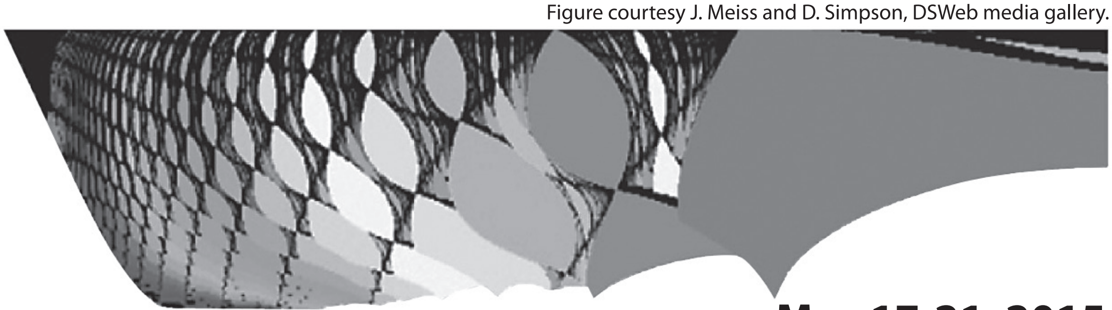
Final Program and Abstracts

2015 SIAM Conference on Applications of Dynamical Systems

Figure courtesy J. Meiss and D. Simpson, DSWeb media gallery.



May 17-21, 2015
Snowbird Ski and Summer Resort
Snowbird, Utah, USA

Sponsored by the SIAM Activity Group on Dynamical Systems

The SIAM Activity Group on Dynamical Systems provides a forum for the exchange of ideas and information between mathematicians and applied scientists whose work involves dynamical systems. The goal of this group is to facilitate the development and application of new theory and methods of dynamical systems. The techniques in this area are making major contributions in many areas, including biology, nonlinear optics, fluids, chemistry, and mechanics. This activity group supports the web portal DSWeb, sponsors special sessions at SIAM meetings, organizes a biennial conference, and awards biennial prizes—the Jürgen Moser Lecture, J. D. Crawford Prize, and the Red Sock Award. The activity group also sponsors the DSWeb Student Competition for tutorials on dynamical systems and its applications written by graduate and undergraduate students and recent graduates. Members of SIAG/DS receive a complimentary subscription to the all-electronic, multimedia SIAM Journal on Applied Dynamical Systems.

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SIAM Registration Desk

The SIAM registration desk is located in the Ballroom Foyer. It is open during the following times:

Saturday, May 16
8:00 AM - 8:00 PM

Sunday, May 17
8:00 AM - 5:00 PM

Monday, May 18
8:00 AM - 6:30 PM

Tuesday, May 19
8:00 AM - 4:30 PM

Wednesday, May 20
8:00 AM - 4:30 PM

Thursday, May 21
8:00 AM - 4:45 PM

Hotel Address

Snowbird Ski and Summer Resort
9320 S. Cliff Lodge Drive
Snowbird, UT 84092-9000
USA

Hotel web address:
http://www.snowbird.com/

Hotel Telephone Number

To reach an attendee or leave a message, call +1-801-742-2222. If the attendee is a hotel guest, the hotel operator can connect you with the attendee's room.

Hotel Check-in and Check-out Times

Check-in time is 4:00 PM and check-out time is 11:00 AM.

Child Care

As a service to SIAM attendees, SIAM has made arrangements for in-room child care. All sitters should be requested with at least 48 hours notice. If you have not already made reservations for child care and would like to inquire about availability, please contact Camp Snowbird at (801)933-2256, or e-mail the camp at *campsnowbird@snowbird.com*.

Corporate Members and Affiliates

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

National Security Agency (DIRNSA)

Oak Ridge National Laboratory, managed by UT-Battelle for the Department of Energy

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United States Department of Energy

List current March 2015.

Funding Agencies

SIAM and the Conference Organizing Committee wish to extend their thanks and appreciation to the U.S. National Science Foundation and the U.S. Department of Energy for their support of this conference.

Leading the applied mathematics community … *Join SIAM and save!*

SIAM members save up to $130 on full registration for the 2015 SIAM Conference on Dynamical Systems (DS15)! 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.

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

If you are a SIAM member, it only costs $10 to join the SIAM Activity Group on Dynamical Systems (SIAG/DS). As a SIAG/DS member, you are eligible for an additional $10 discount on this conference, so if you paid the SIAM member rate to attend the conference, you might be eligible for a free SIAG/DS membership. Check at the registration desk.

Free Student Memberships are available to students who attend an institution that is an Academic Member of SIAM, are members of Student Chapters of SIAM, or are nominated by a Regular Member of SIAM.

