behave like non-competitive agents with low risk tolerance.

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MS42

Inverse Optimal Transport

Discrete optimal transportation problems arise in various contexts in engineering, the sciences and the social sciences. Often the underlying cost criterion is unknown, or only partly known, and the observed optimal solutions are corrupted by noise. In this talk we propose a systematic approach to infer unknown costs from noisy observations of optimal transportation plans. The algorithm requires only the ability to solve the forward optimal transport problem, which is a linear program, and to generate random numbers. It has a Bayesian interpretation, and may also be viewed as a form of stochastic optimization. We illustrate the developed methodologies using the example of international migration flows and matching problems in economics. The proposed framework allows us to estimate the respective transition costs or utilities in these applica-

tions and quantify uncertainty.

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MS42

Weak Solutions for Mean Field Game Master Equations

In this talk we consider master equations arising from mean field game problems, under the Lasry-Lions monotonicity condition. Classical solutions of such equations typically require very strong technical conditions. Moreover, unlike the equations arising from mean field control problems, the mean field game master equations are non-local and even classical solutions often do not satisfy the comparison principle, so the standard viscosity solution approach seems infeasible. We shall propose a new notion of weak solutions for such equations and establish its wellposedness. For the crucial regularity in terms of the measures, we construct a smooth mollifier for functions on Wasserstein space, which is new in the literature and is interesting in its own right. The talk is based on a joint work with Chenchen Mou.

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MS43

Gevrey Class Well Posedness for Non Diffusive Active Scalar Equations

We discuss a family of non diffusive active scalar equations where a viscosity type parameter enters the equations via the constitutive law that relates the drift velocity with the scalar field. We obtain Gevrey class local well-posedness results and convergence of solutions as the viscosity vanishes. This is joint work with Anthony Suen.

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MS43

Thermal Effects in General Diffusion with Biological Applications

All biological activities involve transport and distribution of ions and charged particles in specific biological environments. Moreover, the thermal effects are the key for these activities. In this talk, I will introduce several extended general diffusion systems motivated by the study of ion channels and ionic solutions in biological cells. A general framework is established, which incorporates the energetic variational approaches (EnVarA) with various thermodynamics and kinematic conditions. In particular, we will focus on the interactions between different species, the boundary effects and the temperature effects.

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MS43

Strict/Uniform Physicality of a Gradient Flow Generated by the Anisotropic Landau-de Gennes Energy with a Singular Potential

In this talk we study a gradient flow generated by the Landau-de Gennes free energy that describes nematic liquid crystal configurations in the Q-tensor space. This free energy density functional is composed of three quadratic terms as the elastic energy density part, and a singular potential in the bulk part that is considered as a natural enforcement of a physical constraint on the eigenvalues of Q. Specifically, we give a rigorous proof that if initially the Q-tensor is physical (with the free energy possibly being infinite), then it immediately becomes strictly physical as time evolves, and it becomes uniformly physical at all large times.

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MS43

Analysis of Hydrodynamic Mixture Models

The coupling of Cahn-Hilliard equation with fluid flow models appear frequently in the mathematical studies of hydrodynamic mixture flows. In this talk, I will discuss some recent results on the qualitative analysis of solutions to two coupled hydrodynamic mixture models, namely, the Cahn-Hilliard-Brinkman equations and Cahn-Hilliard-Navier-Stokes-Boussinesq equations, describing the motion of hydrodynamic mixture flows through porous media and under the influence of gravity, respectively. In particular, the global well-posedness and long-time behavior of large-data classical solutions to the models in energy critical spaces will be reported.

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MS45

Representations of Solutions of Laplaces Equation on Planar Polygons

This talk will describe the use of partial Steklov eigenfunctions and eigenvalues to represent solutions of the Dirichlet problem for Laplace's equation on a planar polygon Ω. Assume Ω has N vertices and the boundary data is continuous. This problem may be decomposed into finding the sum of
(i) a harmonic polynomial that interpolates the boundary data at the vertices, and
(ii) N simpler boundary value problems that have nice Steklov representations associated with the boundary data on each side. Each on the individual problems has nice

solutions under natural requirements. Conditions for the solution of the resulting problem to be in $C()\cap$ will be found and error estimates for approximate solutions of the reduced problems will be described. Computations of solutions of this problem on triangles and boxes using this approach have been done by Manki Cho and have been able to generate very accurate solutions. This problem has been notorious difficult to solve using layer potential methods where there has been great difficulty in generating accurate solutions near the corners.

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MS45

A Conformal Mapping Approach to Steklov Eigenvalue Problems

In this talk, a conformal mapping approach to solve Steklov eigenvalues and their related shape optimization problems in two dimensions will be discussed. To apply spectral methods, we first reformulate the Steklov eigenvalue problem in the complex domain via conformal mappings. The eigenfunctions are expanded in Fourier series so the discretization leads to an eigenvalue problem for coefficients of Fourier series. For shape optimization problems, we use gradient ascent approaches to find optimal domains that maximize objective functions involving Steklov eigenvalues.

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MS45

Extremal Spectral Gaps for Periodic Schrdinger Operators

The spectrum of a Schroedinger operator with periodic potential generally consists of bands and gaps. In this talk, for fixed m, we consider the problem of maximizing the gap-to-midgap ratio for the m-th spectral gap over the class of potentials which are pointwise bounded and have fixed periodicity. In one dimension, we prove that the optimal potential is a unique step-function attaining the imposed minimum and maximum values on exactly m intervals. In two-dimensions, we develop an efficient rearrangement method for this problem and apply it to study properties of extremal potentials. Using an explicit parametrization of two-dimensional Bravais lattices, we also consider how the optimal value varies over equal-volume Bravais lattices.

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MS45

Eigencurves for the Breve p-Laplacian in Modeling Slow Dynamics of Phase Transition

This talk outlines the construction of sequences of variational eigenvalues and eigenvectors for a pair of continuous p-homogeneous forms on a reflexive Banach space. For the construction, various quasi-innerproducts are introduced and used directly that leads to a Hilbert-like geometrical description of the eigenproblem. The general results are applied to p-Laplacian type eigenvalue problems subject to various boundary conditions. Lastly, the relevance of the results to slow-dynamics in the modeling of phase transitions is sketched.

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MS47

Almost-Sure Exponential Mixing and Enhanced Dissipation in Stochastic Navier-Stokes

We will overview two recent joint works with Alex Blumenthal and Sam Punshon-Smith regrading the Lagrangian flow map associated to the stochastically-forced 2D Navier-Stokes equations (and similar incompressible fluid models). We show there is a deterministic rate such that passive scalars (without diffusivity) advected by the velocity fields arising from stochastic Navier-Stokes are almost-surely mixed exponentially fast in H^{-s} all with the same deterministic rate assuming Hs initial data. This is optimal in the sense that such random fields cannot mix faster than exponential. Explicit estimates on the random waiting time are also provided in terms of the initial condition of the Navier-Stokes field. We moreover prove that this mixing holds uniformly in the presence of diffusivity on the passive scalar. This in turn implies optimal (in terms of time-scale) enhanced dissipation, that is, exponential decay of the L2 norm that is far faster than that given by the heat equation. In particular, we show that the L2 norm of the passive scalar dissipates on an $O(|log\kappa|)$ time-scale (here κ is the diffusivity). These two works are part of a larger program, providing also the fundamental tools required to provide a rigorous proof of the power spectrum of passive scalar turbulence in the Batchelor regime.

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MS47

Lagrangian Chaos and Scalar Mixing for Models in Fluid Mechanics

In models of fluid mechanics, the Lagrangian flow ϕ^t describes the motion of a passive particle advected by the fluid. It is anticipated that in many regimes (e.g., when the fluid is subjected to some forcing/stirring) that the Lagrangian flow ϕ^t should be chaotic in the sense of (1) sensitivity with respect to initial conditions and (2) fast mixing of passive scalars (equivalently, fast correlation decay for the flow map ϕ^t). I will present a recent joint work with Jacob Bedrossian (U Maryland) and Sam Punshon-Smith (Brown U) in which we rigorously verify these chaotic properties for various incompressible and stochastically forced fluid models on the periodic box, including stochastic 2D Navier-Stokes and stochastic hyperviscous 3D Navier-Stokes. A consequence of our work is a rigorous verification of Yagloms law, a scaling law for passive scalar advection analogous to the famous Kolmogorov 4/5 law for turbu-

lence in the Navier-Stokes equations.

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MS47

Linear Stability of Shear Flows Close to Couette in the 2D Isothermal Compressible Euler Setting

We consider the 2D isothermal compressible Euler equations linearized around a shear flow with constant density. Firstly we consider the Couette case, where we prove a linear growth in time for the compressible part of the fluid. The incompressible part exhibits inviscid damping with slower rates. In addition, we show that the oscillations between divergence and density are enhanced by the shear. Then we consider shear flows close to Couette, where we recover the upper bounds expected in the Couette case. To prove this, we expand properly some operator to isolate the main contributions. Then we perform a fixed point argument in order to infer the weighted energy estimates needed. This is a joint work with Paolo Antonelli and Pierangelo Marcati.

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MS47

On the Stability of Anisotropic Fluid Models

We shall discuss in this talk the mathematical properties of various fluid models, obtained from the Navier-Stokes equation through an anisotropic scaling, corresponding to thin domains or boundary layer flows. Emphasis will be put on instability mechanisms, and their sensitivity to boundary conditions.

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MS49

Dynamics of Euler Flows

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MS49

A Global Attractor for the Critical MG Equation

We discuss a drift diffusion active scalar equation arising in MHD. The fluid viscosity enters via the constitutive law . We prove the existence of a global attractor for the critical MG equation in the limit as the viscosity vanishes. This is joint work with Anthony Suen.

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MS49

Electrodiffusion of Ions in Fluids

The electrodiffusion of ions in fluids is governed by the Nernst-Planck-Navier-Stokes system. We prove global existence and stability results for large data, in two dimensions, with Dirichlet boundary conditions for the Navier-Stokes and Poisson equations, and blocking (vanishing normal flux) or selective (Dirichlet) boundary conditions for the ionic concentrations, for arbitrary Reynolds number, voltages, ionic valences, and species diffusivities. The proofs employ a remarkable structure resulting in the decay of the sum of relative entropies of the ionic concentrations and the kinetic energy of the fluid. This is joint work with Peter Constantin.

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MS50

Nudging of the Stress-Free Rayleigh-Benard System, Analysis and Computations

Farhat, Lunasin and Titi showed in the case of the Rayleigh-Bénard system with stress-free boundary conditions that synchronization can be achieved by nudging with only the horizontal component of velocity. In that work the spatial resolution of the data needed is estimated in terms of enstrophy, palinstrophy and analogues for temperature. Until now the best known estimates for those quantities were exponential in the Rayleigh number. We demonstrate numerically that nudging in this way is actually effective with very coarse. We then present new bounds on those quantities which are algebraic in the Rayleigh number. The sharpness of the bounds are tested with numerical simulations.

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MS50

Continuous Data Assimilation for Large-Prandtl Rayleigh-Benard Convection from Thermal Measurements

This talk will discuss a continuous data assimilation nudging scheme applied to the Rayleigh-Benard convection problem at infinite or large Prandtl numbers using only the temperature field as observables. We rigorously identify conditions that guarantee synchronization between the

observed system and the model, then confirm the applicability of these results via numerical simulations. We also develop estimates on the convergence of an infinite Prandtl model to a large (but finite) Prandtl number generated set of observations. Numerical simulations in this hybrid setting indicate that the mathematically rigorous results are accurate, but of practical interest only for extremely large Prandtl numbers. This is joint work with Nathan Glatt-Holtz, Aseel Farhat, Shane McQuarrie, and Jared Whitehead.

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MS50

Approximating Continuous Data Assimilation for PDEs with Observable Data

In this talk, we introduce some recent results on the continuous data assimilation algorithm in geophysical and fluid dynamical models. In particular, we show the continuous data assimilation algorithm introduced by Azouani, Olson, and Titi in 2014, can be approximated by observable data. Namely, the solution to the assimilation PDE system, approaches the solution of the original system up to an arbitrarily small error exponentially fast in time, if we feed observable data from the latter to the former. We work under the context of 2D Navier-Stokes equations that generates the observational data and provide the feedback control to the α-regularized model. We also comment on the expansion of this scheme to other geophysical models. This work here is jointly with Adam Larios.

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MS51

Models for Memory Effects in Animal Migration

Our main goal is to better understand animal migratory behavior and how it is connected to periodic changes in the environment (seasonal for example). We investigate several models with a range of different types of memorization and decision-making process. Those models are roughly based on the Hughes model but incorporate memory effects so that animals will try to move towards better locations in terms of resources based based on what they see or remember from the environment. We implement the corresponding models in various time-periodic environments, testing when the migration develops periodicity as well as expected. One interesting conclusion of this study is that memory effects need to include some notion of time-scale if proper behavior is to be observed. This is a joint work with B. Fagan and H.-Y. Lin.

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MS51

Differential Equations in Traffic Modeling

Differential equations provide an effective tool to describe the dynamics of vehicular traffic. When dealing with traffic along networks, the freedom of drivers in choosing among different paths need to be considered, leading to the use of concepts from game theory. First, we introduce a formalism capable of dealing with the microscopic modeling of vehicular traffic on a general road network. From the analytic point of view, this amounts to define differential equations on a graph, prove the existence of solutions and provide specific numerical algorithms. Priorities at junctions play a key role and are shown to hinder the continuous dependence from the initial data. Within this framework, drivers are players whose strategies consist in the choice of a specific route, targeting to minimize the travel times. This leads to pose various typical game theoretic questions. In particular, by means of numerical integrations, we show the emergence of Braess paradox as a Nash equilibrium. Differently from various well known examples, we deal here with *non stationary* solutions.

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MS51

A Two Species Hyperbolic-Parabolic Model of Tissue Growth

Models of tissue growth are now well established, in particular in relation to their applications to cancer. They describe the dynamics of cells subject to motion resulting from a pressure gradient generated by the death and birth of cells, itself controlled primarily by pressure through contact inhibition. In the compressible regime we consider, when pressure results from the cell densities and when two different populations of cells are considered, a specific difficulty arises from the hyperbolic character of the equation for each cell density, and to the parabolic aspect of the equation for the total cell density. For that reason, few a priori estimates are available and discontinuities may occur. Therefore the existence of solutions is a difficult problem. In a common work with Piotr Gwiazda and Benoît Perthame we established the existence of weak solutions to the model with two cell populations which react similarly to the pressure in terms of their motion but undergo different growth/death rates.

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MS52

Homogenization of a Stationary Mean-Field Game via Two-Scale Convergence

In this talk, we address the study of the asymptotic behavior of a first-order stationary mean-field game (MFG) with a logarithm coupling, a quadratic Hamiltonian, and a periodically oscillating potential. This study falls into the realm of the homogenization theory, and our main tool is the two-scale convergence. Using this convergence, we rigorously derive the two-scale homogenized and the homog-

enized MFG problems, which encode the so-called macroscopic or effective behavior of the original oscillating MFG. Moreover, we prove existence and uniqueness of the solution to these limit problems. This is a joint work with Diogo Gomes (KAUST) and Xianjin Yang (KAUST).

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MS52

Derivation of Smooth, Short-Time Solutions to a 1st Order MFG Master Equation

We examine some rigorous calculations on the Wasserstein space that allow us to construct classical solutions to the master equation of a first-order mean field game whose Hamiltonian is separable, non-local and highly regular but has no specific geometric property (like convexity). We suggest some further applications of these non-variational methods.

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MS52

Forward-Forward Mean Field Games and Conservation Laws

I will discuss some interesting properties of forward-forward mean field game systems. In particular, I will present curious connections of these systems with conservation laws. Furthermore, building on these connections, I will demonstrate some existence and long-time behavior results for a class of one-dimensional problems.

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MS52

An Optimal Transport Approach for the Planning Problem

The mean field planning problem (MFPP) is formulated by a continuity equation and Hamilton-Jacobi equation with a nonlinear coupling. Firstly introduced by P.-L. Lions in the context of mean field games theory, MFPPs describe strategic interactions among large numbers of players when the initial and final distributions are prescribed. The aim of the presentation is to recast the PDE system as an optimality system of a suitable entropic regularization of the dynamic optimal transportation problem. We will discuss existence of weak solutions using some ideas of minmax duality and dynamic superposition principles. (In collaboration with A. Porretta and G. Savaré)

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MS53

Steklov Representations and Approximations of Regularized Harmonic Functions

Eigenfunction expansion methods have been studied in various ways to study solutions of PDEs. This talk features error estimates for approximations of solutions of Laplace's equation with Dirichlet, Robin or Neumann boundary value conditions using the regularized harmonic Steklov eigenfunctions. Based on the spectral theory of trace spaces, the solutions are represented by orthogonal basis which can be constructed from the Steklov eigenfuntions. When the region is a rectangle, with explicit formulae for the Steklov eigenfunctions, both theoretical analysis and numerical experiments introduces the efficiency and accuracy of the Steklov expansion methods in this talk.

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MS53

Dirichlet-to-Neumann Operators on Differential Forms

The Dirichlet-to-Neumann operator on a compact domain provides a link between the Dirichlet and Neumann data of harmonic functions. However, for differential forms (or vector fields) there is no natural way to separate the boundary data into Dirichlet and Neumann parts. In this talk we will re- view several possible definitions of the Dirichlet-to-Neumann map for differential forms and vector fields. We will also discuss some eigenvalue estimates in terms of eigenvalues of Laplacian on the boundary. In particular, it turns out that the eigenvalue problem on forms of a certain degree shares a lot of important properties with the classical Steklov eigenvalues in two dimensions, and can be regarded as its natural higher dimensional analog.

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MS53

Steklov Spectral Asymptotics for Polygons

We consider the Steklov eigenvalue problem on curvilinear polygons in the plane, with all interior angles measuring less than π. In this setting, we formulate and prove precise spectral asymptotics, with error converging to zero as the spectral parameter increases. The problem turns out to have an interesting relationship to a scattering-type eigenvalue problem on the one-dimensional boundary of the polygon, viewed as a quantum graph.

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MS53

An Isoperimetric Problem for Sloshing with Surface Tension in a Shallow Container

B. A. Troesch (1965) studied the isoperimetric problems of determining the shape of a symmetric canal with a given width and cross-sectional area, and the shape of a radially-symmetric container with a given rim radius and volume, that maximises the fundamental sloshing frequency. Assuming that these containers are shallow, i.e., the fluid depth is small compared to the wavelength, the problem reduces to an extremal problem for the first nonzero eigenvalue of a singular Sturm-Liouville ODE and Troesch proved that the parabolic cross-section furnishes the largest fundamental frequency for both classes of containers. We extend Troesch's result by including surface tension effects on the fluid free surface, restricting ourselves to a pinned contact line and a flat equilibrium free surface. Adopting a recent variational characterisation of fluid sloshing with surface tension, we derive the pinned-edge linear sloshing problem which is now an eigenvalue problem for a system of coupled second-order ODEs. The first-order optimality condition for the isoperimetric solution coincides with Troesch's and the stationary solution of the isoperimetric problem is found to be a nonlinear perturbation of the parabolic cross-section. We show that the unique stationary solution is the maximiser by using the extremal property of the sloshing frequency. This is joint work with Christel Hohenegger and Braxton Osting.

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MS54

Multi-Phase Models of Amphiphilic Systems

Amphiphilic materials arise in both biological and synthetic polymer systems. They are characterized by partial phase segregation: the hydrophobic constituent is immiscible in the solvent phase but the hydrophilic part is not. On the other hand, molecular attachment restricts mixing of the hydrophilic phase and solvent. The compromise between these effects is the creation of phase domain structures analogous to lipid bilayers and micelles. This talk explores a multiphase model which derives from the Cahn-Hilliard/Ohta-Kawasaki theory of polymer phase separation. Families of equilibria with different morphologies are analyzed in terms of their bifurcation structure and stability. This leads to a prediction of the morphological phase diagram. Dynamical aspects will also be discussed.

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MS54

Curve Lengthening and Phase Separation for Bilayers

Bilayers are fundamental structures within the biological community. When absorbing lipid material form the bulk phase the bilayers grow and the resulting motion has been captured formally as motion against curvature regularized by surface diffusion. We show that this model can be rigorously derived from the FCH gradient flows, capturing it as a center-stable manifold with such large dimension that it acts as the Galerkin approximation for the normal velocity. We combine these rigorous results with formal asymptotics for multicomponent lipid models, showing phase separation and the impact of the spatial inhomogeneity upon the curvature driven flow.

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MS54

Non-Hexagonal Lattices from a Two Species Interacting System

A two species interacting system motivated by the density functional theory for triblock copolymers contains long range interaction that affects the two species differently. In a two species periodic assembly of discs, the two species appear alternately on a lattice. A minimal two species periodic assembly is one with the least energy per lattice cell area. There is a parameter b in $[0,1]$ and the type of the lattice associated with a minimal assembly varies depending on b. There are several thresholds defined by a number $B = 0.1867...$ If $b \in [0, B)$, a minimal assembly is associated with a rectangular lattice whose ratio of the longer side and the shorter side is in $[\sqrt{3}, 1)$; if $b \in [B, 1-B]$, a minimal assembly is associated with a square lattice; if $b \in (1-B, 1]$, a minimal assembly is associated with a rhombic lattice with an acute angle in $[\frac{\pi}{3}, \frac{\pi}{2})$. Only when $b = 1$, this rhombic lattice is a hexagonal lattice. None of the other values of b yields a hexagonal lattice, a sharp contrast to the situation for one species interacting systems, where hexagonal lattices are ubiquitously observed.

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MS54

A Study of the Toughness of Epoxy Resins:Phase-Field Modeling of Fracture

We explore the relation between fracture toughness and micro-structures of epoxy material under four different types of processing. The concept of effective toughness

is used as an indicator to represent the macroscopic toughness. The micro-structure is obtained from the X-ray CT scanning and stand for the heterogeneity of the material. We numerically study the effects of heterogeneous elasticity on toughness based on the phase field model. Numerical simulations show that one type of material has higher effective toughness than others statistically, this result is consistent with the experiments.

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MS55

Uniqueness and Regularity Results of Diffuse Interface Models for Binary Fluids

Diffuse Interface models are nowadays widely employed in Fluid Dynamics to model the free interface motion of mixtures of two different fluids or phases. In this approach, the interface is represented as the zero level set of a label function (or difference of fluid concentrations), whose values 1 and -1 represent the pure phases. Free boundary problems are suitable limit of such Diffuse Interface systems. The kinematic condition of the interface translates into a transport equation for the label function. Two important regularizations, Allen-Cahn and Cahn-Hilliard dynamics, have been introduced in literature to account for a partial mixing of fluids occurring at the interface. In this talk I will present some recent results concerning the existence and uniqueness of weak and regular solutions for viscous and inviscid fluids.

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MS55

Inertial Manifolds for the Hyperviscous Navier-Stokes Equations

I will talk about the existence of inertial manifolds for the hyperviscous Navier-Stokes equations. An inertial manifold is a globally invariant, finite-dimensional smooth manifold which exponentially attracts all trajectories of a dynamical system induced by the underlying evolution equation. The existence of an inertial manifold for an infinite-dimensional evolution equation represents the best analytical form of reduction of an infinite system to a finite-dimensional one. Whether the Navier-Stokes equations possess an inertial manifold is an open problem.

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MS55

Partial Regularity Results of Solutions to the 3D Incompressible Navier–Stokes Equations and Other Models

We present some recent developments of the partial regularity theory of the three-dimensional incompressible Navier–Stokes equations, originally developed by Scheffer (1976-1980) and Caffarelli, Kohn & Nirenberg (1982). We will discuss some new results in the case of the hyperdissipative Navier–Stokes equations as well as in other models of fluid mechanics.

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MS55

Global Solutions for the Active Hydrodynamics

The active hydrodynamics arising in biology/biophysics is described by the Q-tensor liquid crystal framework. The global weak solutions with large initial data will be discussed.

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MS56

Zigzagging of Stripe Patterns in Growing Domains

The Swift-Hohenberg equation is a PDE which models formation of stripe and spot patterns in many physical settings. We study a modification in which pattern formation is triggered by a propagating interface, and discuss the bifurcation structure based on the interface speed. This talk will focus on analytical results in reduced equations, in particular a singular perturbation problem for a system of ODEs arising from a traveling wave ansatz in a PDE describing the evolution of the angle of the stripe pattern. We also present numerical results in the Swift-Hohenberg and reduced equations which organize the bifurcation structure into a two-dimensional surface we call the moduli space.

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MS56

Fisher-KPP Dynamics in a Diffusive Rosenzweig-MacArthur Model

We prove the existence of traveling fronts in diffusive Rosenzweig-MacArthur population models and investigate their relation with fronts in a scalar Fisher-KPP equation. More precisely, we prove the existence of fronts in a

Rosenzweig-MacArthur predator-prey model in two situations: when the prey diffuses at the rate much smaller than that of the predator and when both the predator and the prey diffuse very slowly. Both situations are captured as singular perturbations of the associated limiting systems. In the first situation we demonstrate clear relations of the fronts with the fronts in a scalar Fisher-KPP equation. Indeed, we show that the underlying dynamical system in a singular limit is reduced to a scalar Fisher-KPP equation and the fronts supported by the full system are small perturbations of the Fisher-KPP fronts. In the second situation for the Rosenzweig-MacArthur model we prove the existence of the fronts but without observing a direct relation with Fisher-KPP equation.

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MS56

Slow and Fast Traveling Waves for a General Fisher-Keller-Segel Equation

A significant project over recent decades is the understanding of the effect of advection, or "drift," on front propagation. In this talk, I will focus on the particular setting of a Fisher-Keller-Segel system, in which the front separates the explored and unexplored areas of a population of bacteria and the advection arises via a chemotaxis term. The goal of the talk is to identify the conditions under which the advection has nontrivial effect on the front speed. In particular, we show that there is a transition between "pulled" and "pushed" fronts, depending on the strength of the chemotaxis.

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MS56

Traveling Waves of a Go-or-Grow Model of Glioma Growth

Glioblastoma multiforme is an aggressive brain tumor that is extremely fatal. Gliomas are characterized by both high amounts of cell proliferation as well as diffusivity, which make them impossible to remove with surgery alone. To gain insight on the mechanisms most responsible for tumor growth and the difficult task of forecasting future tumor behavior, we investigate a mathematical model in which tumor cell motility and cell proliferation are considered as separate processes. We explore the existence of traveling wave solutions and determine conditions for various wave front forms.

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MS57

Interior Schauder Estimates for the Fourth Order Hamiltonian Stationary Equation

We study the regularity of the Lagrangian Hamiltonian stationary equation, which is a fourth order nonlinear PDE. Consider the function $u : B_1 \to \mathbb{R}$ where B_1 is the unit ball in $\mathbb{R}^n$. The gradient graph of u, given by $\{(x, Du(x))|x \in B_1\}$ is a Lagrangian submanifold of the complex Euclidean space. The function θ is called the Lagrangian phase for the gradient graph and is defined by $\theta = Im \log \det(I + iD^2u)$ or equivalently, $\theta = \sum_i \arctan(\lambda_i)$, where λ_i represents the eigenvalues of the Hessian of u. The special Lagrangian equation is a second order nonlinear PDE given by $\theta = c$ where c is a constant. The Hamiltonian stationary equation is given by the following fourth order nonlinear PDE

$$\Delta_g \theta = 0$$

where Δ_g is the Laplace-Beltrami operator and g is the induced Riemannian metric from the Euclidean metric on $\mathbb{R}^{2n}$, which can be written as $g = I_n + (D^2u)^2$. In this talk (based on joint work with Micah Warren), I will show that $C^{1,1}$ solutions of the Hamiltonian Stationary equation for all phases in dimension two, will satisfy interior $C^{2,\alpha}$ estimates and also show that $C^{2,\alpha}$ solutions of the Hamiltonian stationary equation are smooth and satisfy interior Holder estimates in any dimension n.

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MS57

A Generalization of the Tristram-Levine Knot Signatures as a Singular Furuta-Ohta Invariant for Tori

Given a knot inside K inside an integer homology sphere Y, the Casson-Lin-Herald invariant can be interpreted as signed count of conjugacy classes of irreducible representations of the knot complement into SU(2) mapping the meridian of the knot to a fixed conjugacy class. It is interesting because it determines the Tristram-Levine signature of the knot associated to the conjugacy class chosen. Which conjugacy classes can be chosen is determined by the Alexander polynomial $\triangle_K$ of the knot. Turning things around, given a 4-manifold X with the integral homology of $S^1 \times S^3$ and an embedded torus T inside X which is homologically knotted in that $H_1(T;\mathbb{Z})$ surjects onto $H_1(X;\mathbb{Z})$, we define a signed count of conjugacy classes of irreducible representations of the torus complement into SU(2) which satisfy an analogous fixed conjugacy class condition to the one mentioned above for the knot case. Which conjugacy classes can be used is determined by the Alexander polynomial of the torus $\triangle_T$, and our count recovers the Casson-Lin-Herald invariant of the knot in the product case, i.e,

when $X = S^1 \times Y$ and $T = S^1 \times K$. Therefore, our invariant can be regarded as implicitly defining a Tristram-Levine signature for tori. We also explain why our invariant can also be considered as a singular Furuta-Ohta invariant as well as a special case of a larger family of Donalson type invariants we also define.

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MS57

Gluing in Geometric Analysis via Maps of Banach Manifolds with Corners and Applications to Gauge Theory

We describe a new approach to gluing families of solutions to nonlinear partial differential equations in geometric analysis using the Inverse Mapping Theorem for smooth maps of Banach manifolds with corners. In the special case of smooth Banach manifolds with boundary, we illustrate the method by applying it to glue families of anti-self-dual G-connections over pairs of closed, four-dimensional, oriented, smooth Riemannian manifolds, where G is compact Lie group.

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MS57

The Asymptotic Geometry of the Hitchin Moduli Space

Hitchin's equations are a system of gauge theoretic equations on a Riemann surface that are of interest in many areas including representation theory, Teichmuller theory, and the geometric Langlands correspondence. The Hitchin moduli space carries a natural hyperkahler metric. A conjectural description of its asymptotic structure appears in the work of physicists Gaiotto-Moore-Neitzke and there has been a lot of progress on this recently. I will discuss some recent results. ?

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MS58

Relaxation of 2D Incommensurate Heterostructures and Networks of Domain Walls

We discuss novel mathematical models for the analysis and computational prediction of mechanical relaxation of two-dimensional layered atomic crystals in the presence of large-scale moir patterns. The concept of configuration space or hull, previously introduced for the study of transport properties in aperiodic materials by Bellissard et al., is shown to allow for a unified description of continuum as well as atomistic models of elastic relaxation for a wide range of materials in the truly incommensurate (aperiodic) regime. In the case of twisted bilayers with identical materials, we will present some preliminary analysis and numerical results in the asymptotic regime of small twist angle (inducing a large-scale moir pattern) and small interlayer Van der Waals forces, in particular the well-known case of graphene/graphene but also MoS2/MoS2.

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MS58

Floquet Ti: Laser-Driven Graphene Observables and Edge States

Topological insulators offer unique physics and potential application due to their topologically protected propagating edge states. The topology is generated by the electronic band structure of the materials. Here we study laser-driven graphene, where the Hamiltonian becomes time dependent, and thus is called a Floquet Topological Insulator. This generates topology in three dimensions: two spacial, and one time variable. We study edge states and their stability in this work along with the methodology for computing electronic observables in this context.

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MS58

Topological Equivalence of Continuum Models with their Discrete Tight-Binding Limits in the IQHE

We study the tight-binding regime of a non-interacting electron in a two-dimensional crystal subject to a perpendicular constant magnetic field, and prove that the Fermi projection of the scaled continuum Hamiltonian converges in norm to that of a discrete tight-binding model as long as the Fermi energy lies within a spectral gap. A corollary of this is that the topological invariants of the respective systems are equal. The edge system is also studied and an analogous equivalence is proven between continuum and tight-binding reduction as well. (joint work with M. I. Weinstein)

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MS58

Analysis on Topologically Protected Wave Motion

Mathematical analysis on wave dynamics in topological material is a current research focus. In this talk, we will first introduce the topologically protected wave propagation,especially the charility and immunity to defects and disorders. Then, we will present a rigorous justification of the 2-D Dirac system derived from the Maxwell's equation with a slowly modified honeycomb material weight. This 2-D Driac system is regarded as the simplest model to describe the wave dynamics in topological materials. With some analysis and numerical simulations on this equation, we will explain why chiral wave propagation is admissible in topological materials.

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MS59

Dissipation Enhancement by Mixing and Applications to Cahn-Hilliard Equation

We quantitatively study the interaction between diffusion and mixing in both the continuous, and discrete time setting. In discrete time, we consider a mixing dynamical system interposed with diffusion. In continuous time, we consider the advection diffusion equation where the advecting vector field is assumed to be sufficiently mixing. We then study the addictive Cahn-Hilliard equation. In two and three dimensions, we prove that the two components can be mixed to their average arbitrary fast by selecting the flows with sufficient small dissipation time.

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MS59

On Singularity Formation for the Two Dimensional Unsteady Prandtls System

We consider the 2D unsteady Prandtls system. We give a precise description of singular solutions for a reduced problem on the trace of the tangential derivative along the transversal axis. A stable blow-up pattern and a countable family of other unstable solutions are found. The blow-up point is ejected to infinity in finite time, and solutions form a plateau with growing length. The proof uses modulation techniques and different energy estimates in the various zones of interest.

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MS59

Long Time Dynamics in the Rotating Euler Equations

We investigate long time dynamics of solutions to the rotating Euler equations in three spatial dimensions. We develop a framework that is adapted to the symmetries and the dispersive properties of this problem and show how it can be used to understand the behavior of small data solutions, uniformly in the parameter of rotation. The key idea is to use the available symmetries as much as possible, rather than to pursue a more brute force approach. While this streamlines the deduction of some energy type estimates, it also requires a fresh look at the (linear) dispersive estimates, deviating from the classical stationary phase intuition.

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MS59

On Universal Mixers

The problem of mixing via incompressible flows is classical and rich with connections to several branches of analysis including PDE, ergodic theory, and topological dynamics. I will discuss some recent developments in the area and present a construction of universal mixers - incompressible flows that asymptotically mix arbitrarily well general solutions to the corresponding transport equation - on bounded domains in all dimensions. This mixing is in fact exponential in time (i.e., essentially optimal) for any initial condition with at least some degree of regularity, while there exists no uniform mixing rate for all measurable initial conditions.