Join onsite at the registration desk, go to *www.siam.org/joinsiam* to join online or download an application form, or contact SIAM Customer Service:

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Standard Audio/Visual Set-Up in Meeting Rooms

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.

The Plenary Session Room will have two (2) screens, one (1) data projector and one (1) overhead projector. The data projectors support VGA connections only. Presenters requiring an HDMI or alternate connection must provide their own adaptor.

All other concurrent/breakout rooms will have one (1) screen and one (1) data projector. The data projectors support VGA connections only. Presenters requiring an HDMI or alternate connection must provide their own adaptor.

If you have questions regarding availability of equipment in the meeting room of your presentation, please see a SIAM staff member at the registration desk.

Internet Access

Complimentary wireless Internet access will be available in the guest rooms and public areas of the Cliff Lodge, the Lodge at Snowbird, and the Inn. Additionally, complimentary wireless Internet access will be available in the meeting space of the Cliff Lodge.

Email stations will also be available during registration hours.

Registration Fee Includes

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

Job Postings

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

Important Notice to Poster Presenters

Poster Session 1 is scheduled for Tuesday, May 19, 8:30 PM-10:30 PM. Poster Session 1 presenters are requested to put up their posters in the Ballroom between 8:00 and 8:30 PM on Tuesday, at which time boards and push pins will be available. Poster displays must be removed at 10:30 PM, the end of Poster Session 1. Posters remaining after this time will be discarded. SIAM is not responsible for discarded posters.

Poster Session 2 is scheduled for Wednesday, May 20, 8:30 PM-10:30 PM. Poster Session 2 presenters are requested to put up their posters in the Ballroom between 8:00 and 8:30 PM on Wednesday, at which time boards and push pins will be available. Poster displays must be removed at 10:30 PM, the end of Poster Session 2. Posters remaining after this time will be discarded. SIAM is not responsible for discarded posters.

For information about preparing a poster, please visit *http://www.siam.org/meetings/guidelines/presenters.php.*

SIAM Books and Journals

Display copies of books and complimentary copies of journals are available on site. SIAM books are available at a discounted price during the conference. If a SIAM books representative is not available, completed order forms and payment (credit cards are preferred) may be taken to the SIAM registration desk. The books table will close at 11:00 AM on Thursday, May 21.

Journal Editor Panel Sponsors

AIP Publishing (Chaos)

APS Publishing (PRL and PRE)

Elsevier Publishing (Physica D)

Elsevier Publishing (Physics Letters A)

IOP Publishing (Nonlinearity)

Table Top Displays

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Elsevier

IOP Publishing

Oxford University Press

SIAM

Name Badges

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

Comments?

Comments about SIAM meetings are encouraged! Please send to:

Cynthia Phillips, SIAM Vice President for Programs (*vpp@siam.org*).

Please Note

SIAM is not responsible for the safety and security of attendees' computers. Do not leave your laptop computers unattended. Please remember to turn off your cell phones, pagers, etc. during sessions.

Get-togethers

- **Welcome Reception**
  Saturday, May 16
  6:00 PM – 8:00 PM

- **Business Meeting**
  (open to SIAG/DS members)
  Monday, May 18
  8:30 PM - 9:30 PM
  Complimentary beer and wine will be served.

- **Poster Session and Dessert Reception I**
  Tuesday, May 19
  8:30 PM - 10:30 PM

- **Poster Session and Dessert Reception II**
  Wednesday, May 20
  8:30 PM - 10:30 PM

Recording of Presentations

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

Social Media

SIAM is promoting the use of social media, such as Facebook and Twitter, in order to enhance scientific discussion at its meetings and enable attendees to connect with each other prior to, during and after conferences. If you are tweeting about a conference, please use the designated hashtag to enable other attendees to keep up with the Twitter conversation and to allow better archiving of our conference discussions. The hashtag for this meeting is #SIAMDS15.

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To enhance your conference experience, we're providing a state-of-the-art mobile app to give you important conference information right at your fingertips. With this TripBuilder EventMobile™ app, you can:

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Featured Minisymposia

Featured Minisymposia will include a selective group of talks that describe and promote recent significant advances in a theme deemed to be of high priority for current and near future research in Dynamical Systems and their Applications.