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MS60

Maximum-Principle-Preserving Third-Order Local Discontinuous Galerkin Method for Convection-Diffusion Equations on Overlapping Meshes

Local discontinuous Galerkin (LDG) methods are popular for convection-diffusion equations. In LDG methods, we introduce an auxiliary variable p to represent the derivative of the primary variable u, and solve them on the same mesh. It is well known that the maximum-principle-preserving (MPP) LDG method is only available up to second-order accuracy. Recently, we introduced a new algorithm, and solve u and p on different meshes, and obtained stability and optimal error estimates. In this talk, we will introduce this approach and construct MPP third-order LDG methods for convection- diffusion equations on overlapping meshes. The new algorithm is more flexible and does not increase any computational cost. Numerical evidence will be given to demonstrate the accuracy and good performance of the third-order MPP LDG method.

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MS60

High-Order Bound-Preserving Discontinuous Galerkin Methods for Stiff Multispecies Detonation

In this talk, we develop third-order conservative sign-preserving time integrations and seek their applications in multispecies and multireaction chemical reactive flows. In this problem, the density and pressure are nonnegative, and the mass fraction for the ith species, denoted as z_i, $1 \leq i \leq M$, should be between 0 and 1, where M is the total number of species. There are four main difficulties in constructing high-order bound-preserving techniques. First of all, most of the bound-preserving techniques available are based on Euler forward time integration. Therefore, for problems with stiff source, the time step will be significantly limited. Secondly, the mass fraction does not satisfy a maximum-principle and hence it is not easy to preserve the upper bound 1. Thirdly, in most of the previous works, the algorithm relies on second-order Strang splitting methods. Finally, most of the previous ODE solvers for stiff problems cannot preserve the total mass and the positivity of the numerical approximations at the same time. In this talk, we will discuss third-order conservative sign-preserving Rugne-Kutta methods to overcome all the difficulties. Numerical experiments will be given to demonstrate the good performance of the bound-preserving technique and the stability of the scheme for problems with

stiff source terms.

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MS61

3D Gravity Water Waves with Vorticity

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MS61

Contour Dynamics for SQG Fronts

The surface quasi-geostrophic (SQG) equations consist of a transport equation in two space dimensions for an active scalar, whose physical interpretation is as a surface buoyancy. The incompressible transport velocity is given by the perpendicular Riesz transform of the buoyancy. An interesting class of solutions is one in which the buoyancy is piecewise constant with a jump across a curve or front. Contour dynamics, introduced by Zabusky et. al. for the two-dimensional incompressible Euler equations, leads to a nonlinear, nonlocal evolution equation for the location of the front with an unusual type of logarithmic dispersion. We will discuss the derivation of this equation for infinite fronts and some of its properties. This is joint work with Jingyang Shu and Qingtian Zhang.

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MS61

Dynamics of Singular Vortex Patches

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MS62

A Partial Laplacian as an Infinitesimal Generator on the Wasserstein Space

In this talk, we consider special linear operators which we term partial Laplacians on the Wasserstein space, and which we show to be partial traces of the Wasserstein Hessian. We verify a distinctive smoothing effect of the "heat flows" they generated for a particular class of initial conditions. To this end, we will develop a theory of Fourier analysis and conic surfaces in metric spaces and discuss a class of Sobolev functions. To achieve this goal, we solve a recovery problem on the set of Sobolev functions on the Wasserstein space. We remark that this infinitasimal generators is closely related to the common noise in mean field games, and we anticipate they will play a role in future studies of viscosity solutions of PDEs in the Wasserstein space.

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MS62

Weak Solutions of Mean Field Game Master Equations

In this talk we study master equations arising from mean field game problems, under the crucial monotonicity conditions. Classical solutions of such equations require very strong technical conditions. Moreover, unlike the master equations arising from mean field control problems, the mean field game master equations are non-local and even classical solutions typically do not satisfy the comparison principle, so the standard viscosity solution approach seems infeasible. We shall propose a notion of weak solution for such equations and establish its wellposedness. Our approach relies on a new smooth mollifier for functions of measures, which unfortunately does not keep the monotonicity property, and the stability result of master equations. The talk is based on a joint work with Jianfeng Zhang.

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MS63

Remarks Around the Euler Equations

I will discuss circulation conservation and spatial confinement for systems related to the Euler equations.

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MS63

On the Extension of Onsager's Conjecture for General Conservation Laws

We show that weak solutions of general conservation laws in bounded domains conserve their generalized entropy, and other respective companion laws, if they possess a certain fractional differentiability of order 1/3 in the interior of the domain, and if the normal component of the corresponding fluxes tend to zero as one approaches the boundary. This extends various recent results of the authors. of Gwiazda, Michálek, and Świerczewska-Gwiazda to the case of a bounded domain. The talk is based on a common result with Claude Bardos, Agnieszka Świerczewska-Gwiazda, Edriss Titi and Emil Wiedemann

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MS63

Vanishing Viscosity Limit and Renormalized Solutions to Euler Equations

We address a question arose in *Weak solutions, Renormalized Solutions and Enstrophy Defects in 2D Turbulence* by Lopes- Mazzucato-Nussenzveig, 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. A crucial ingredient of the proof is a uniqueness result for continuity equations with velocity field whose derivative can be represented by a singular integral operator of an L^1 function. We will show how to derive this result by combining stability estimates via optimal transport techniques and some tools from harmonic analysis. This is based on a joint work with G.Crippa, S.Spirito and C.Seis.

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MS64

Solving Variational Problems on Triangle Meshes using Nonlinear Rotation-Invariant Coordinates

Variational problems are at the core of many applications in geometry processing. The choice of a representation fitting a specific problem can considerably simplify solving the problem. We consider the Nonlinear Rotation-Invariant Coordinates (NRIC) that represent the immersions of a triangle mesh with fixed combinatorics as a vector that stacks all edge lengths and dihedral angles of the mesh. It is known that this representation associates a unique vector to an equivalence class of vertex positions that differ by a rigid motion. Previously, integrability conditions that ensure the existence of vertex positions matching given NRIC have been established. We develop the machinery needed to use the NRIC for numerically solving variational problems, as they offer benefits such as their inherent invariance to rigid transformations and their natural occurrence in deformation energies. To this end, we provide explicit formulas for the first and second derivatives of the integrability conditions facilitating the use of Hessians in NRIC-based optimization problems. Moreover, these formulas allow to compute the tangent space of the NRIC manifold and search for interesting infinitesimal variations, e.g. isometric ones. Additionally, we introduce a fast and robust algorithm that reconstructs vertex positions from almost integrable NRIC. Our experiments on a collection of variational problems underline that NRIC-based optimization is particularly effective for near-isometric problems.

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MS65

Agent-Based and Continuous Models of Swarms: Insights Gained Through the Lens of Dynamical Systems

A common class of models for biological systems is a collection of identical agents which interact through attraction, repulsion, and alignment. When these social interactions are pairwise and additive they yield a natural energy formulation. Models with these characteristics include Kuramoto's synchronizing oscillators and the aggregation equation description of attractive/repulsive swarms. I will review a set of discrete models and their continuous analogs and show how energy methods can help identify equilibria and determine their stability both numerically and analytically. These systems can manifest a menagerie of behaviors including clumping, collapse, pattern formation and hysteretic behavior.

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MS65

Instability of a Non-Isotropic Micropolar Fluid

A micropolar fluid is a fluid which posits a microstructrure taking into account angular momentum. We study a viscous incompressible micropolar fluid in three dimensions governed by the Navier-Stokes equations coupled to evolution equations for the angular velocity and the moment of inertia of the constituent particles. In particular we show that a for rod-like microstructure subject to a fixed torque the unique equilibrium of the system is unstable.

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MS65

On the Dynamics of Polymeric Fluids

We investigate the stability and global existence of weak solutions to a free boundary problem governing the evolution of finitely extensible bead-spring chains in dilute polymers. We construct weak solutions of the two-phase model by performing the asymptotic limit as the adiabatic exponent γ goes to ∞ for a macroscopic model which arises from the kinetic theory of dilute solutions of nonhomogeneous polymeric liquids, where the polymeric molecules are idealized as bead-spring chains with finitely extensible nonlinear elastic (FENE) type spring potentials. This class of models involves the unsteady, compressible, isentropic, isothermal Navier-Stokes system in a bounded domain Ω two and three space dimensions. The convergence of these solutions, up to a subsequence, to the free-boundary problem is established using techniques in the spirit of Lions and Masmoudi (1999).

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MS65

Phase Extraction and Defect Dynamics in Convection Patterns

Patterns with a nearly periodic microstructure are ubiquitous. Oftentimes, a useful (reduced) description of these patterns is in terms of an underlying *phase field*. This phase field, however, is not directly observable, and indeed, for typical patterns with defects, there might not even be a single-valued phase field that describes the global pattern. I will discuss some approaches to studying the dynamics of defects in nearly periodic *stripe patterns* using a phase field description., In particular I will highlight the interplay between ideas from signal processing, variational analysis and numerical methods, that allows us to make some progress on this problem.

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MS66

A Diffuse Domain Method for Solving PDEs in Complex Geometries

In this talk we will present a quasi-incompressible NSCH model for two-phase flows with variable density. This model will be coupled with a diffuse domain approach to mimic the fluid flow in a complex domain (DD-NSCH). The original complex physical boundary is now characterized by a DD variable that has a thin transition layer across the boundary. Validations, including the asymptotic analysis and numerical test, are presented to show that the DD-NSCH system converges to the original NSCH model as the transition layer of DD variable becomes thin enough. Several numerical examples that involve the fluid flows in complex domain will be presented to show the capability of the DD-NSCH system.

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MS66

Self-Organizing Patterns in Biological Systems

Self-organizing patterns are ubiquitous in physical and biological systems such as diblock copolymers, animal coats, skin pigmentation as well as excitable neurons. We discovered bubble assembly in a nonlocal geometric variational problem which appears to be the sharp interface limit of the FitzHugh-Nagumo system in dimension three and higher. The locations of the bubbles are determined by the Green's function of Helmholtz operator. In this talk, the two dimensional problem is also revisited and comparisons are made to different PDE models like the Gierer-Meinhardt system and the Keller-Segel system.

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MS66

Computational Modeling of Dense Bacterial Colonies Growing on Hard Agar

The physical interactions of growing bacterial cells with each other and with their surroundings significantly affect the structure and dynamics of biofilms. Here a 3D agent-based model is formulated to describe the establishment of simple bacterial colonies expanding by the physical force of their growth. With a single set of parameters, the model captures key dynamical features of colony growth by non-motile, non EPS-producing E. coli cells on hard agar. The model, supported by experiment on colony growth in different types and concentrations of nutrients, suggests that radial colony expansion is not limited by nutrients as commonly believed, but by mechanical forces. Nutrient penetration instead governs vertical colony growth, through thin layers of vertically oriented cells lifting up their ancestors from the bottom. Overall, the model provides a versatile platform to investigate the influences of metabolic and environmental factors on the growth and morphology of bacterial colonies.

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MS66

The Threshold Dynamics Method for Wetting Dynamics

In this talk, we will present a modified threshold dynamics method for wetting dynamics, which significantly improves the behavior near the contact line compared to the previous method (J. Comput. Phys. 330 (2017) 510528). The new method is also based on minimizing the functional consisting of weighted interface areas over an extended domain including the solid phase. However, each interface area is approximated by the Lyapunov functional with a different Gaussian kernel. We show that a correct contact angle (Young's angle) is obtained in the leading order by choosing correct Gaussian kernel variances. We also show the Gamma convergence of the functional to the total surface energy. The method is simple, unconditionally stable, and is not sensitive to the inhomogeneity or roughness of the solid surface. It is also shown that the dynamics of the contact point is consistent with the dynamics of the interface away from the contact point. Numerical examples will be presented to show significant improvements in the accuracy of the contact angle and the hysteresis behavior of the contact angle.

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MS67

High Order Explicit Local Time-Stepping Methods For Hyperbolic Conservation Laws

In this talk we present and analyze a general framework for constructing high order explicit local time stepping (LTS) methods for hyperbolic conservation laws. In particular, we consider the model problem discretized by Runge-Kutta discontinuous Galerkin (RKDG) methods and design LTS algorithms based on the strong stability preserving Runge-Kutta (SSP-RK) schemes, that allow spatially variable time step sizes to be used for time integration in different regions of the computational domain. The proposed algorithms are of predictor-corrector type, in which the interface information along the time direction is first predicted based on the SSP-RK approximations and Taylor expansions, and then the fluxes over the region of the interface are corrected to conserve mass exactly at each time step. Following the proposed framework, we detail the corresponding LTS schemes with accuracy up to the fourth order, and prove their conservation property and nonlinear stability for the scalar conservation laws. Numerical experiments are also presented to demonstrate excellent performance of the proposed LTS algorithms.

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MS67

Computational Study of Lateral Phase Separation in Biological Membranes

We consider conservative and non-conservative phase-field models for the numerical simulation of lateral phase separation and coarsening in biological membranes. An unfitted finite element method is devised for these models to allow for a flexible treatment of complex shapes in the absence of an explicit surface parametrization. For a set of biologically relevant shapes and parameter values, we compare the dynamic coarsening produced by conservative and non-conservative numerical models, its dependence on certain geometric characteristics and convergence to the final equilibrium.

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MS68

Nonlinear PDEs in Machine Learning

We will discuss some recent work using PDE-based techniques, such as the maximum principle and viscosity solutions, to prove discrete to continuum results in graph based learning. The first part of the talk will show how PDE-based arguments can be used to improve spectral convergence rates for graph Laplacians by exploiting regularity of the continuum eigenfunctions of the Laplace-Beltrami operator. The spectrum of the graph Laplacian is used for dimension reduction in machine learning algorithms such as spectral clustering or Laplacian eigenmaps. The second part will consider graph constructions based on k-nearest neighbors (knn), which are often used in practice, but not in theoretical analysis. We show that PDE-continuum limits can be fundamentally different on knn graphs, which explains differences in performance of Lipschitz learning and p-Laplacian regularization in practice compared to theory.

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MS68

Rates of Convergence for Graph Total Variation Based Optimziation Problems: Cheeger Cuts and Trend Filtering

In the past years there has been a rapid development of PDE and variational methods in order to study large sample asymptotics of solutions to graph based machine learning optimization problems for clustering, dimensionality reduction, and semi-supervised learning. While establishing convergence guarantees was important, most of the existing results only show convergence without providing any rates. In this talk I will present a framework that allows us to obtain, for the first time, a series of probabilistic estimates for the error of approximation of solutions of variational problems with TV-like objective functions with solutions to graph counterparts constructed from randomly sampled data. The rates of convergence are given in terms of the connectivity of the graph, the number of data points, and the intrinsic dimension of the data. We will focus on variational problems to clustering based on balanced graph cuts, and graph trend filtering using L^1-type regularization terms.

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MS68

From the Graph Laplacian to PDE's in Semi-Supervised Learning

Given a data set $X_n = \{x_i\}_{i=1}^n$ and a subset of training labels $\{y_i\}_{i \in Z_n}$ where $Z_n \subset \{1, ..., n\}$ the goal of semi-supervised is to infer labels on the unlabelled data points $\{x_i\}_{i \notin Z_n}$. In this talk we use a random geometric graph model with connection radius ϵ_n. The framework is to consider objective functionals which reward the regularity of the estimated labels and impose or reward the agreement with the training data, more specifically we will consider discrete p-Laplacian regularization. The talk concerns the asymptotic behaviour in the limit where the number of unlabelled points increases while the number of training labels becomes asymptotically small. The results are to give conditions on which the constrained discrete p-Laplacian regularisation problem converges to a constrained continuum weighted p-Laplacian regularisation problem in the large data limit ($n \to \infty$). We uncover a delicate interplay between the regularizing nature of the functionals considered and the nonlocality inherent to the graph constructions. To establish asymptotic consistency we make use of a discrete-to-continuum topology that is based on optimal transport and variational methods such as Γ-convergence. I will give almost optimal ranges on the scaling of ϵ_n for asymptotic consistency to hold.

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MS69

Stability of Spiral Wave Patterns in Models of Excitable and Oscillatory Media

Spiral wave patterns are frequently observed in nature, including cardiac arrhythmias and chemical oscillations, and are commonly modeled with reaction-diffusion systems. We investigate the stability of rigidly rotating spiral waves on bounded domains by analyzing the spectral properties of the linearized reaction-diffusion operator. This talk focuses on understanding bifurcations from the rigidly rotating patterns to the period-doubled structures of alternans and line defects and highlights how the domain and heterogeneities influence the transitions.

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MS69

Long Time Dynamics of Waves in Stochastic Bistable RDEs

In the previous years we developed techniques to study the dynamics of traveling waves in SPDEs. More specifically, we defined a phase for the waves, defined a stochastic traveling wave and showed stability on polynomial time scales. In contrast to deterministic waves, one cannot hope for exponential orbital stability, but one can study how the deviation from the traveling waves behaves on average. Proving long time bounds for this deviation is considered to be a hard problem, but we can give numerical evidence and hopefully some preliminary analytical results.

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MS69

Asymptotic Stability of Pulled Fronts

We study the nonlinear asymptotic stability of critical, or pulled, traveling fronts invading unstable homogeneous states. We prove that the critical front is nonlinearly stable in a weighted L^∞ space with algebraic rate $t^{-3/2}$. Our proof uses pointwise semigroup methods to overcome the presence of essential spectrum touching the imaginary axis. We apply these techniques to the Fisher-KPP equation and recover the famous result of Gallay as well as a Lotka-Volterra competition model where our result is new.