Sunday, May 17

2:00 PM – 4:00 PM

MS14: Applications of Algebraic Topology to Neuroscience

Room: Ballroom I

Organizers:

Chad Giusti, University of Pennsylvania, USA

Robert W. Ghrist, University of Pennsylvania, USA

Danielle Bassett, University of Pennsylvania, USA

MS15: Data Assimilation in the Life Sciences

Room: Ballroom II

Organizers:

Elizabeth M. Cherry, Cornell University, USA

Timothy Sauer, George Mason University, USA

MS16: Data-Driven Modeling of Dynamical Processes in Spatially-Embedded Random Networks

Room: Maybird

Organizer: Gyorgy Korniss, Rensselaer Polytechnic Institute, USA

MS17: Stochastic Delayed Networks

Room: Primrose A

Organizer: Gabor Orosz, University of Michigan, Ann Arbor, USA

MS18: Localized Pattern Formation in Reaction-diffusion Equations

Room: Primrose B

Organizer: Arik Yochelis, Ben Gurion University Negev, Israel

Featured Minisymposia

Wednesday, May 20

4:00 PM - 6:00 PM

MS104: Non-Autonomous Instabilities

Room: Ballroom I

Organizer: Sebastian M. Wieczorek, University College Cork, Ireland

MS105: Random Walks, First Passage Time and Applications

Room: Ballroom II

Organizers:

Theodore Kolokolnikov, Dalhousie University, Canada

Sidney Redner, Santa Fe Institute, USA

MS106: Time-Delayed Feedback

Room: Wasatch B

Organizer: Andreas Amann, University College Cork, Ireland

MS107: Emerging Strategies for Stability Analysis of Electrical Power Grids

Room: Maybird

Organizers:

Lewis G. Roberts, University of Bristol, United Kingdom

Florian Dorfler, ETH Zürich, Switzerland

MS108: Invariant Manifolds Unravelling Complicated Dynamics

Room: Primrose A

Organizers:

Stefanie Hittmeyer, University of Auckland, New Zealand

Pablo Aguirre, Universidad Técnica Federico Santa María, Chile

MS109: Medical Applications

Room: Primrose B

Organizers:

Dan D. Wilson, University of California, Santa Barbara, USA

Jeff Moehlis, University of California, Santa Barbara, USA

Minitutorials

Sunday, May 17

2:00 PM - 4:00 PM

MT1: Network Dynamics

Room: Ballroom III

Organizer: Louis M. Pecora, United States Naval Research Laboratory, USA

Wednesday, May 20

4:00 PM - 6:00 PM

MT2: Stochastic Dynamics of Rare Events

Room: Ballroom III

Organizer: Eric Forgoston, Montclair State University, USA

Invited Plenary Speakers

*** All Invited Plenary Presentations will take place in the Ballroom***

Sunday, May 17

11:45 AM - 12:30 PM

IP1 Advances on the Control of Nonlinear Network Dynamics

Adilson E. Motter, *Northwestern University, USA*

Monday, May 18

11:00 AM - 11:45 AM

IP2 Mathematics of Crime

Andrea L. Bertozzi, *University of California, Los Angeles, USA*

6:00 PM - 6:45 PM

IP3 Filtering Partially Observed Chaotic Deterministic Dynamical Systems

Andrew Stuart, *University of Warwick, United Kingdom*

Tuesday, May 19

11:00 AM - 11:45 AM

IP4 Fields of Dreams: Modeling and Analysis of Large Scale Activity in the Brain

Bard Ermentrout, *University of Pittsburgh, USA*

Invited Plenary Speakers

Wednesday, May 20

11:00 AM - 11:45 AM

IP5 Cooperation, Cheating, and Collapse in Biological Populations

Jeff Gore, *Massachusetts Institute of Technology, USA*

Thursday, May 21

11:15 AM - 12:00 PM

IP6 Brain Control - It's Not Just for Mad Scientists

Jeff Moehlis, *University of California, Santa Barbara, USA*

4:15 PM - 5:00 PM

IP7 The Robotic Scientist: Distilling Natural Laws from Raw Data, from Robotics to Biology and Physics

Hod Lipson, *Cornell University, USA*

Prize Presentation and Special Lecture

The Prize Presentation and Special Lecture will take place in the Ballroom.

SIAM Activity Group on Dynamical Systems Prizes

Sunday, May 17

8:00 PM - 8:15 PM

Prize Presentations - Jürgen Moser and J. D. Crawford

J. D. Crawford Prize Recipient

Florin Diacu, *University of Victoria, Canada*

Jürgen Moser Lecturer

John Guckenheimer, *Cornell University, USA*

8:15 PM - 9:00 PM

Jürgen Moser Lecture: Dynamics and Data

John Guckenheimer, *Cornell University, USA*

SIAM Activity Group on Dynamical Systems (SIAG/DS)

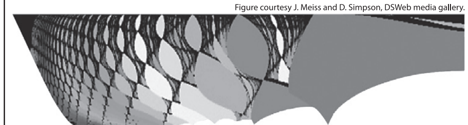
www.siam.org/activity/ds

A GREAT WAY TO GET INVOLVED!

Collaborate and interact with mathematicians and applied scientists whose work involves dynamical systems.

2015 SIAM Conference on Applications of Dynamical Systems

Figure courtesy J. Meiss and D. Simpson, DSWeb media gallery.



Snowbird Ski and Summer Resort
Snowbird, Utah, USA

ACTIVITIES INCLUDE:

- DSWeb portal
- Special sessions at SIAM meetings
- Biennial conference
- Jürgen Moser Lecture
- J. D. Crawford Prize
- Red Sock Award

BENEFITS OF SIAG/DS MEMBERSHIP:

- Listing in the SIAG's online membership directory
- Additional $10 discount on registration at the SIAM Conference on Applied Dynamical Systems *(excludes students)*
- Dynamical Systems Magazine
- Subscription to *SIAM Journal on Applied Dynamical Systems*
- Electronic communications about recent developments in your specialty
- Eligibility for candidacy for SIAG/DS office
- Participation in the selection of SIAG/DS officers

ELIGIBILITY:

- Be a current SIAM member.

COST:

- $10 per year
- Student members can join 2 activity groups for free!

2014-15 SIAG/DS OFFICERS

Chair: Timothy D Sauer, George Mason University
Vice Chair: Vivi Rottschafer, Universiteit Leiden
Program Director: Lora Billings, Montclair State University
Secretary and DS Magazine Chief Editor: Elizabeth Cherry, Rochester Institute of Technology
DSWeb Portal Editor-in-Chief: Peter van Heijster, Queensland University of Technology

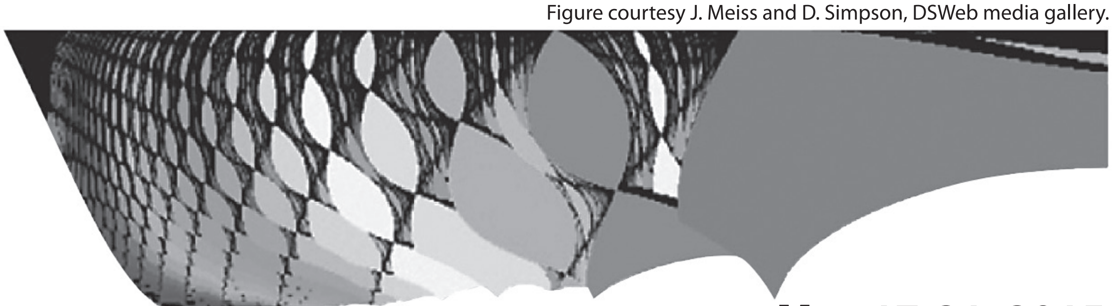
TO JOIN:

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

Final Program

2015 SIAM Conference on Applications of Dynamical Systems

Figure courtesy J. Meiss and D. Simpson, DSWeb media gallery.



May 17-21, 2015
Snowbird Ski and Summer Resort
Snowbird, Utah, USA

Saturday, May 16

Registration

8:00 AM-8:00 PM

Room:Ballroom Foyer

SIAM Workshop on Network Science (May 16-17 -- separate fees apply)

9:00 AM-8:30 PM

Room:Cottonwood Room - Snowbird Center

Welcome Reception

6:00 PM-8:00 PM

Room:Ballroom

Sunday, May 17

Registration

8:00 AM-5:00 PM

Room:Ballroom Foyer

SIAM Workshop on Network Science (May 16-17 -- separate fees apply)

8:30 AM-6:00 PM

Room:Cottonwood Room - Snowbird Center

Sunday, May 17

MS1

Patterns in Partial Differential Equations - Part I of II

9:00 AM-11:00 AM

Room:Ballroom I

For Part 2 see MS19

Patterns play an important role in the dynamics of many dissipative and dispersive PDEs, posed on large or unbounded domains. This minisymposium will feature contributions that investigate intrinsically multi-dimensional aspects of the dynamics of patterns, including their existence, stability, instability, slow evolution, and interaction. Examples include interfaces between patterned and un-patterned state, point defects or vortices, and line defects. We expect to bring together researchers with a variety of backgrounds, employing a variety of techniques, such as diffusive and dispersive stability estimates, energy methods from the calculus of variations, or spatial dynamics and bifurcation methods.