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MS69

Fronts of Foraging Locusts

Juvenile locusts aggregate in hopper bands that march and forage through fields. These bands display collective behavior by forming coherent structures such as a distinct traveling front. Such swarming behavior can be studied from two perspectives, an individual-based (microscopic) and a collective (macroscopic). In this talk we focus on a PDE model for the collective behavior being driven by resource-dependent foraging. We develop and motivate a pair of transport equations with conserved mass coupled to a dynamic resource field. Using an elementary traveling-wave analysis, we find a selection principle that determines the vegetation left behind by a front of locusts. We also show that existence of traveling waves relies on resource-dependent foraging.

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MS70

An Index Estimate for Yang-Mills in Connections and an Application to Einstein Metrics

In this talk I want to discuss two related questions about the variational structure of the Yang-Mills functional in dimension four. The first is the question of 'gap' estimates; i.e., determining an energy threshold below which any solution must be an instanton, hence a minimizer for the Y-M energy. The second question is about non-minimal solutions, and in this case the problem is to estimate the index of a solution. I will present some recent work (joint with Kelleher and Streets) that attempts to address each question when the base manifold has positive scalar curvature. I will also mention some other geometric applications in 4-d.

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MS70

The Kapustin-Witten Equations with the Nahm Pole Boundary Condition

We will discuss Witten's gauge theory approaches to define the Jones polynomial for a knot over general 3-manifold by counting solutions to the Kapustin-Witten equations. We will discuss the ideal boundary of the Kapustin-Witten moduli space and its' relationship with G2 monopole equations. This talk will be based on joint work with Sergey Cherkis.

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MS70

Adiabatic Limits of Yang-Mills Connections on Collapsing K3 Surfaces

In this talk I will discuss the vector bundle analogue of the degeneration problem for Ricci flat K3 surfaces considered by Gross-WIlson (and later Gross-Tosatti-Zhang). Namely, given an elliptically fibered K3 surface equipped with complex vector bundle, what are the convergence properties of a family of $SU(n)$ ASD Yang-Mills connections as the elliptic fibers collapse? Under certain geometric assumptions, I will demonstrate $W^{1,p}$ convergence away from a finite number of fibers, and show how the limit is uniquely determined by the sequence of holomorphic structures. This is joint work with Ved Datar and Yuguang Zhang.

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MS70

Singular Ricci-Flat Metrics on Quasi-Projective Varieties

A fundamental theorem of Yau says that every compact Kaehler manifold with trivial canonical bundle admits a unique Kaehler Ricci-flat metric in every Kahler class. In subsequent work, Tian and Yau investigated the existence of a complete Ricci-flat Kaehler metric on quasi-projective manifolds. We will discuss extensions of these results to the singular setting. In particular, we show the existence of a Ricci-flat Kaehler current on a class of quasi-projective varieties with crepant singularities and moreover we identify the metric geometry of this singular Ricci-flat current. This is joint work with Bin Guo and Tristan Collins.

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MS71

Refined Approaches for Energy Minimization

Energy minimization and optimization are incredibly important in many fields. For example, many important PDE problems, such as the Allen-Cahn model for dynamic phase transitions in material microstructures, can be formulated as an energy minimization problem. This talk will present various optimization algorithms and their application to computing Allen-Cahn dynamics.

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MS71

On the Well-Posedness of the Inviscid Quasi-Geostrophic Equations for Large-Scale Geophysical Flows

When the length scale of the flow is on the same order as the Rossby deformation radius, which is often the case in the interior of the flow, the impact of the free surface/interface deformations on the the vorticity field is no longer negligible, and has to be accounted for in the model. In this talk, we present some new results concerning the well-posedness of the barotropic quasi-geostrophic equation and the multi-layer QG equations, where the top surface, and the layer interfaces for the multilayer QG, are left free to evolve. It is shown that, when the free surface/interfaces are included as components of the potential vorticity, the models remain globally well-posed, under certain generic assumptions on the initial state and the boundary of the domain.

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MS71

A Sharp Embedding Result Arising from a Fluid-Structure Interaction Problem

We prove a sharp Sobolev-type embedding for functions with *pth*-integrable deformation on rough sets, if the trace on the boundary, defined in the sense of geometric measure theory, is also *pth*-integrable. The question of the validity of such an embedding arises naturally in studying the motion of rigid bodies in a viscous fluid, when collisions are present. This is joint work with Nikolai Chemetov, University of Lisbon.

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MS71

Mathematical Analysis of the Jin-Neelin Model of El Nino-Southern-Oscillation

The Jin-Neelin model for the El NinoSouthern Oscillation (ENSO for short) is considered for which we establish existence and uniqueness of global solutions in time over an unbounded channel domain. The result is proved for initial data and forcing that are su?ciently small. The smallness conditions involve in particular key physical parameters of the model such as those that control the travel time of the equatorial waves and the strength of feedback due to vertical-shear currents and upwelling; central mechanisms in ENSO dynamics. From the mathematical view point, the system appears as the coupling of a linear shallow water system and a nonlinear heat equation. Because of the very di?erent nature of the two components of the system, we found it convenient to prove the existence of solution by semi-discretization in time and utilization of a fractional step scheme. The main idea consists of handling the coupling between the oceanic and temperature components by dividing the time interval into small sub-intervals of length k and on each sub-interval to solve successively the oceanic component, using the temperature T calculated on the previous sub-interval, to then solve the sea-surface temperature (SST for short) equation on the current sub-interval. The passage to the limit as k tends to zero is ensured via a priori estimates derived under the aforementioned smallness conditions. In collaboration with Yining Cao, Mickael Chekroun, and Aimin Huang.

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MS72

Angled Crested Type Water Waves

We consider the two-dimensional water wave equation which is a model of ocean waves. The water wave equation is a free boundary problem for the Euler equation where we assume that the fluid is inviscid, incompressible, irrotational and the air density is zero. In the case of zero surface tension, we show that the singular solutions recently constructed by Wu are rigid. In the case of non-zero surface tension, we construct an energy functional and prove an a priori estimate without assuming the Taylor sign condition. This energy reduces to the energy obtained by Kinsey and Wu in the zero surface tension case for angled crested water waves. We show that in an appropriate regime, the zero surface tension limit of our solutions is the one for the gravity water wave equation which includes waves with angled crests.

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MS72

Validity of Steady Prandtl Layer Expansions

In this talk, I will present the following result: let the viscosity $\varepsilon \to 0$ for the 2D, steady Navier-Stokes equations in the region $0 < x < L$ and $0 < y < \infty$, with no-slip boundary condition at $y = 0$. For $0 < L << 1$, we prove the validity of the steady Prandtl layer expansion for scaled Prandtl boundary layers, which include the celebrated Blasius layer. This is joint work with Yan Guo.

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MS72

On Well-Posedness and Global Solutions for the Muskat Problem

We consider the Muskat problem for one fluid or two fluids, with or without viscosity jump, with or without rigid boundaries, and in arbitrary space dimension d of the interface. The surface tension effect can be neglected or taken into account. In both cases, the Muskat problem, to leading order, is scaling invariant in the Sobolev space $H^{s_c}(\mathbb{R}^d)$ with $s_c = 1 + \frac{d}{2}$. Firstly, by employing a paradifferential approach, we prove local well-posedness for large data in any subcritical Sobolev spaces $H^s(\mathbb{R}^d)$, $s > s_c$. Secondly, we prove that small data in the scaling invariant Besov space $\dot{B}^1_{\infty,1}(\mathbb{R}^d)$ lead to global strong solutions. The starting point of these results is a new reformulation solely in terms of the Drichlet-Neumann operator. Partly joint work with B. Pausader (Brown University).

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MS72

Justification of the Peregrine Soliton from Full Water Waves

The Peregrine soliton $Q(x,t) = e^{it}(1 - \frac{4(1+2it)}{1+4x^2+4t^2})$ is an exact solution of the 1d focusing nonlinear schrödinger equation (NLS) $iB_t + B_{xx} = -2|B|^2 B$, having the feature that it decays to e^{it} at the spatial and time infinities, and with a peak and troughs in a local region. It is considered as a prototype of the rogue waves by the ocean waves community. The 1D NLS is related to the full water wave system in the sense that asymptotically it is the envelope equation for the full water waves. In this paper, working in the framework of water waves which decay non-tangentially, we give a rigorous justification of the NLS from the full water waves

equation in a regime that allows for the Peregrine soliton. As a byproduct, we prove long time existence of solutions for the full water waves equation with small initial data in space of the form $H^s(\mathbb{R}) + H^{s'}(\mathbb{T})$, where $s \geq 4, s' > s + \frac{3}{2}$.

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MS73

Blowup Condition of the Incompressible Navier-Stokes Equations in Terms of One Velocity Component

We provide a new regularity criterion of smooth solutions of the incompressible Navier-Stokes equations via the one component of the velocity field in various scaling invariant spaces with a natural growth condition of the L^∞ norm near a possible blow-up time.

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MS73

Navier-Stokes Equations and Onsager's Conjecture

We will discuss recent results on the validity of the energy equality for the Naiver-Stokes equations.

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MS73

Ill-Posedness for the Generalized SQG Equations with Singular Velocity

We consider the family of generalized SQG equations, which are incompressible 2D active scalar equations generalizing the 2D Euler and SQG equations. When the velocity is more singular than the active scalar, up to one derivative, Chae-Constantin-Cordoba-Gancedo-Wu have established local well-posedness with a clever commutator estimate. We show that if the velocity becomes even more singular, then the equation is ill-posed. The proof is based on construction of degenerating approximate solutions and application of a generalized version of the energy estimate. Joint work with D. Chae and S.-J. Oh.

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MS74

Dynamics of Grain Boundaries with Evolving Lattice Orientations and Triple Junctions

A new mathematical model for evolution of grain boundaries is considered. Our model includes both with dynamic lattice orientations and triple junction drag. First, we derive some system of geometric differential equations to describe motion of such grain boundaries using the energetic variational approach. Next, we relax the curvature effect to concentrate to analyze the effect of lattice orientations and triple junction drag. Wellposedness and numerical results for the relaxation model will be presented.

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MS74

A Unified Disconnection Model for the Grain Boundary and Triple Junction Dynamics

The microstructure in polycrystalline materials consists of grain boundaries (GBs) and triple junctions (TJs), at which three GBs meet. The concurrent evolution of the network of GBs/TJs is described by a unified mechanism based on disconnections in the GB plane (line defects characterized by both dislocation Burgers vector and step height). The grain boundary and triple junction migration is described in terms of the thermally-activated nucleation and kinetically-limited motion of disconnections of multiple types/modes. We propose this crystallography-respecting continuum model for the disconnection mechanism of GB/TJ dynamics derived by a variational approach based on the principle of maximum energy dissipation. The resultant TJ dynamics is reduced to an optimization problem with certain constraints that account for the geometric necessity, conservation of Burgers vector, and thermal-kinetic limitation of disconnection flux. We perform analytical analysis and numerical simulations based on our model to demonstrate the dependence of the GB and TJ mobilities and the TJ drag effect on the disconnection properties.

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MS74

From Atomistic Model to the PeierlsNabarro Model with Gamma-Surface for Dislocations

The PeierlsNabarro (PN) model for dislocations is a hybrid model that incorporates the atomistic information of the dislocation core structure into the continuum theory. In this paper, we study the convergence from a full atom-

istic model to the PN model with gamma-surface for the dislocation in a bilayer system. We prove that the displacement field and the total energy of the dislocation solution of the PN model are asymptotically close to those of the full atomistic model. Our work can be considered as a generalization of the analysis of the convergence from atomistic model to Cauchy-Born rule for crystals without defects.

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MS74

Energy and Dynamics of Grain Boundaries Based on Underlying Microstructure

Grain boundaries are surface defects in polycrystalline materials. Energetic and dynamic properties of grain boundaries play vital roles in the mechanical and plastic behaviors of polycrystalline materials. The properties of grain boundaries strongly depend on their microscopic structures. We present continuum models for the energy and dynamics of grain boundaries based on the continuum distribution of the line defects (dislocations or disconnections) on them. The long-range elastic interaction between the line defects is included in the continuum models to maintain stable microstructure on grain boundaries during the evolution. The continuum models is able to describe both normal motion and tangential translation of the grain boundaries due to both coupling and sliding effects that were observed in atomistic simulations and experiments.

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MS76

On a Model Arising in Fluid Mechanics and Collective Behaviors

We will present a family of equations which give rise to particular solutions of the Euler-Alignment system. This system is the macroscopic version of the Cucker-Smale model which is concerned with the motion of a collection of agents. We will show that, under suitable assumptions on the initial data the solutions form singularities in finite time. Joint work with Victor Arnaiz.

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MS76

Relative Entropy Method for Measure-Valued Solutions of Fluid Equations

In this talk we consider measure–valued solutions (MVS) for a number of problems arising in fluid dynamics. In particular we are concerned with existence of such solutions as well as certain properties which make them a useful solution paradigm. We will firstly recall the concept of measure–valued solutions in fluid dynamics and discuss the applications of the relative entropy method for such solutions. We then define MVS for each problem at hand and show that they enjoy the weak–strong uniqueness property or perform a singular limit. Among the particular problems we consider are Euler–type models, which arise in mathematical biology as a fluid dynamical approximation in modelling of collective behaviour of animals.

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MS76

The Navier-Stokes-End-Functionalized Polymer System

The problem of minimizing energy dissipation and wall drag in turbulent pipe and channel flows is a classical one which is of great importance in practical engineering applications. Remarkably, the addition of trace amounts of polymer into a turbulent flow has a pronounced effect on reducing friction drag. To study this mathematically, we introduce a new boundary condition for Navier-Stokes equations which models the situation where polymers are irreversibly grafted to the wall. This boundary condition is time-dependent and generalizes the classical Navier-Friction condition. Global well-posedness is established in 2D and the boundary conditions are shown to lead to the strong inviscid limit and exhibit drag reduction. Talk is based on joint work with Joonhyun La.

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MS76

Pushing Forward the Theory of Well-Posedness for Systems of Conservation Laws Verifying a Single Entropy Condition

For hyperbolic systems of conservation laws in one space dimension, the best theory of well-posedness is restricted to solutions with small total variation [A. Bressan, G. Crasta, and B. Piccoli, Well-posedness of the Cauchy problem for nn systems of conservation laws. Mem. Amer. Math. Soc., 146(694):viii+134, 2000]. Looking to expand on this theory, we push in new directions. One key difficulty is that for many systems of conservation laws, only one nontrivial entropy exists. In 2017, in joint work with A. Vasseur, we proved uniqueness for the solutions to the scalar conservation laws which verify only a single entropy condition. Our result was the first result in this direction which worked directly on the conservation law. Further, our method was based on the theory of shifts and a-contraction developed by Vasseur and his team. These theories are general theories and apply also to the systems case, leading us to hope the framework we built for the scalar conservation laws will apply to systems. In this talk, I review the current progress on using the theory of shifts and a-contraction to push forward the theory of well-posedness for systems of conservation laws in one space dimension.

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MS77

On the First Critical Field of a 3D Anisotropic Su-

perconductivity Model

We analyze the Lawrence-Doniach model for highly anisotropic superconductors with layered structure in 3D. For an applied magnetic field that is perpendicular to the layers, there are two critical values for the strength of the magnetic field at which the superconductor has phase transitions. In this talk, we will present some recent work on characterizations of the first critical field at which the magnetic field first penetrates the superconductor to create defects in the material. Such characterizations are achieved by analyzing a mean field model that is the Gamma-limit of the Lawrence-Doniach model in appropriate regimes.

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MS78

Minimizers and Splitting in TFDW Type Models

The Thomas-Fermi-Dirac-von Weizäcker (TFDW) model is a physical model describing ground state electron configurations of many-body systems. In this work we are concerned with variants of the TFDW model in which the Newtonian potential is replaced by a more general one. We describe the structure of minimizing sequences for those models, and then we use long-range attractive potentials to obtain more information about this structure for the TFDW model in particular.

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MS78

A Homogenization Result in the Gradient Theory of Phase Transitions

A variational model in the context of the gradient theory for fluid-fluid phase transitions with small scale heterogeneities is studied. Several regimes are considered depending on the ratio between this scale and that governing the energy barrier of the phase transition.

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MS78

Optimal Design of Wall-Bounded Heat Transport

Flowing a fluid is a familiar way to cool: fans cool electronics, water cools nuclear reactors, the atmosphere cools the Earth. This talk discusses a class of variational problems originating from fluid dynamics concerning the design of wall-bounded incompressible flows for achieving optimal heat transport. Guided by a perhaps unexpected connection between this general class of optimal design problems and other more familiar "energy-driven pattern formation" problems originating in materials science, we construct nearly optimal flows featuring self-similar "branching" patterns in the advection-dominated limit. The patterns remind of (carefully designed versions) of the complex multi-scale patterns occurring in naturally turbulent fluids, but whether real atmospheric turbulence achieves optimal heat transport insofar as its scaling is concerned remains a question of great theoretical interest. As an application of our results, we show that in Rayleigh's original two-dimensional model of Rayleigh-Benard convection between stress-free walls, optimal heat transport is not achieved. This is joint work with Charlie Doering (Univ. of Michigan).

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MS78

Existence and Stability of Liquid-Solid Phases in a Simple Swarming Model

In this talk I will present on a variational nonlocal interaction model with mass and hard-height constraints. This model can used be used to describe steady-states of crowd motion or tumor growth. Minimizers of this variational problem are considered to be in three phases: solid, liquid, and an intermediate solid-liquid phase, and mixtures of these phases. It was shown in earlier work that for sufficiently small or large masses minimizers are only in solid or liquid phases. In this work, we obtain the existence of liquid-solid phases for intermediate masses which are observed in numerical studies, and analyze their variational stability.

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MS79

Swarming Models with Local Alignment Effects: Phase Transitions and Hydrodynamics

We will discuss a collective behavior model in which individuals try to imitate each other's velocity and have a preferred asymptotic speed. It is a variant of the well-known Cucker-Smale model in which the alignment term is localized. We showed that a phase change phenomenon takes place as diffusion decreases, bringing the system from a "disordered" to an "ordered" state. This effect is related to recently noticed phenomena for the diffusive Vicsek model. We analysed the expansion of the large friction limit around the limiting Vicsek model on the sphere leading to the so-called Self-Organized Hydrodynamics (SOH). This talk is based on papers in collaboration with Bostan, and with Barbaro, Caizo and Degond.

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MS79

Multicomponent Coagulation Equation for Aerosol Dynamics

Abstract not available

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MS79

Global Mild Solutions of the Landau and Non-Cutoff Boltzmann Equation

Abstract not available

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MS79

Uniqueness of Solutions to a Gas-Solid Interacting System

Abstract not available

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MS80

Finite Volume Weno Schemes for Nonlinear Parabolic Problems with Degenerate Diffusion on Non-Uniform Meshes

We consider numerical approximation of the degenerate advection-diffusion equation, which is formally parabolic but may exhibit hyperbolic behavior. We develop both explicit and implicit finite volume weighted essentially non-oscillatory (WENO) schemes in multiple space dimensions on non-uniform computational meshes. The diffusion degeneracy is reformulated through the use of the Kirchhoff transformation. Space is discretized using WENO reconstructions with adaptive order (WENO-AO), which have several advantages, including the avoidance of negative linear weights and the ability to handle irregular computational meshes. A special two-stage WENO reconstruction procedure is developed to handle degenerate diffusion. Time is discretized using the method of lines and a Runge-Kutta time integrator. We use Strong Stability Preserving (SSP) Runge-Kutta methods for the explicit schemes, which have a severe parabolically scaled time step restriction to maintain stability. We also develop implicit Runge-Kutta methods. SSP methods are only conditionally stable, so we discuss the use of L-stable Runge-Kutta methods. Through a von Neumann (or Fourier mode) stability analysis, we show that smooth solutions to the linear problem are unconditionally L-stable on uniform computational meshes when using an implicit Radau IIA Runge-Kutta method.

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MS80

Anderson Acceleration for Nonlinear PDE

Anderson Acceleration is an extrapolation technique used to accelerate the convergence of fixed-point iterations. It can effectively post-process both Picard-like and Newton-like iterations to both accelerate and stabilize the solution process for discretized systems encountered in the approximation of nonlinear partial differential equations. We will discuss recent theoretical advances and consider some of the uses of this method for efficient simulation of nonlinear PDE.

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MS80

Fast Algorithms for Deep Learning based PDE Solvers

In this talk, we introduce two fast algorithms for solving nonlinear and high-dimensional PDEs and eigenvalue problems. One is motivated by the two grid method in traditional nonlinear solvers and one is motivated by the self-paced learning in machine learning.

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MS81

Wasserstein Information Geometric Learning

Optimal transport (Wasserstein metric) nowadays play important roles in data science and machine learning. In this talk, we brief review its development and applications in machine learning. In particular, we will focus its induced differential structure. We will introduce the Wasserstein natural gradient in parametric models. The metric tensor in probability density space is pulled back to the one on parameter space. We derive the Wasserstein gradient flows and proximal operator in parameter space. We demonstrate that the Wasserstein natural gradient works efficiently in several statistical machine learning problems, including Boltzmann machine, generative adversary models (GANs) and variational Bayesian statistics.

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MS81

Variational and Statistical Approaches to Deep Learning: Robustness and Confidence using Modified Losses

We discuss recent work on variational approaches to regularization in deep learning. In particular we derive the input gradient regularization model starting from the min-max two player game formulation of training models for adversarial robustness. We discuss the choice of loss functions for the classification problems, and the impact of these choices on robustness and accuracy We discuss con-

fidence for neural networks classification.

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MS81

Consistency of Graph Total Variation Below the Connectivity Threshold

We consider graph total variation and related functionals on random geometric graphs whose vertices are i.i.d samples of an underlying probability measure. It was recently shown that when the bandwidth of such graphs is above the connectivity threshold then the appropriately rescaled functionals Γ-converge to the weighted continuum total variation. This in turn implies asymptotic consistency of a variety of graph cut-based models in machine learning. Here we show that, when appropriately stated, the Γ-convergence and the asymptotic consistency hold even below the connectivity threshold, as long as the typical degree diverges to infinity.

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MS82

An Interacting Particle Model for Fish in a Changing Environment

The Arctic environment is shifting rapidly in response to climate change. As changes occur in the marine environment, there is a question of what will happen to the ecosystems dependent upon these environments. In this talk, we will discuss the capelin, a small planktivorous fish that undertakes migrations of hundreds of kilometers in the northern oceans. The capelin is found in Newfoundland and Labrador, around Iceland and Greenland, in the Barents Sea, and off the coast of Alaska. It acts as a biological pump, bringing biomass from plankton blooms in the Arctic ocean down into the subarctic regions. The capelin is a key source of food for species such as the cod and herring, which sustain many of the northern fisheries. As such, understanding the changes that the capelin are undergoing has a profound role in understanding the sustainability of these fisheries in the face of climate change. In past work, we have used a three-zoned off-lattice interacting particle model to simulate and predict the spawning migration of the Icelandic stock of the capelin. In this talk, we extend this model to the Barents Sea, and also extend it temporally to include part of the feeding migration. We discuss how these simulations can be used to predict the Arctic and subarctic ecosystems' responses to the rapidly changing oceanic environment.

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MS83

On Monopoles with Nonmaximal Symmetry Breaking

While the 3-dimensional BPS equations have long been studied by mathematicians and physicists as well, many conjectured (analytic) properties of solutions have not been rigorously proved yet. The issue becomes even more complicated—and less explored—in the case of nonmaximal symmetry breaking. In this talk, I will give an outline of the problem, and report on our contribution to the theory. In particular, I will present new results about the asymptotic form of solutions, and the corresponding Nahm transform. This is a joint project with Benoit Charbonneau and Gonalo Oliveira.

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MS83

Kapustin-Witten Monopole Equations

I will describe two extentions of the Bogomolnyi equation to the case when the gauge group is complex. These are obtained by extending the Hodge star operator either in the complex linear or the complex anti-linear manner. The main results, joint with kos Nagy, are: 1) A construction of an open set in the moduli space of solutions to the complex linear extention of the Bogomolnyi equation, and 2) A vanishing theorem stating that any complex anti-linear monopole reduces to a solution of the equations with real gauge group.

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MS83

On Orientations for Gauge-Theoretic Moduli Spaces

This talk is based on joint work with Dominic Joyce and Markus Upmeier. We would like to discuss problems on the orientability of moduli spaces that appear in various gauge-theoretic moduli problems; and how to orient those moduli spaces if they are orientable. We begin with mentioning backgrounds and motivation, and recall basics in the theory of the anti-self-dual instantons such as the Atiyah-Hitchin-Singer complex, the Kuranishi model and its orientation problems. We then introduce more general framework and techniques to discuss the problems for other

gauge-theoretic moduli spaces e.g. in Vafa-Witten theory and Kapustin-Witten one; and deliver new results on the orientation problems including the anti-self-dual instanton moduli space case.

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MS84

Ill-Posedness Results for Certain Nonlinear Wave Equations in Smooth Function Classes

Ill-posedness results are sketched for a class of systems of equations that purportedly model surface water waves. These results do not come from considering the equations in very large function classes, but are valid in standard energy spaces. This project is joint with David Ambrose, David Nicholls, and Timur Milgrom.

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MS84

Variational Reduction Formulas for Predicting High-Order Critical and Stochastic Transitions

In this talk, a general, variational approach to derive low-order reduced systems will be introduced. The approach is based on the concept of optimal parameterizing manifold (PM) that substitutes the more classical notion of slow manifold when breakdown of slaving occurs. An optimal PM provides the manifold that describes the average motion of the neglected scales as a function of the resolved scales. Our reduction formulas are dynamically-based as derived analytically from the original equation and contingent upon the calibration of few (scalar) parameters obtained from minimization of cost functionals depending on short training dataset collected from direct numerical simulation. The resulting reduced systems thus optimized allow for (i) predicting high-order critical transitions such as onset of chaos in the deterministic setting, and in the stochastic context, for (ii) inferring statistics of noise-induced transitions out of a single trajectory segment and noise realization. A Rayleigh-Benard system and a stochastic Ginzburg-Landau equation will serve as illustrations. This talk is based on a joint work with Honghu Liu and James McWilliams.

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MS84

Boundary Layers for Incompressible Fluids: The Annoyance of Characteristic Points

In the setting of incompressible fluid mechanics, when we impose no-slip conditions for the viscous equations and no-penetration for the inviscid equations, a rigorously obtained boundary layer analysis is well beyond our current understanding. In such a case, every point on the boundary is characteristic (for both equations). From work originating in a 2002 paper of Roger Temam and Xiaoming Wang, however, we know that when there is strict inflow on one boundary component and strict outflow on another, the boundary layer is sufficiently weakened to allow a successful boundary layer analysis. It is the lack of characteristic points on the boundary that makes this work. Behind this result is the knowledge that strong solutions to the Euler equations exist in this setting, a very nontrivial result originating in the Russian school in the 1960s and 1970s. Their approach, like all known approaches, fails if there are even isolated characteristic points, as there must be were we to allow inflow/outflow across a single boundary component. We discuss the situation for a simplified, linear model of the 2D Euler equations in the unit disk with inflow on the top, outflow on the bottom, and two characteristic points on the left and right. This is work in progress with Gung-Min Gie of the University of Louisville.

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MS84

Convective Stability with an Additional Stochastic Heat Source

We develop a variational formalism to estimate critical parameters at which stability of a conductive state is guaranteed when the traditional, deterministic Rayleigh-Bnard is augmented with an additional stochastic (in time) heat source. The stability criterion is reduced to a Monte Carlo solution of eigenvalue problems, the mean of which dictates the stability (or lack thereof) of the underlying system. We demonstrate application of this methodology on two specific cases: 1) a bulk internal stochastic source and 2) a stochastic variation in the temperature field on the boundary. Numerical solutions of the relevant eigenvalue problems yield quantitative relationships between the critical parameters for each setting and direct numerical simulations of the physical system validate these results.

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MS85

Dispersive Solutions for the Kdv Flow

We consider the Korteweg-de Vries (KdV) equation, and prove that small localized data yields solutions which have dispersive decay on a quartic time-scale. This result is

optimal, in view of the emergence of solitons at quartic time, as predicted by inverse scattering theory.

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MS85

Water Waves with Time-Dependent and Deformable Angled Crests (or Corners)

I will describe a new set of estimates for the 2d water waves problem, in which the free surface has an angled crest (or corner) with a time-dependent angle that changes with the evolution of the water wave, and with a corner vertex that can move in all directions. There are no symmetry constraints on the crest, and the fluid can have bulk vorticity. This is joint work with D. Coutand.

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MS85

Sharp Fronts for the Sqg Equation

Piecewise-constant fronts of the surface quasi-geostrophic (SQG) equation support surface waves. For fronts that are described as a graph, the contour dynamics equation is a nonlocal quasi-linear equation with logarithmic dispersion. Formal expansion of the equation admits only odd-degree nonlinearities. With smallness and smoothness assumptions on the initial data, solutions exist and are global. For two SQG fronts, the contour dynamics equations form a system with more complicated dispersion relations as well as quadratic nonlinearities. We also prove local well-posedness of the two SQG front problem. This is joint work with John K. Hunter and Qingtian Zhang.

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MS85

On the Relativistic Landau Equation

In this talk I will explain recent results on the relativistic Landau equation. When particles are fast moving, then relativistic effects become important. In a joint work with Maja Taskovic, I will explain very recent results on the relativistic Landau equation (with no spatial dependence). We prove an entropy dissipation estimate, and discuss it's implications including the global existence of weak solutions and the propagation of high moments. Our aim is to develop a theory for this understudied and physically important model. In another work which is joint with Zhenfu Wang, I will explain our proof of the uniqueness of weak solutions to the relativistic Landau equation that have bounded moments.

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MS86

Well-Posedness of the 2D Euler Equations when Velocity Grows at Infinity

We discuss existence of solutions to the 2D Euler equations with vorticity bounded and velocity growing at infinity. If time permits, we will also mention results and open questions related to uniqueness and continuous dependence on the initial data for these solutions.

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MS86

The Stokes Equation and its Fundamental Solution on the Hyperbolic Space

We derive and discuss the properties of the fundamental solution to the Stokes equation in the hyperbolic space. Time permitting, we also address the lack of the Stokes paradox in this setting, which in some sense, does lead to a paradoxical situation both for the Stokes and the Navier-Stokes equations on the exterior domain.

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MS86

On the Vanishing Viscosity Problem for the Navier-Stokes Equations

We address the inviscid limit problem for the Navier-Stokes equations in a half space, with initial datum that is analytic only close to the boundary of the domain, and has finite Sobolev regularity in the complement. We prove that for such data the solution of the Navier-Stokes equations converges in the vanishing viscosity limit to the solution of the Euler equation, on a constant time interval. The result is joint with Vlad Vicol and Fei Wang.

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MS86

Vorticity Measures and Vanishing Viscosity

In this talk, we consider a sequence of Leray-Hopf weak solutions of the 2D Navier-Stokes equations on a bounded domain, in the vanishing viscosity limit. We provide sufficient conditions on the associated vorticity measures, away from the boundary, which ensure that as the viscosity vanishes the sequence converges to a weak solution of the Euler equations. The main assumptions are local interior uniform bounds on the L^1-norm of vorticity and the local uniform

convergence to zero of the total variation of vorticity measure on balls, in the limit of vanishing ball radii.

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MS87

Numerical Solutions to the Free Boundary Problem for a Void in a Solid with Anisotropic Surface Energy

We determine the effect of elastic stress on the equilibrium shape of a void with anisotropic surface energy in a two-dimensional solid. In particular we investigate the case of large anisotropy for which the void has corners. The equilibrium shape is determine numerically using a piecewise spectral representation of the shape. The elastic stresses are determined from a boundary integral equation for the elastic stress that is based on a complex-variables formulation of the Airy function. Our numerical method has spectral convergence compared to the exact solution for known test cases. Our results describe the influence of anisotropy and elastic stress on the void shape and corner angle.

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MS87

Modeling Cell Wall Morphology and Elongation at the Root Tip

The morphogenetic mechanisms that define shape of the plant cell wall are still poorly understood. We build a vertex model to describe the growth, elasticity, and re-meshing of the cell wall material. We investigate theoretically how dynamics of growth and material property modulate the cell wall morphology and elongation rate at the root tip.

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MS89

Gradient Flow Approach to the Boltzmann and Landau Equations

In this talk I will present an interpretation of the spatially homogeneous Boltzmann equation as the gradient flow of the entropy. This gradient flow structure relies on a geometry on the space of probability measures that takes the collision process between particles into account. This point of view leads to a new approach to proving propagation of chaos for Kac's random walk and its convergence to the Boltzmann equation. I will also discuss a similar interpretation of the Landau equation.

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MS89

Dislocations Dynamics: From Microscopic Models to Macroscopic Crystal Plasticity

Dislocation theory aims at explaining the plastic behavior of materials by the motion of line defects in crystals. Peierls-Nabarro models consist in approximating the geometric motion of these defects by nonlocal reaction-diffusion equations. We study the asymptotic limit of solutions of Peierls-Nabarro equations. Different scalings lead to different models at microscopic, mesoscopic and macroscopic scale. This is a joint work with E. Valdinoci.

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MS89

Some Remarks on a System of Cross-Diffusion Equations with Formal Gradient Flow Structure

We study a system of cross-diffusion equations that results, as a formal limit, from an interacting particle system with multiple species. In the first part of the talk we exploit the (formal) gradient flow structure of the system to prove the existence of weak solutions. This is based on a priori bounds obtained from the dissipation of the corresponding entropy and the use of dual variables. In the second part, we discuss strong solutions and a weak-strong stability result under certain conditions on the diffusion constants.

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MS89

Interacting Particle Systems and Asymptotic Gradient Flows Structures

Cross diffusion systems arise naturally in the context of interacting multi-species systems in the presence of finite volume effects. Different mean-field systems were formally derived - these cross-diffusion systems often lack a full gradient flow (GF) structure. This lack is caused by the approximations made in the derivation, however the systems often agree with a GF up to a certain order of expansion. We refer to such systems asymptotic gradient flow (AGF) in the following. In this talk we discuss the notion of AGF for a cross diffusion system, which was derived by Bruna and Chapman in 2012 from a stochastic system of interacting Brownian particles using the method of matched

asymptotics. The system has a GF structure in the symmetric case of all particles having the same size and diffusivity and an AGF structure in general. However the 'closeness' of the AGF to a full GF can be used to study the behaviour of solution near the equilibrium. In the special case of one species being stationary, the system reduces to a nonlinear Fokker-Planck equation. This scalar equation has again an AGF structure. We discuss its possible entropy-mobility pairs and compare their respective equilibrium solutions with the stationary solution of the AGF and MC simulations of the underlying particle system.