Organizer: Keith Promislow
Michigan State University, USA

Organizer: Noa Kraitzman
Michigan State University, USA

9:00-9:25 Bifurcation and Competitive Evolution of Network Morphologies in the Strong Functionalized Cahn-Hilliard Equation

Noa Kraitzman, Michigan State University, USA

9:30-9:55 Nonlinearity Saturation as a Singular Perturbation of the Nonlinear Schrödinger Equation

Karl Glasner, University of Arizona, USA

10:00-10:25 Dark-Bright, Dark-Dark, Vortex-Bright and Other Multi-Component NLS Beasts: Theory and Recent Applications

Panayotis Kevrekidis, University of Massachusetts, USA

10:30-10:55 Nonlinear Stability of Source Defects

Bjorn Sandstede, Brown University, USA

Sunday, May 17

MS2

Dynamics of Boolean Switching Networks

9:00 AM-11:00 AM

Room:Ballroom II

Modeling complex systems in general, and gene regulation in particular, presents particular challenges. The challenges include the large size of biologically relevant gene networks and the ability to parameterize ODE models. The available data are often only qualitative and therefore it is not clear how to compare them to a precise solutions of an ODE system. An attractive answer to these challenges is the framework of switching systems, which combine continuous time evolution of an ODE system with discrete, or Boolean quantization of the phase space. The minisymposium will bring together the leading researchers in the area to provide an overview of this very active field.

Organizer: Tomas Gedeon
Montana State University, USA

Organizer: Roderick Edwards
University of Victoria, Canada

9:00-9:25 Database for Switching Networks As a Tool for Study of Gene Networks

Tomas Gedeon, Montana State University, USA

9:30-9:55 Gene Network Models Including mRNA and Protein Dynamics

Roderick Edwards, University of Victoria, Canada

10:00-10:25 Evolution of Gene Networks

Leon Glass, McGill University, Canada

10:30-10:55 Dynamics of Autonomous Boolean Networks

Otti D'Huys and Nicholas D. Haynes, Duke University, USA; Miguel C. Soriano and Ingo Fischer, Universitat de les Illes Balears, Spain; Daniel J. Gauthier, Duke University, USA

Sunday, May 17

MS3

Ocean-in-the-loop: Towards Real-Time Monitoring in Geophysical Flows - Part I of II

9:00 AM-11:00 AM

Room:Ballroom III

For Part 2 see MS21

Improved modeling and prediction of fluid dynamics is needed to better understand ocean and atmospheric transport along with associated applications including contaminant dispersion, environmental modeling, and underwater acoustic propagation. Major recent advances in closed-loop adaptive sampling, Lagrangian data assimilation, uncertainty quantification, and phase space transport are providing improved understanding of transport phenomena. The purpose of this minisymposium is to expose the audience to recent progress and developments, as well as to bring together researchers developing new mathematical methods and applications for use in understanding flow transport.

Organizer: Eric Forgoston
Montclair State University, USA

Organizer: Ani Hsieh
Drexel University, USA

9:00-9:25 Tracking of Geophysical Flows by Robot Teams: An Experimental Approach

Ani Hsieh, Dhanushka Kularatne, and Dennis Larkin, Drexel University, USA; Eric Forgoston, Montclair State University, USA; Philip Yecko, Cooper Union, USA

9:30-9:55 Controlled Lagrangian Prediction Using An Ensemble of Flow Models

Fumin Zhang, Georgia Institute of Technology, USA

10:00-10:25 Conditional Statistics with Lagrangian Coherent Structures

Wenbo Tang and Phillip Walker, Arizona State University, USA

10:30-10:55 Controlling Long-Term Spatial Distributions of Autonomous Vehicles in Stochastic Flow Environments

Christoffer R. Heckman, University of Colorado Boulder, USA; Ani Hsieh, Drexel University, USA; Ira B. Schwartz, Naval Research Laboratory, USA

Sunday, May 17

MS4

Dynamics of Rigid Bodies and Fluids

9:00 AM-11:00 AM

Room:Magpie A

This interdisciplinary minisymposium will address mathematical methods used in the rigid body mechanics, fluid mechanics, and fluid-structure interaction. The lectures will include topics on dynamics of nonholonomic systems, coupled rigid body and fluid motion, links between nonholonomic mechanics and fluids, and a geometric approach to numerical fluid dynamics. The unifying idea of this minisymposium is the representation of the rigid body and fluid dynamics in the form of of the Euler-Poincare (resp., Lie-Poisson) equations in the Lagrangian (resp., Hamiltonian) setting.

Organizer: Dmitry Zenkov
North Carolina State University, USA

Organizer: Scott D. Kelly
University of Illinois at Urbana-Champaign, USA

9:00-9:25 The Lie-Dirac Reduction for Nonholonomic Systems on Semidirect Products

Hiroaki Yoshimura, Waseda University, Japan; François Gay-Balmaz, Ecole Normale Superieure de Paris, France

9:30-9:55 Discretization of Hamiltonian Incompressible Fluids

Gemma Mason, California Institute of Technology, USA; Christian Lessig, Technische Universität Berlin, Germany; Mathieu Desbrun, California Institute of Technology, USA

10:00-10:25 Constrained Motion of Point Vortices Interacting Dynamically with Rigid Bodies in Ideal Flow