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MS90

Wave Propagation in Moving Random Media and Applications to Imaging

We describe an imaging methodology based on a novel transport theory for waves in a moving random medium. The medium is modeled by small temporal and spatial random fluctuations of the wave speed and mass density and it moves due to an ambient flow. We summarize the theory and show how to use it to image wave sources and to estimate the flow velocity.

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MS90

Multiscale Analysis of Wave Propagation and Imaging in Random Media

We discuss an imaging technique based on intensity speckle correlations over incident field position. Its purpose is to reconstruct a field incident on a strongly scattering random medium. Our analysis clarifies the conditions under which the method can give a good reconstruction and characterizes its performance. The analysis is carried out in the white-noise paraxial regime.

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MS91

A Nonlinear Fluid-Mesh-Shell Interaction Problem

We consider a nonlinear, moving boundary, fluid-structure interaction problem between an incompressible, viscous fluid flow, and an elastic structure composed of a cylindrical shell supported by a mesh-like elastic structure. The fluid flow is modeled by the time-dependent Navier-Stokes equations in a three-dimensional cylindrical domain, while the cylindrical shell is described by the two-dimensional linearly elastic Koiter shell equations allowing **displacements in all three spatial directions**. The mesh-like structure is modeled as a **one-dimensional hyperbolic net** made of linearly elastic curved rods. The fluid and the mesh-supported structure are coupled via the kinematic and dynamic coupling conditions describing continuity of velocity and balance of contact forces at the fluid-structure interface. We will show the main steps in the proof of the existence of a weak solution to this nonlinear, moving boundary problem. The proof is based on the time-discretization via Lie operator splitting, an Arbitrary Lagrangian-Eulerian mapping, and a non-trivial compactness result. Numerical simulations describing blood flow interacting with an artery treated with a vascular stent will be shown as an example.

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MS91

Attractors for Internal Waves in Stratified Fluids: A Numerical Analysis Viewpoint

It is well-known in the physics community that inertial or internal fluid waves in domains with sloping walls can form geometric patterns which are singular, and that these patterns accumulate most of the wave energy. Recently,Colin de Verdire and Saint-Raymond (2018) and Dyatlov and Zworski made the connection between this phenomenon and the spectral theory of certain zeroth-order pseudo-differential operators. In this talk, we present a convergent discretization for approximating the spectrum of these operators.

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MS91

On the Dynamics of Ferrofluids: A Relaxation Limit from the Rosensweig Model Towards Equilibrium

We show existence of global weak solutions of the Rosensweig model of ferrofluids, using DiPerna-Lions the-

ory of compressible fluids. Then, we investigate the relaxation to equilibrium $\epsilon \to 0$ using the relative entropy method. If the limiting system has a Lipschitz continuous solution, we can show a convergence rate in ϵ, if the limiting system has only a weak solution, we obtain strong convergence of a subsequence in L^2.

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MS91

A Finite Element Method for the Q-Tensor Model of Nematic Liquid Crystals

We consider the Landau-de Gennes Q-Tensor model of nematic liquid crystals. In this model, the state of nematic liquid crystals can be described by the macroscopic Q-tensor order field. The Q-tensor order parameter is a symmetric, traceless 3 by 3 matrix with no a priori bounds on the eigenvalues. Given a state of liquid crystal, its associated Landau-de Gennes energy consists of two parts, namely an elastic energy functional and bulk potential energy functional. In order to enforce a physical bound on the eigenvalues of the Q-tensor, we use the Maier-Saupe energy as the bulk energy functional. We propose a finite element discretization of the Landau-de Gennes energy and show that the discretization Gamma converges to the Landau-de Gennes energy. Moreover, we propose a gradient descent method to numerically solve for the minimizer of the discrete energy. We show the finite element method faithfully captures the defect patterns of the liquid crystals in several numerical experiments.

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MS92

Semiclassical Limit from Hartree to Vlasov Poisson Equation

Abstract not available

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MS92

Long-Time Asymptotics for Homoenergetic Solutions of the Boltzmann Equation

In this talk I will consider a particular class of solutions of the Boltzmann equation, known as homo-energetic solutions, which are useful to describe the dynamics of Boltzmann gases under shear, expansion or compression in non-equilibrium situations. I will present different possible long-time behavior of these solutions, as well as some open problems in this direction. This analysis constitutes a first mathematically rigorous result on the dynamics of Boltzmann gases in open systems. This is a joint work with R.D.James and J.J.L.Velzquez.

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MS92

On the Large-Data Cauchy Theory of the Landau and Non-Cutoff Boltzmann Equations

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MS92

Polynomial and Exponential Weighted Lpk Solutions of the System of Boltzmann Equations for Monatomic Gas Mixtures

We consider system of Boltzmann equations for binary interactions with vector value solutions modeling the dynamics of an arbitrary mixture of I monatomic gases, with each species being described by its own distribution function, interacting billiard-like with themselves and the rest of the species. Following recent proof of existence and uniqueness oof vector value solution to this system of Boltzmann equations, by means of generation and propagation of polynomial and exponential estimates, I will present the gain of integrability and propagation of Lpk-norms for the vector value solution, 1¡ p = 8, with polynomial and exponential weights. This is a work with I. Gamba and M. Pavic-Colic.

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MS93

Direct Sampling Methods for Coefficient Determination Inverse Problems

In this talk we will discuss Direct Sampling Methods

(DSMs) for coefficient determinations in inverse problems when only one or two measurements are available. Direct sampling methods are a family of simple and efficient inversion methods which aim at providing a good estimate of the locations of inhomogeneities inside a homogeneous background representing various physical media with a single or a small number of boundary measurement events in both full and limited aperture cases. In each of the inverse problem concerned, e.g. electrical impedance tomography, diffusive optical tomography and the heat potential inverse problem, a family of probing functions is introduced and an indicator function is defined using a dual product between the observed data and the probing function under an appropriate choice of Sobolev scale. Numerical results have illustrated that the index function is effective in locating small abnormalities, and is cost-effective, computationally simple method and robust against noise. This talk is based on joint works with Kazufumi (North Carolina State University), Keji Liu (Shanghai University of Finance and Economics) and Jun Zou (Chinese University of Hong Kong)

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MS94

Mean Field Games with State Constraints

Mean Field Games (MFG) with state constraints are differential games with infinitely many agents, each agent facing a constraint on his state. In this case, the existence and uniqueness of Nash equilibria cannot be deduced as for unrestricted state space because, for a large set of initial conditions, the uniqueness of solutions to the minimization problem which is solved by each agent is no longer guaranteed. Therefore, we attack the problem by interpreting equilibria as measures in a space of arcs and we introduce the definition of mild solution for MFG with state constraints. More precisely, we define a mild solution as a pair $(u, m) \in C([0, T] \times \overline{\Omega}) \times C([0, T]; \mathcal{P}(\overline{\Omega}))$, where m is given by $m(t) = e_t\sharp\eta$ for some constrained MFG equilibrium η and

$$u(t,x) = \inf_{\gamma\in\Gamma,\gamma(t)=x} \Big\{ \int_t^T \Big[L(\gamma(s),\dot\gamma(s))+F(\gamma(s),m(s))\Big]\, ds+G(\gamma(T),m(T))\Big\}.$$

The aim of this talk is to provide a meaning of the PDE system associated with these games. For this, we will analyze the regularity of mild solution and we will show that it satisfies the MFG system in suitable point-wise sense. These results have been obtained in collaboration with Piermarco Cannarsa (Rome Tor Vergata) and Pierre Cardaliaguet (Paris-Dauphine).

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MS94

Rigorous Continuum Limit for the Discrete Network Formation Problem

Motivated by recent papers describing the formation of biological transport networks we study a discrete model proposed by Hu and Cai consisting of an energy consumption function constrained by a linear system on a graph. For the spatially two-dimensional rectangular setting we prove the rigorous continuum limit of the constrained energy functional as the number of nodes of the underlying graph tends to infinity and the edge lengths shrink to zero uniformly. The proof is based on reformulating the discrete energy functional as a sequence of integral functionals and proving their Γ-convergence towards a continuum energy functional.

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MS94

An Anisotropic Interaction Model for Simulating Fingerprints

Motivated by the simulation of fingerprint databases, which are required in forensic science and biometric applications, I will discuss a class of interacting particle models with anisotropic repulsive-attractive interaction forces. In existing models, the forces are isotropic and particle models lead to non-local aggregation PDEs with radially symmetric potentials. The central novelty in the models I consider is an anisotropy induced by an underlying tensor field. This innovation does not only lead to the ability to describe real-world phenomena more accurately, but also renders their analysis significantly harder compared to their isotropic counterparts. I will discuss the role of anisotropic interaction in these models, present a stability analysis of line patterns, and show numerical results for the simulation of fingerprints.

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MS95

Stochastic Graphon Games

We introduce a class of static games with a continuum of players as limits of finite player static games for which player sget idiosyncratic random signals. We analyze the limits as graphon games and we emphasize the differences with static mean field games. If time permits, we shall also discuss dynamic versions and the infinite dimensional PDEs involved in their solutions.

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MS95

A Particle Method for Nonlocal Equations with Reaction

We will discuss ongoing work, in which we develop particle methods for nonlocal diffusive PDEs, with applications in

kinetic theory and mathematical biology.

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MS96

A Lower Bound for the Hausdorff Measure of Blow Up Sets of the Seiberg-Witten Equation with Two Spinors

I will describe a construction of a lower bound for the Hausdorff measure of blow up sets of the Seiberg-Witten equation with two spinors provided the determinant line bundle is non-trivial. This result relies on the fact, whose proof I will discuss in some detail as well, that the blow up set is a cycle when equipped with suitable multiplicity function.

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MS96

Recent Progress on the Kapustin-Witten Equations

I will report on some recent advances on the Gaiotto-Witten program develop to manifold invariants from the Kapustin-Witten equations.

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MS96

Canonical Metrics on Hopf Surfaces

I will describe a construction of canonical metrics on all Class 1 Hopf surfaces generalizing the classical Boothby metric. The metrics are steady solitons for a certain modified Ricci flow equation, and also solutions to the type IIB string equations. The construction involves a Kaluza-Klein ansatz, resulting in a coupling of the Einstein and Yang-Mills equations on a quotient orbifold.

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MS96

Singular Instanton Floer Homology for Sutured Manifolds

Singular instanton Floer homology was first introduced by Kronheimer and Mrowka in 2011, and it was a crucial ingredient in their proof that Khovanov homology detects unknot. We will prove an excision property for singular instanton Floer homology, which allows the excision surface to cut through the singularity. As an application, we generalize the definition of singular instanton Floer homology to sutured manifolds, and show that the resulting homology theory detects the trivial braid. This is joint work with Yi Xie.

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MS97

Co-existence of Both Stable and Unstable Solitary Waves in One System

For a big class of coupled KdV-type nonlinear dispersive equations, there are situations where both stable and unstable solitary wave solutions co-exist. Some unstable solitary wave resolve into a train of stable solitary waves and some blow up in finite time. This phenomena do not appear in single equations.

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MS97

Reduction of Optimal Control Problems in Infinite Dimension based on Parameterization

In this talk, we present a new approach for the design of low-dimensional suboptimal controllers to optimal control problems of nonlinear evolution equations. The approach relies on a new concept called finite-horizon parameterizing manifolds (PMs). Given a low-mode truncation of the evolution equation on a finite time horizon, a PM provides an approximate parameterization of the unresolved dynamics by the resolved one so that the unexplained energy is reduced in a mean-square sense when this parameterization is applied. Analytic formulas of such PMs are derived based on backward-forward auxiliary systems. These formulas allow for an effective derivation of reduced systems of ordinary differential equations, which aim to model the evolution of the low-mode truncation of the controlled state variable, where the unresolved dynamics is approximated by the PM function applied to the low modes. A priori error estimates for the resulting PM-based low-dimensional suboptimal controllers are derived under a second-order sufficient optimality condition. Numerical results on optimal control of the Burgers-Sivashinsky equation will also be presented to illustrate the approach. This is joint work with Mickael D. Chekroun (University of California, Los Angeles).

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MS98

Analyticity Results for the Navier-Stokes Equations

We consider the NavierStokes equations posed on the half space, with Dirichlet boundary conditions. We give a direct energy based proof for the instantaneous space-time analyticity and Gevrey class regularity of the solutions, uniformly up to the boundary of the half space. We then discuss the adaptation of the same method for bounded domains.

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MS98

On the Asymptotic Stability of Stratified Solutions for the 2D Boussinesq Equations with a Velocity Damping Term

In this talk we will present the 2D Boussinesq equations with a velocity damping term in a strip T[-1,1], with impermeable walls. In this physical scenario, where the Boussinesq approximation is accurate when density/temperature variations are small, our main result is the asymptotic stability for a specific type of perturbations of a stratified solution: the temperature of the fluid is decreasing with the depth. To prove this result, we use a suitably weighted energy space combined with linear decay, Duhamel's formula and "bootstrap" arguments.

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MS98

Gravity Water Waves and Emerging Bottom

To understand the behavior of waves at a fluid surface in configurations where the surface and the bottom meet (islands, beaches), one encounters a difficulty: the presence in the bulk of the fluid of an edge, at the triple line. To solve the Cauchy problem, we need to study elliptic regularity in such domains, understand the linearized operator around an arbitrary solution, and construct an appropriate procedure to quasi-linearize the equations. Using those tools, I will present some a priori estimates.

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MS98

Euler Equations in Domains with Rough Boundaries

Uniqueness of solutions to the 2D Euler equations is generally not known when the velocity is not a priori almost Lipschitz, as is the case in domains with rough boundaries. I will show that uniqueness can be established as long as the vorticity remains constant near the insufficiently regular part of the domain boundary. I will also present sufficient conditions under which this happens globally in time, as well as examples demonstrating sharpness of these results in an appropriate sense.

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MS99

Incompressible Fluids Through a Porous Medium

In a perforated domain, the asymptotic behavior of the fluid motion depends on the rate (inter-hole distance)/(size of the holes). We will present the standard framework and explain how to find the critical rate where "strange terms" appear for the Laplace and Navier-Stokes equations. Next, we will study Euler equations where the critical rate is totally different than for parabolic equations. These works are in collaboration with V. Bonnaillie-Noel, M. Hillairet, N. Masmoudi, C. Wang and D. Wu.

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MS99

On the Convergence of Numerical Approximations of the Incompressible Euler Equations

Numerical and analytic results on the convergence properties of approximate solution sequences for the incompressible Euler equations are presented. Numerically, it has been observed that computed solution sequences for rough initial data (for which the uniqueness of solutions is not known) show no indication of convergence in the conventional sense. This has motivated us to consider alternative solution concepts, such as statistical solutions. Statistical solutions are formulated as time-parametrized probability measures on L^2 satisfying a certain evolution equation. Numerical experiments indicate that approximations to statistical solutions may exhibit a convergent behaviour with increasing numerical resolution, even when the statistical solution is concentrated on rough initial data and convergence is not observed on the level of individual samples. Analytically, sufficient conditions for convergence to a statistical solution are given. These sufficient conditions appear to be satisfied robustly, even for very rough initial data.

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MS99

Numerical Approximation for Invariant Measures of the 2D Navier-Stokes Equations

We consider the problem of approximating statistically steady states of the 2D stochastic Navier-Stokes equations (SNSE) via an approximating sequence of measures generated from a space-time discretization of the 2D SNSE. More specifically, we consider a spectral Galerkin spatial discretization and a semi-implicit Euler time scheme. We show that successive iterations of the Markov semigroup associated to the discretized system, starting from any initial probability distribution, converge to the invariant measure of the continuous system. The proof is obtained with two main steps: a spectral gap result for the discretized system which is independent of the discretization parameters, and finite time L^2-convergence of the discretized system towards the continuous one. Most importantly, this approach allows us to obtain explicit rates of convergence with respect to the number of iterations in the Markov chain, up to (also explicit) numerical discretization error.

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MS99

Optimal Bounds on the Heat Transfer in the Marangoni-Bnard Convection

We address the problem of deriving quantitative bounds on the average upward heat transport, the Nusselt number, for the Pearson's model of Bnard-Marangoni convection. Inspired by numerical experiments [Fantuzzi, Pershin & Wynn, 2018], we improve by a logarithmic factor the best available upper bound on the Nusselt number, $Nu \leq cMa^{2/7}$ [Hagstrom & Doering, 2010], where Ma is the Marangoni number. This is done by solving a variational problem induced by splitting the temperature field into a background profile and fluctuation around it.

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MS100

Predictions of Molecular Binding/Unbinding Kinetics: Geometrical Flows, Transition Paths, and Multi-State Brownian Dynamics

Molecular binding and unbinding are fundamental to many biological processes. Environmental water fluctuations impact the corresponding thermodynamics and kinetics, and challenge theoretical descriptions. Here, we develop a hybrid approach to predict the (un)binding kinetics for a generic ligand-pocket model. We use a variational implicit-solvent model (VISM) to calculate the solute-solvent interfacial structures and the corresponding free energies, and combine the VISM with the string method to obtain the minimum energy paths and transition states between the various "dry" and "wet" hydration states. The resulting dry-wet transition rates are used in a spatially-dependent multi-state continuous-time Markov chain Brownian dynamics simulations, and the related Fokker–Planck equation calculations, of the ligand stochastic motion, providing the mean first-passage times for binding and unbinding. Our findings agree well with the existing explicit-water molecular dynamics. Our study provides a significant step forward towards efficient, physics-based interpretation and predictions of the complex kinetics in realistic ligand-receptor systems.