Michael Fairchild and Scott Kelly, University of North Carolina, Charlotte, USA

10:30-10:55 The Poincare-Hopf Theorem in Nonholonomic Mechanics

Oscar Fernandez, Wellesley College, USA; Anthony M. Bloch, University of Michigan, USA; Dmitry Zenkov, North Carolina State University, USA

Sunday, May 17

MS7

The Dynamics and Computation of Neuronal Networks

9:00 AM-11:00 AM

Room:Wasatch B

The dynamics of neuronal networks provide rich information regarding the nature of computation and information encoding in the brain. This minisymposium explores recent work in the modeling of neuronal dynamics, emphasizing implications on sensory processing and network connectivity. The speakers will draw particular attention to new mathematical advances in characterizing the structure-function relationship for complex neuronal networks and techniques for understanding the biophysical processes underlying network dynamics.

Organizer: Victor Barranca
New York University, USA

Organizer: Douglas Zhou
Shanghai Jiao Tong University, China

9:00-9:25 Reconstruction of Structural Connectivity in Neuronal Networks Using Compressive Sensing of Network Dynamics

Victor Barranca, New York University, USA; Douglas Zhou, Shanghai Jiao Tong University, China; David Cai, Shanghai Jiao Tong University, China and Courant Institute of Mathematical Sciences, New York University, USA

9:30-9:55 Theoretical Modeling of Neuronal Dendritic Integration

Songting Li, Courant Institute of Mathematical Sciences, New York University, USA; Douglas Zhou, Shanghai Jiao Tong University, China; David Cai, Courant Institute of Mathematical Sciences, New York University, USA

10:00-10:25 Topology Reconstruction of Neuronal Networks

Douglas Zhou, Yanyang Xiao, Yaoyu Zhang, and Zhiqin Xu, Shanghai Jiao Tong University, China; David Cai, Shanghai Jiao Tong University, China and Courant Institute of Mathematical Sciences, New York University, USA

10:30-10:55 Functional Connectomics from Data: Constructing Probabilistic Graphical Models for Neuronal Networks

Eli Shlizeman, University of Washington, USA

Sunday, May 17

MS8

Wave-turbulence Interactions in Geophysical and Astrophysical Fluid Dynamics

9:00 AM-11:00 AM

Room:Maybird

The interaction of waves and turbulence is a topic of fundamental importance in geophysical and astrophysical fluid dynamics, where wave dynamics result from density stratification, rotation, magnetism, and compressibility. The interactions of wave dynamics with turbulence can have significant implications, transferring energy over long distances or across scales, and impacting the formation and evolution of coherent structures. This minisymposium brings together researchers to present recent results in wave-turbulence interaction in both geophysical and astrophysical settings.

Organizer: Ian Grooms
New York University, USA

Organizer: Jared P. Whitehead
Brigham Young University, USA

9:00-9:25 Internal Wave Generation by Convection

Daniel Lecoanet, University of California, Berkeley, USA; Keaton Burns, Massachusetts Institute of Technology, USA; Geoffrey M. Vasil, University of Sydney, Australia; Eliot Quataert, University of California, Berkeley, USA; Benjamin Brown, University of Colorado Boulder, USA; Jeffrey Oishi, Farmingdale State College, USA

9:30-9:55 Interaction of Inertial Oscillations with a Geostrophic Flow

Jim Thomas, Courant Institute of Mathematical Sciences, New York University, USA; Shafer Smith, Courant Institute, Center for Atmosphere Ocean Science, USA; Oliver Buhler, Courant Institute of Mathematical Sciences, New York University, USA

10:00-10:25 Investigation of Boussinesq non-linear Interactions Using Intermediate Models

Gerardo Hernandez-Duenas, National University of Mexico, Mexico; Leslie Smith, University of Wisconsin, USA; Samuel Stechmann, University of Wisconsin, Madison, USA

10:30-10:55 Interactions Between Near-Inertial Waves and Turbulence in the Ocean

Jacques Vanneste, University of Edinburgh, United Kingdom

Sunday, May 17

MS9

Dynamics on Networks and Network Topology in Ecology and Epidemiology

9:00 AM-11:00 AM

Room:Superior A

The spread of pathogens in population networks or of invasive species in fragmented landscapes give rise to dynamical systems defined on networks. The topology of the network has implications for the dynamics, constraining, for example, if spread through the network is wave-like or if new clusters can form at long distances from old ones. New topological tools such as persistent topology developed for studying data sets such as large point clouds or networks allow for new insights into dynamics on networks. Topics in the minisymposium include spatially embedded contagion networks and network-mediated dynamical systems models in ecology and epidemiology, all informed by the underlying network topology.

Organizer: Christopher Strickland
University of North Carolina at Chapel Hill, USA

Organizer: Patrick Shipman
Colorado State University, USA

9:00-9:25 Network Spread and Control of Invasive Species and Infectious Diseases

Christopher Strickland, University of North Carolina at Chapel Hill, USA; Patrick Shipman, Colorado State University, USA

9:30-9:55 Topological Data Analysis for and with Contagions on Networks

Dane Taylor, University of North Carolina at Chapel Hill, USA; Florian Klimm, Humboldt University Berlin, Germany; Heather Harrington, University of Oxford, United Kingdom; Miroslav Kramar and Konstantin Mischaikow, Rutgers University, USA; Mason A. Porter, University of Oxford, United Kingdom; Peter J. Mucha, University of North Carolina at Chapel Hill, USA

continued on next page

10:00-10:25 Local Inference of Gene Regulatory Networks from Time Series Data

Francis C. Motta, Kevin McGoff, Anastasia Deckard, Xin Guo Guo, Tina Kelliher, Adam Leman, Steve Haase, and John Harer, Duke University, USA

10:30-10:55 Patterns in Discrete Ecological Dynamical Systems Revealed Through Persistent Homology

Rachel Neville, Colorado State University, USA

Sunday, May 17

MS10

Dynamics Modeling with Transformations Between Partial- and Delay Differential Equations

9:00 AM-11:00 AM

Room:Superior B

Travelling wave solutions of the governing partial differential equations (PDEs) of distributed parameter systems often lead to the transformation of the infinite dimensional problem to a corresponding system of delay differential equations (DDEs). The transformations from DDEs to PDEs may also be useful for analyzing certain classes of dynamical systems. The lectures give a spectrum of these transformations revealing the intricate dynamical properties of these systems, like the peculiar stability properties of periodic retarded systems, neutral systems with multiple delays, tau-nonstabilizable systems, delayed boundary value problems and variable delay systems, which are often linked to models of dynamic contact problems.

Organizer: Gabor Stepan

Budapest University of Technology and Economics, Hungary

9:00-9:25 What Is Wrong with Non-Smooth Mechanics and How Memory Effects Can Fix It?

Robert Szalai, University of Bristol, United Kingdom

9:30-9:55 Differential Equations with Variable Delay and Their Connection to Partial Differential Equations

Gunter Radons, Andreas Otto, and David Mueller, Chemnitz University of Technology, Germany

10:00-10:25 Stability Analysis of PDEs with Two Spatial Dimensions Using Lyapunov Methods and SOS

Evgeny Meyer and Matthew Peet, Arizona State University, USA

10:30-10:55 Delayed Boundary Conditions in Control of Continua

Gabor Stepan, Budapest University of Technology and Economics, Hungary; Li Zhang, Nanjing University of Aeronautics and Astronautics, China

Sunday, May 17

MS11

Multiscale Models to Understand the Social and Physical World - Part I of II

9:00 AM-11:00 AM

Room:White Pine

For Part 2 see MS29

The scientific community has developed a rich and diverse library of mathematical models capable of capturing complex processes and interactions over a broad range of scales in space and time. In this session, we feature a variety of researchers exploring the application of mathematical models to the social and physical world. The topics of this session cover several scales, from interacting particles to population models to PDEs, and include both stochastic and deterministic models. Talks will address applications such as earthquakes, swimming microorganisms, and human crowd dynamics.

Organizer: Alethea Barbaro

Case Western Reserve University, USA

Organizer: Brittany Erickson

Portland State University, USA

9:00-9:25 Phase Transitions in Models for Social Dynamics

Alethea Barbaro, Case Western Reserve University, USA

9:30-9:55 A Center Manifold and Complex Phases for a Large Number of Interacting Particles

Bjorn Birnir, University of California, Santa Barbara, USA; Luis Bonilla, Universidad Carlos III de Madrid, Spain; Jorge Cornejo-Donoso, University of California, Santa Barbara, USA

10:00-10:25 Mathematical Challenges in Ground State Formation of Isotropic and Anisotropic Interaction

David T. Uminsky, University of San Francisco, USA

10:30-10:55 Modeling Earthquake Cycles on Faults Separating Variable Materials

Brittany Erickson, Portland State University, USA

Sunday, May 17

MS12

Network Synchronization in Mechanical Systems and Beyond - Part I of II

9:00 AM-11:00 AM

Room:Primrose A

For Part 2 see MS30

This minisymposium focuses on the role of synchronization, coordination, and dynamical consensus in mechanical systems and beyond. Examples range from bridges and mechanical pendula to self-organizing networks of moving agents, with application in robotics and animal behavior. This minisymposium aims at various theoretical and experimental aspects of synchrony-induced phenomena and their control and brings together applied mathematicians and mechanical engineers.