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MS100

Cauchy-Born Rule and Stability of Crystalline Solids at Finite Temperature

In this talk, we will present some recent progress on finite temperature Cauchy-Born rule. We prove, under certain sharp stability conditions at zero temperature, that the solids is stable when temperature is low. This gives a criterion for the onset of instabilities of crystalline solids as temperature increases. Based on the stability conditions at both zero and finite temperature, we show that the finite temperature version of CauchyBorn rule gives a correct nonlinear elasticity model in the sense that elastically deformed states of the atomistic model are closely approximated by solutions of the continuum model with free energy functionals obtained from the CauchyBorn rule at finite temperature.

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MS100

Numerical Homogenization of Levy-Type Nonlocal Problems with Oscillating Coefficients

In this work, we propose numerical algorithms for solving the homogenized of Lvy-type nonlocal problems with rapidly oscillating coefficients. We consider cases of heterogeneous coefficients with symmetric locally periodic kernels and random micro-structures in both one dimensional and two dimensional cases. Based on the idea of Ewalds summation and fast Fourier transform, we propose an efficient algorithm to solve the homogenized problems.

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MS100

Modeling and Analysis on Distribution of Oxygen Partial Pressure in Electrolytes with Different Structures: Explaining Degradation of Solid Oxide Electrolyzer Cells

It is found in the experiments that solid oxide electrolyzer cells (SOECs) with a Gadolinium doped Ceria (GDC) barrier sandwiched between the Yttria-stabilized Zirconia (YSZ) electrolyte and a Lanthanum Strontium Cobalt Ferrite (LSCF) or iron doped strontium titanates (STF) or Cobalt substituted SrTi0.3Fe0.7O3 (STFC):GDC oxygen electrode shows a significantly lower degradation rate comparing with cells with pure YSZ electrolyte and an Sr-doped LaMnO3 (LSM):YSZ oxygen electrode. In order to investigate the mechanisms leading to such phenomena and optimize the design of SOECs to achieve expected durability, a diffused interface model is proposed to investigate the distribution of oxygen partial pressure in the multi-layer electrolyte of solid oxide electrolyzer cells. Influence of operating condition, structures and properties of the electrolyte on the distribution of oxygen partial pressure are studied. Furthermore, it has been mentioned in many literature that shrinkage mismatching and inter-reaction between YSZ and GDC yield a low oxygen ion diffusivity zone during the co-firing process of the electrolyte, besides the mixing of two materials. In our numerical simulation results, the maximum oxygen partial pressure in the electrolyte is obtained at the interface of YSZ and the low

oxygen ion diffusivity layer. This explains pore formation observed in some experiments at the corresponding position in the electrolyte.

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MS102

Asymptotic Profiles of Homogeneous Gradient Flows

We study the gradient flow of absolutely p-homogeneous convex functionals on a Hilbert space and establish sharp convergence rates of the flow. Moreover, we study next order asymptotics and prove that asymptotic profiles of the solution are eigenfunctions of the subdifferential operator of the functional. To this end, we compare with solutions of an ordinary differential equation which describes the evolution of eigenfunction under the flow. Our work applies, for instance, to local and nonlocal versions of PDEs like p-Laplacian evolution equations, the porous medium equation, and fast diffusion equations, herewith generalizing many results from the literature to an abstract setting. We also demonstrate how our theory extends to general homogeneous evolution equations which are not necessarily a gradient flow. Here we discover an interesting integrability condition which characterizes whether or not asymptotic profiles are eigenfunctions.

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MS102

Kurdyka-Lojasiewicz-Simon Inequality for Gradient Flows in Metric Spaces

The classical Lojasiewicz inequality and its extensions by Simon and Kurdyka have been a considerable impact on the analysis of the large time behaviour of gradient flow in Hilbert spaces. Our aim is to adapt the classical Kurdyka-Lojasiewicz and Lojasiewicz-Simon inequalities to the general framework gradient flow in metric spaces. We show that the validity of a Kurdyka-Lojasiewicz inequality imply trend to equilibrium in the metric sense, and the Lojasiewicz-Simon inequality has the advantage to derive decay estimates of the trend to equilibrium and finite time of extinction. The entropy method have proved to be very useful to study the large time behaviour of solutions to many EDPs. This method is based in the entropy-entropy production/dissipation (EEP) inequality, which correspond to Lojasiewicz-Simon inequality, and also in the entropy transportation (ET) inequality. We show that for geodesically convex functionals Lojasiewicz-Simon inequality and entropy transportation (ET) inequality are equivalent. We apply our general results to gradient flow in Banach spaces and in spaces of probability measures with Wasserstein distances. For the energy functional associated with a doubly-nonlinear equations on R^N we obtain the equivalence between Lojasiewicz-Simon inequality, generalized log-Sobolev inequality and p-Talagrand inequality; also we get decay estimates for its solutions. Joint work with Daniel Hauer (Sydney University

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MS102

Gradient Flows for the Stochastic Amari Neural Field Model

We shall discuss certain aspects of a nonlocal stochastic partial integro-differential equation with applications to the so-called Amari-type neural field model [Amari, S. (1977), Biol. Cybern.], which are mean-field models for neural activity in the cortex, cf. [Bressloff, P.C. (2012), J. Phys. A: Math. Theor.]. In particular, under suitable assumptions on the coupling kernel, we show that via an infinite dimensional change of coordinates the equation admits a gradient flow structure, which has consequences for regularity, long-time behavior and uniqueness of invariant probability distributions. The results are based on [Kuehn, C. and Tölle, J.M. (2019), J. Math. Biol., in press, `https://doi.org/10.1007/s00285-019-01393-w`].

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MS103

Fractional White-Noise Limit and Paraxial Approximation for Waves in Random Media

This work is devoted to the asymptotic analysis of high frequency wave propagation in random media with long-range dependence. We are interested in two asymptotic regimes, that we investigate simultaneously: the paraxial approximation, where the wave is collimated and propagates along a privileged direction of propagation, and the white-noise limit, where random fluctuations in the background are well approximated in a statistical sense by a fractional white noise. The fractional nature of the fluctuations is reminiscent of the long-range correlations in the underlying random medium. A typical physical setting is laser beam propagation in turbulent atmosphere. Starting from the high frequency wave equation with fast non-Gaussian random oscillations in the velocity field, we derive the fractional ItSchrdinger equation, that is, a Schrdinger equation with potential equal to a fractional white noise. The proof involves a fine analysis of the backscattering and of the coupling between the propagating and evanescent modes. Because of the long-range dependence, classical diffusion-approximation theorems for equations with random coefficients do not apply, and we therefore use moment

techniques to study the convergence.

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MS105

A Rigorous Derivation of a Ternary Boltzmann Equation for a Classical System of Particles

In this talk we present a rigorous derivation of a new kinetic equation describing the limiting behavior of a classical system of particles with three particle instantaneous interactions. This equation, which we call ternary Boltzmann equation, can be understood as a step towards modeling a dense gas in non-equilibrium. It is derived from laws of instantaneous particle interactions, preserving momentum and energy.

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MS105

On the Relativistic Landau Equation

We study the Cauchy problem for the spatially homogeneous relativistic Landau equation with Coulomb interactions. The difficulty of the problem lies in the extreme complexity of the kernel in the relativistic collision operator. We construct a new decomposition of such kernel, and use it to prove several a priori estimates and the existence of a true weak solution for a large class of initial data. This is joint work with Robert M. Strain.

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MS105

Partial Regularity in Time for the Landau Equation (with Coulomb Interaction)

We prove that the set of singular times for weak solutions of the space homogeneous Landau equation with Coulomb potential constructed as in [C. Villani, Arch. Rational Mech. Anal. 143 (1998), 273-307] has Hausdorff dimension at most 1/2. This is a joint work with Maria Gualdani, Franois Golse and Cyril Imbert.

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MS105

Kinetic Description of a Boltzmann-Rayleigh Gas with Annihilation

We consider the dynamics of a tagged point particle in a gas of moving hard-spheres that are non-interacting among each other. This model is known as the ideal Rayleigh gas. We add to this model the possibility of annihilation (ideal Rayleigh gas with annihilation), requiring that each obstacle is either annihilating or elastic, which determines whether the tagged particle is elastically reflected or removed from the system. We provide a rigorous derivation of a linear Boltzmann equation with annihilation from this particle model in the Boltzmann-Grad limit. Moreover, we give explicit estimates for the error in the kinetic limit by estimating the contributions of the configurations which prevent the Markovianity. The estimates show that the system can be approximated by the Boltzmann equation on an algebraically long time scale in the scaling parameter.

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MS106

Spectral Bands, Tight Binding Limits, Topological Band Gaps and Bifurcations in Periodic Schrdinger Operators

We will discuss properties of spectral bands for periodic Schrdinger operators established with Keller, Osting and Weinstein in a symmetry setting that includes the Square Lattice and the Lieb Lattice. In particular, we will give conditions for band intersections and describe their geometries. We will also discuss tight binding limits of these models, as well as modifications thereof that open up band gaps of both topological and non-topological type. In addition, we will discuss current joint work with Bandres, Osting and Rechtsman on nonlinear bifurcations of tight-binding models, as well as nonlinear Dirac models derived in the study of these lattice models. If time permits, we will show some numerical simulations indicating the richness of these models in a variety of settings.

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PP1

Two-Phase Hele-Shaw Flows Induced by Dynamical Mother Bodies

A two-phase problem describes an evolution of the interface $\Gamma(t) \subset \mathbb{R}^2$ between two immiscible fluids, occupying regions Ω_1 and Ω_2 in a Hele-Shaw cell. The interface evolves due to the presence of sinks and sources located in Ω_j, $j = 1, 2$. The case where one of the fluids is effectively inviscid, that is, it has a constant pressure, is called one-phase problem. This case has been studied extensively. Much less progress has been made for the two-phase problem (also know as the "Muskat problem'). The main difficulty of the two-phase problem is the fact that the pressure on the interface, separating the fluids, is unknown. However, if we assume that the free boundary remains within the family of algebraic

curves under negligible surface tension, then the problem is drastically simplified. In this article, we introduce a notion of a two-phase mother body (the terminology comes from the potential theory) as a union of two distributions $\sigma_j(t)$ with integrable densities of sinks and sources, allowing to control the evolution of the interface. We use the tools of complex analysis such as the Schwarz function, complex potential and then introduced two-phase mother body to find the evolution of the curve $\Gamma(t)$ as well as two harmonic functions p_j, the pressures, defined almost everywhere in Ω_j and satisfied prescribed boundary conditions on $\Gamma(t)$.

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PP1

Numerical Solution for a System of 3D Partial Differential Equations

In this presentation, we consider the solution of the steady flow in athree-dimensional lid-driven cavity using numerical methods. The three-dimensional velocity-vorticity formulation, used by Davies Carpenter(2001), is considered. The cubical lid-driven cavity problem is solved. The problem is discretized using the Chebyshev discretization in the y and z directions, and fourth-order finite differences are used for the discretization in the x direction. Newton linearization is used to linearize the problem and a direct solver isdevoted to solve the problem. The problem has been coded in both the MATLAB and FORTRAN-environments.The lid-driven cavity problem is used typically to test new methods and codes. The lid-driven cavity can be introduced as a fluid contained in a cube domain with stationary rigid walls and a moving wall. Parallelization has been performed to speed up theimplementation, and the three-dimensional lid-driven cavity solution was obtained at Re= 100 and Re= 1000 to show an agreement with the Younget al.(2000) results.

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PP1

Time Domain Finite Element Method for Nonlinear Maxwell's Equations

We discuss a time domain finite element method for the approximate solution of Nonlinear Maxwell's equations. A weak formulation is derived for the electric and magnetic fields with appropriate initial and boundary conditions, and the problem is discretized both in space and time. For this system, we prove an error estimate. In addition, computational experiments are presented to validate the method, the electric and magnetic fields are visualized. The method also allows treating complex geometries of various physical systems coupled to electromagnetic fields in 3D.

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PP1

A Mean Field Game Model of Innovation

When businesses invest in research and development (R&D) they tend to only account for the private increase in value that any such research provides. This overlooks the fact that a technology developed by one business might vastly affect how other businesses operate. The lack of accounting for the social or external value of an innovation is known as a knowledge spillover effect and it can result in the sub-optimal allocation of research investment by a business. In this poster I describe a mean field game model to more accurately capture the size and distribution of this effect among firms. Preliminary results, including existence and uniqueness of solutions to the model and simulations using patent data, will be presented as well as future outlooks. One particularly interesting example of how this might be used is in the more effective allocation of government research subsidies based on the social or external value of new innovations.

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PP1

Generalised Langevin Dynamics with Simulated Annealing for Optimisation

One way to find the minimum of a nonconvex function is to use overdamped Langevin dynamics with a decreasing noise term, a realisation of simulated annealing. For the case where the function is a quadratic, it can be explicitly shown that there can be an advantage to using the underdamped Langevin dynamics rather than the overdamped dynamics depending on the strength of the quadratic. There was recent work by Monmarché that applies simulated annealing to the underdamped dynamics which incorporates momentum to overcome local minima even without noise. This work extends the idea to an approximation of generalised Langevin dynamics, which adds yet another auxiliary momentum variable to the underdamped Langevin dynamics, along with evidence to suggest that exploration of the state space is increased considerably.

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PP1

Global Well-Posedness of the Adiabatic Limit of Quantum Zakharov System in 1D

We prove the low-regularity global well-posedness of the

adibatic limit of the Quantum Zakharov system and consider its semi-classical limit, that is, the convergence of our model equation as the quantum parameter tends to zero. We also show ill-posedness in negative Sobolev spaces and discuss the existence of ground-state soliton solutions in high spatial dimensions.

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PP1

Model Reduction for Fractional Elliptic Problems Using Kato's Formula

We present a fractional Laplace solver which costs an order of magnitude less than traditional solvers and illustrate the efficiency with an application to climate modeling. Fractional partial differential equations have exceptional potential to model physical phenomena not modeled by classical partial differential equations. Specifically, time/space fractional diffusion equations (fDEs) can be used to describe anomalous diffusion seen in large scale climate dynamics. To numerically evaluate the capability of fDEs in this setting, we implement methods based on our solver of the fractional Laplace problem. Our solver utilizes Kato's integral solution to express the problem as a Gaussian quadrature. Cost is greatly decreased by using Model Reduction to quickly query fractional Laplace solves at each quadrature node. Numerical comparisons to other methods will be provided.

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PP1

A Spectral Flow Method for Computing Nodal Deficiencies on Graphs

We use a spectral flow method to compute the nodal deficiency of the eigenvectors of a graph Laplacian, similar to [G. Berkolaiko, G. Cox, J. Marzuola, Nodal deficiency, spectral flow, and the Dirichlet-to-Neumann map]. In particular, we examine graphs whose vertices are sampled from some domain and their graph Laplacian L. Let v be the kth eigenvector of L. We perturb L with an operator modeled off of a Dirac measure localized to the nodal set of v, and show that this perturbed operator Γ-converges to a well-behaved operator on the underlying continuum domain. We then use this to show that nodal domains of the graph converge to nodal domains of the continuum, corresponding to the kth eigenvalue, and recover the nodal deficiency of the domain. Applications to data analysis and spectral clustering are also discussed.

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PP1

Generalized (s, S) Policy for Concave Piecewise Linear Ordering Cost

We study the stochastic inventory control systems for an infinite horizon in which the ordering cost is piecewise linear concave. Our analysis is concerned with the generalization of classical s, S policy. In the first phase, we provide certain conditions that guarantee a single s_ϵ, S_ϵ policy is optimal. In the second phase, we focus on generalization and demonstrate that there exists two thresholds of inventory levels such that if the current inventory $x \leq \sigma_\epsilon$ then order up to S_ϵ is optimal, and if inventory $\sigma_\epsilon < x \leq s_\epsilon$ then order up to s_ϵ is optimal. Therefore, we name our prolonged policy is $(\sigma_\epsilon, s_\epsilon, S_\epsilon)$.

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PP1

Biot-Pressure System with Unilateral Displacement Constraints

The *quasistatic* Biot-Pressure system is a coupled system of parabolic and elliptic partial differential equations that describe the small deformations of and fluid flow through a fully saturated elastic and porous structure. It models the situation in which the inertia effects are negligible. This arises naturally in the classical Biot model of consolidation for a linearly elastic and porous solid which is saturated by a slightly compressible viscous fluid. Our objective is to extend the existence-uniqueness-regularity theory for such systems to include problems with constraints on the displacement. Such contact problems are highly nonlinear and ubiquitous in the applications.

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PP1

Approximation of the Two-Parameter Mittag-Leffler Function using a Real Distinct Poles Rational Function

When solving fractional differential equations and equations with structural derivatives, the generalized Mittag-Leffler function and its inverse is extremely useful. However, their computational complexities have made them difficult to deal with numerically. In this work, we propose a rational function with real distinct poles to approximate the two-parameter Mittag-Leffler function. Under some mild conditions, this approximation is proven and empirically shown to be L-Acceptable. This approximation is especially useful in developing efficient and accurate numerical schemes for solving fractional differential equations. Some applications of this approximation are presented.

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PP1

A Robust Numerical Technique for Nonlinear Differential Equations

Singularly perturbed differential equations arise in several scientific and technical fields. An Element-free Galerkin(EFG) method, a truly meshless approach, based on moving least-squares(MLS) approximation has been proposed for solving nonlinear singularly perturbed differential equations. The MLS approximation has been applied to construct the shape functions. The proposed method is

based on the global weak form and requires a background cell for computing the numerical integrations. The essential boundary conditions in the present formulation have been imposed by using the Lagrange multiplier method. Numerical results have been presented to verify the computational precision of the method. To conclude, the EFG approach is found to be a simple, efficient and robust method with great potential in engineering applications.

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PP1

On Existence and Uniqueness of Solutions to Nonlocal Conservation Laws

We present recent existence and uniqueness results for nonlocal conservation laws. These are conservation laws where the flux function depends nonlocally on the solution, i.e. on the spatial integration of the solution over a specified area of integration. We show results for the scalar Cauchy problem on $\mathbb{R}$, for the multi-dimensional Cauchy problem on $\mathbb{R}^n$ with a specific analysis of the regularity of the area of integration and for the scalar initial boundary value problem with non-negative velocity functions and the application in traffic flow. As it turns out there is no need of prescribing an Entropy condition to obtain unique weak solutions.

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PP1

Discontinuous Galerkin Methods using Poly-Sinc Approximation

Discontinuous Galerkin (DG) methods [1] are a class of numerical methods to find accurate approximate solutions to differential equations. The idea of a DG method is to find a local polynomial approximation on a partition and join these local approximations in a piecewise global function. The discontinuous points lend themselves to increasing the accuracy of the DG approximation by minimizing the jumps at these points. Several methods proposed parameters to penalize the jumps at the discontinuous points; however, parameter tuning is needed [2]. We use Lagrange interpolation with non-equidistant points generated by conformal mappings, such as Sinc points, to minimize the jumps at the discontinuous points [3]. We use a simple second-order ordinary differential equation to validate our scheme. We demonstrate that our poly-Sinc approximation method has a lower error in the L^2 norm than those of Lagrange interpolation with equidistant points. Moreover, our scheme is devoid of penalty parameters. [1] B. Cockburn, G. E. Karniadakis, and C.-W. Shu, "The Development of Discontinuous Galerkin Methods," in Discontinuous Galerkin Methods, Springer, 2000, pp. 3-50. [2] F. Mueller, D. Schoetzau, and C. Schwab, "Symmetric Interior Penalty Discontinuous Galerkin Methods for Elliptic Problems in Polygons," SIAM Journal on Numerical Analysis, vol. 55, no. 5, pp. 2490-2521, 2017. [3] F. Stenger, Handbook of Sinc Numerical Methods. CRC Press, 2011.

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PP1

Big Data Simulation and Analysis of Numerical Solutions from the Elder Problem

The author has used the d3f software [1] for solving the PDEs describing the Elder problem [2]. The d3f software has been adapted to run on the Spark cluster. This setup allows the mass parallel runs of the d3f software, as well as efficient post-processing and further analysis of the result data. Some important run metrics calculated, and the estimates for even more extensive simulations provided. Simulations are undertaken for the wide range of Rayleigh number (Ra) from 0 to 500, with grid levels from 6 to 9, and with different time steps. Ra subranges containing the bifurcation points [2] explored in more details. Having the representative set of simulations, the author has estimated the conditional probabilities of 1-, 2- or 3-fingers solutions in steady states. The method for automatic recognition (labeling) of steady-state solutions described. Also, the author has presented an approach on how to build a predictive model for the Elder problem, i.e., a model which can predict a final steady state using a few early-time observations.

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PP1

Discrete-Time Disease Model with Population Motion under the Kolmogorov Equation View

We introduce the Susceptible-Infected-Removed (SIR) model and the Susceptible-Exposed-Infected-Removed (SEIR) model coupled with a social mobility model (SMM). We discretize them by a Forward Euler Method, which can be viewed through a mean-field approximation from a discrete version. We calculate basic reproduction number R_0 using the next generation matrix method. Then we obtain hyperbolic forward Kolmogorov equations (high-dimensional PDEs) and show that its projected characteristics corresponding to these models coincide with population motivation. Finally, we use the Deep Galerkin Method (DGM) to solve the high order nonlinear PDEs. In this project, we can improve the global prediction of epidemics dynamics, which can provide suggestions on "how to control " epidemics. In addition, we also use these methods to solve the Cancer Immunotherapy model. We believe this Cancer Immunotherapy model can provide another way to observe the blockade of immune checkpoints in the tumor dynamics.

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PP1

Convergence of a Stochastic Structure-Preserving Scheme for Computing Effective Diffusivity in Random Flows

We propose an implicit structure-preserving scheme to compute the effective diffusivity for particles moving in stochastic flows when the velocity is generated by a non-separable Hamitonian. We compute the motion of particles using the Lagrangian formulation, which is modeled by stochastic differential equations (SDEs). We propose a robust numerical integrator to solve the SDEs and provide a sharp uniform in time error estimates for the numerical integrator in computing effective diffusivity. The proof follows a probabilistic approach, which interprets the solution process generated by our numerical integrator as a Markov process. By exploring the ergodicity of the solution process, we prove the convergence analysis of our method in computing long time solutions. We present numerical results to demonstrate the accuracy and efficiency of the proposed method in computing effective diffusivity for several chaotic and stochastic flows generated from non-separable Hamitonians.

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PP1

Parameterization Method for Nonlinear Manifolds of PDEs

We develop a method for parameterizing nonlinear manifolds of PDEs near stationary solutions. We apply this method to the Nagumo equation, the Gray-Scott equations, and Schrodinger's equation. Specifically, we solve for the nonlinear manifold that converges to an unstable traveling wave solution in backward time in the direction of the eigenfunction.

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PP1

A Mathematical Analysis of Stock Price Oscillations within Financial Markets

The application of econophysics in modeling investment assets market behavior is considerably increasing and is highly becoming an area of interest for econophysicists. This study investigated stock price oscillatory behavior in stock markets. We applied mathematical methods to derive the stock market price oscillatory model from the physics field. We considered two distinct price level cases that is, high and low price cases and presented/ derived a corresponding model for each case. We managed also to derive an explicit time function which measures and calculate the time taken by stock prices to oscillate between two values. Also, from the low-price oscillation model we managed to investigate stock price motion at different times with all other external forces held constant. Results obtained showed that, although stock price movement (volatility) is time dependent, it is propelled and fueled by market forces such as stock volume, market size and classical forces of demand and supply. Above all we evaluated our model using means difference test of hypothesis using actual and estimated stock price data. We failed to reject our null hypothesis and concluded that, there is no statistical significant difference in the means which highly support the precision of our model. Despite all this, we sensed a gap that other researchers can work on such as the application of simple harmonic oscillations in stock markets.

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PP1

Global Existence of the Nonisentropic Compressible Euler Equations with Vacuum Boundary Surrounding a Variable Entropy State

Global existence for the nonisentropic compressible Euler equations with vacuum boundary for all adiabatic constants $\gamma > 1$ is shown through perturbations around a rich class of background nonisentropic affine motions. The notable feature of the nonisentropic motion lies in the presence of non-constant entropies, and it brings a new mathematical challenge to the stability analysis of nonisentropic affine motions. In particular, the estimation of the curl terms requires a careful use of algebraic, nonlinear structure of the pressure. With suitable regularity of the underlying affine entropy, we are able to adapt the weighted energy method developed for the isentropic Euler by Hadzic and Jang to the nonisentropic problem. For large γ values, inspired by Shkoller and Sideris, we use time-dependent weights that allow some of the top-order norms to potentially grow as the time variable tends to infinity. We also exploit coercivity estimates here via the fundamental theorem of calculus in time variable for norms which are not top-order. This is based on joint work with Mahir Hadzic and Juhi Jang.

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PP1

PDEs: a Transport-Diffusion Analysis of the Effect of Migrating Leachate on Aquifers

To advise residents living close to landfills on the safety of the water they use for domestic purposes, environmental health experts in developing countries frequently conduct laboratory analyses of collected samples of water in areas close to landfills. Results from such studies - after laboratory examination of water samples - show, as expected, increasing volumes of leachate constituents with proximity to the landfill. These studies are, however, more reactive than proactive, as groundwater would already have been polluted by leachate at the time of the analysis. Solutions to and consequences of the problem of groundwater contamination by leachate from landfills can be grossly expensive. It is thus desirable to determine, ahead of time, if and when the problem of groundwater invasion by leachate

is likely to occur in future and the extent of damage expected, in order to take prior corrective action.
This study, carried out in Ghana, thus employed the advection-dispersion equation to simulate the transport of leachate in aquifers based on concentrations observed in leachate samples from a case-study engineered landfill site in Ghana. Concentration and depth of infiltration exhibited a negative relationship, as diffusion and dispersion occur with dilution of leachate by groundwater. Simulations were done in MATLAB.

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PP1

Spatio-Temporal Gamma Oscillations in a Mean Field Model of Electroencephalographic Activity in the Neocortex

This poster presentation demonstrates a possible mechanism for the emergence of transient gamma oscillations in the neocortex using a well-established mean field model of electroencephalographic activity in the neocortex. It is shown through numerical bifurcation analysis that gamma oscillations emerge robustly in the solutions of the model and transition to beta oscillations through coordinated modulation of the responsiveness of inhibitory and excitatory neuronal populations. The spatio-temporal pattern of propagation of these oscillations across the neocortex is illustrated by solving the equations of the model using a finite element software package. It is shown that the inherent spatial averaging effect of commonly used electrocortical measurement techniques can significantly alter the amplitude and pattern of fast oscillations in neocortical recordings, and hence can potentially affect physiological interpretations of these recordings. This poster presentation is accompanied by a talk which is focused on rigorous analytical results on well-posedness, regularity, and global dynamics of the mean field model used in this presentation.

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PP1

On a Cahn-Hilliard Variational Model for Lithium Batteries

We study a Cahn-Hilliard variational model for lithium-ion batteries. This model was proposed to accurately describe the dynamic process of ion intercalation under elasticity within a single crystal of composite electrode material. The primary analytical complication for this model is a nonlinear Neumann boundary condition for the chemical potential, which accounts for the varying quantities of lithium-ions within the crystal. Utilizing a recently proposed generalized gradient structure, we apply a minimizing movements type approach to prove existence of weak solutions to the aforementioned variational model.

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PP1

A Model for Currency Exchange Rates

The catastrophic economic events like, oil price shock in 1973, the 9/11 event in 2001, stock market crash in October, 1987 and crash in late 2008 etc, impacted the US economy without warning from sharp downturns to actual market crashes. And the current economic theory and statistical models are not enough to analyze those events. So, We are going to constitute the models to predict and recovery of US economy with major factors: commodities, stock, bond and currency. Here, I am going to predict the trend μ and recover the volatility σ of currency exchange rates using models "Stochastic Differential Equations"

$$\frac{dS}{S} = \mu(S,t)dt + \sigma(S,t)dB_t(\omega) \tag{6}$$

where, for each time t, $S = S_t(\omega)$ is a random variable representing the price of financial asset (exchange rate in my case) for the trial ω, with predicting trend of exchange rates by system of differential equations and recovering of volatility of exchange rates by using inverse problem in "Dupire's Equations" which is obtained from "Black-Scholes Equations".

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PP1

Primal-Dual Weak Galerkin Finite Element Methods for PDEs

Weak Galerkin (WG) finite element method is a numerical technique for PDEs where the differential operators in the variational form are reconstructed/approximated by using a framework that mimics the theory of distributions for piecewise polynomials. The usual regularity of the approximating functions is compensated by carefully-designed stabilizers. The fundamental difference between WG methods and other existing finite element methods is the use of weak derivatives and weak continuities in the design of numerical schemes based on conventional weak forms for the underlying PDE problems. WG methods are well suited to a wide class of PDEs by providing the needed stability and accuracy in approximations. This poster will outline a recent development of WG, called "Primal-Dual Weak Galerkin (PD-WG)", for problems for which the usual numerical methods are difficult to apply. The essential idea of PD-WG is to interpret the numerical solutions as a constrained minimization of some functionals with constraints that mimic the weak formulation of the PDEs by using weak derivatives. The resulting Euler-Lagrange equation offers a symmetric scheme involving both the primal variable and the dual variable (Lagrange multiplier). PD-WG method is applicable to several challenging problems for which existing methods may have difficulty in applying; these problems include the second order elliptic equations

in nondivergence form, Fokker-Planck equation, and elliptic Cauchy problems.

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PP1

Global Sobolev Persistence for the Fractional Boussinesq Equations with Zero Diffusivity

We address the persistence of regularity for the 2D α-fractional Boussinesq equations with positive viscosity and zero diffusivity in general Sobolev spaces, i.e., for $(u_0, \rho_0) \in W^{s,q}(\mathbb{R}^2) \times W^{s,q}(\mathbb{R}^2)$, where $s > 1$ and $q \in (2, \infty)$. We prove that the solution $(u(t), \rho(t))$ exists and belongs to $W^{s,q}(\mathbb{R}^2) \times W^{s,q}(\mathbb{R}^2)$ for all positive time t for a range of exponents q depending on α, where $\alpha \in (1, 2)$ is arbitrary.

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PP1

The Landau Equation as a Gradient Flow

The Landau equation is an important kinetic theoretical equation in plasma physics describing grazing collisions of particles. Indeed, it can be formally seen as a limiting case of the Boltzmann equation which Hilbert suggested to use to understand the passage of particle systems to continuum mechanics in his 6th problem. Mathematically, it also poses interesting challenges concerning existence and uniqueness of solutions. In this poster, I will recount current progress by the author in applying the powerful gradient flow theory to study various properties of this equation.

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Italicized names indicate session organizers

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Expected Paid Attendance	470	
Revenue		
Registration Income		$166,430
	Total	$166,430
Expenses		
Printing		$2,000
Organizing Committee		$3,800
Invited Speakers		$12,550
Food and Beverage		$24,000
AV Equipment and Telecommunication		$23,200
Advertising		$6,500
Conference Labor (including benefits)		$44,295
Other (supplies, staff travel, freight, misc.)		$13,950
Administrative		$15,458
Accounting/Distribution & Shipping		$8,781
Information Systems		$15,157
Customer Service		$5,326
Marketing		$10,109
Office Space (Building)		$6,099
Other SIAM Services		$5,734
	Total	$196,959
Net Conference Expense		($30,529)
Support Provided by SIAM		$30,529
		$0

Estimated Support for Travel Awards not included above:

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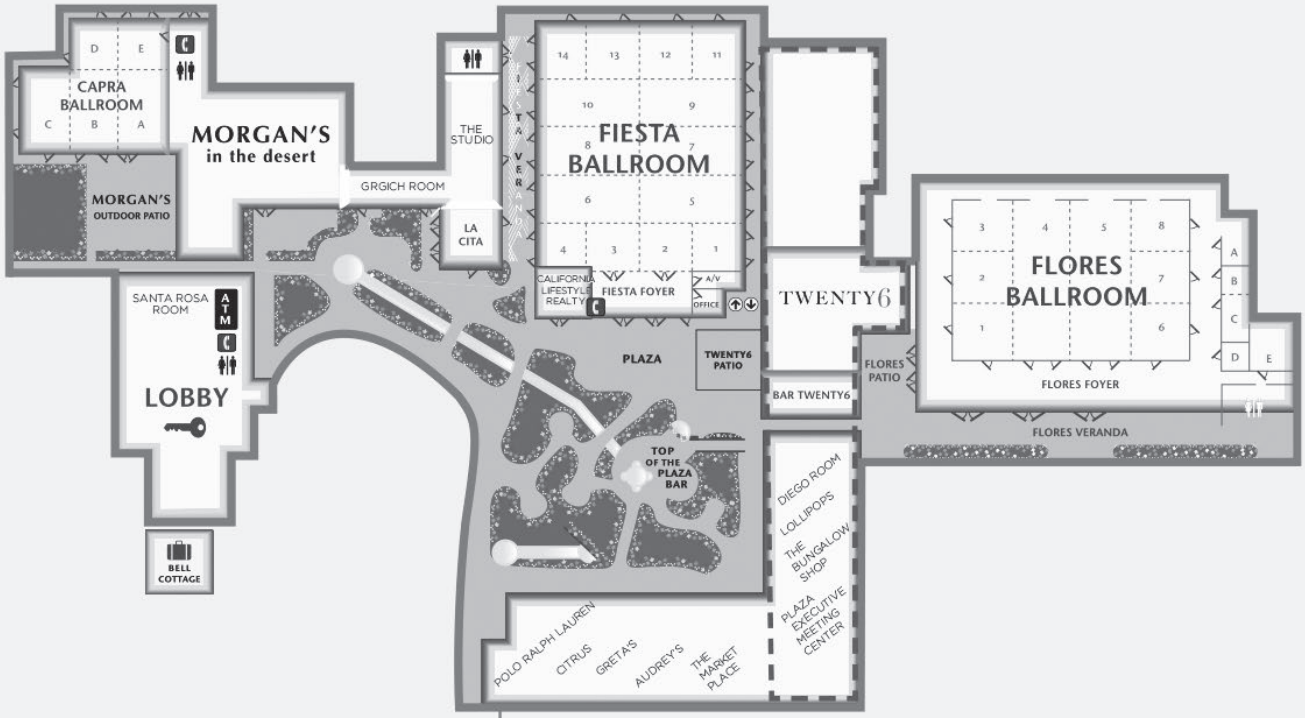

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