Organizer: Igor Belykh
Georgia State University, USA

Organizer: Maurizio Porfiri
Polytechnic Institute of New York University, USA

9:00-9:25 Wind-Induced Synchrony Causes the Instability of a Bridge: When Millennium Meets Tacoma

Igor Belykh and Russell Jeter, Georgia State University, USA; Vladimir Belykh, Lobachevsky State University of Nizhny Novgorod, Russia

9:30-9:55 Versatile Vibrations: Partially Synchronized States in Mechanical Systems from Microns to Kilometers

Daniel Abrams, Northwestern University, USA

10:00-10:25 Synchronization over Networks Inspired by Echolocating Bats

Subhradeep Roy and *Nicole Abaid*, Virginia Tech, USA

10:30-10:55 Network Graph Can Promote Faster Consensus Reach Despite Large Inter-Agent Delays

Min Hyong Koh and *Rifat Sipahi*, Northeastern University, USA

Sunday, May 17

MS13

Dynamics of High Dimensional Stochastic Models

9:00 AM-11:00 AM

Room:Primrose B

High dimensional models can arise from spatially extended systems or systems with large numbers of interacting units (i.e. atoms, neurons, people, ect.). The observed global behavior of these systems can be characterized through the analysis and simulation of large dimensional differential equation (SDE) and stochastic partial differential equation (SPDE) models. We look at applications including pattern formation, ferromagnets, molecular dynamics, and viscoelastic fluids.

Organizer: Katherine Newhall
University of North Carolina at Chapel Hill, USA

9:00-9:25 Low-Damping Transition Times in a Ferromagnetic Model System

Katherine Newhall, University of North Carolina at Chapel Hill, USA

9:30-9:55 Tipping and Warning Signs for Patterns and Propagation Failure in SPDEs

Christian Kuehn, Vienna University of Technology, Austria; Karna V. Gowda, Northwestern University, USA

10:00-10:25 Fluctuating Hydrodynamics of Microparticles in Viscoelastic Fluids

Scott McKinley, University of Florida, USA

10:30-10:55 Stochastic Boundary Conditions for Molecular Dynamics: From Crystal to Melt

Gregory J. Herschlag, Duke University, USA; Sorin Mitran, University of North Carolina, Chapel Hill, USA

Sunday, May 17

MS23

Oscillations in Systems with Relays

9:00 AM-11:00 AM

Room:Magpie B

This minisymposium aims to strengthen the link between the theory and applications of systems with relay nonlinearities. A particular attention will be given to those theoretical tools that allow designing closed orbits in real life applications. Both local bifurcation technique and available global methods will be addressed. On the modelling side, the minisymposium covers the relay systems described by discontinuous differential equations as well as functional-differential equations with hysteresis operators.

Organizer: Dmitry Rachinskiy
University of Texas at Dallas, USA

9:00-9:25 Population Dynamics with the Preisach Operator

Dmitry Rachinskiy, University of Texas at Dallas, USA

9:30-9:55 Self-Oscillations Via Two-Relay Controller: Design, Analysis, and Applications

Luis T. Aguilar, Instituto Politécnico Nacional, Mexico; Igor Boiko, The Petroleum Institute of Abu Dhabi, United Arab Emirates; Leonid Fridman and Rafael Iriarte, Universidad Nacional Autonoma de Mexico, Mexico

10:00-10:25 Periodic Solutions in Dynamical Systems with Relay: Existence, Stability, Bifurcations

Pavel Gurevich, Free University of Berlin, Germany

10:30-10:55 Reaction-Diffusion Equations with Discontinuous Relay Nonlinearity

Sergey Tikhomirov, St. Petersburg State University, Russia; Pavel Gurevich, Free University of Berlin, Germany

Sunday, May 17

MS116

Torus Canards in Applications

9:00 AM-11:00 AM

Room:Wasatch A

Torus canards arise in slow/fast systems in which the fast subsystem contains families of attracting and repelling limit cycles that meet in a saddle-node bifurcation of limit cycles. In models of neuronal systems, the transition from spiking (rapid firing of the membrane potential) to bursting (alternating intervals of spiking and quiescence) can occur via torus canards. Characterised by long excursions near the repelling manifold of limit cycles, torus canards are the higher-dimensional analogue of classical canards. This minisymposium consists of case studies that illustrate how torus canards give rise to rich dynamical phenomena in various applications.

Organizer: Kerry-Lyn Roberts
University of Sydney, Australia

Organizer: Theodore Vo
Boston University, USA

9:00-9:25 The Interaction Between Classical Canards and Torus Canards
Theodore Vo, Boston University, USA

9:30-9:55 Averaging and Generic Torus Canards
Kerry-Lyn Roberts, University of Sydney, Australia

10:00-10:25 Averaging and Kam Theory in Torus Canards
Albert Granados, INRIA, France

10:30-10:55 Torus Canard Breakdown
Andrey Shilnikov, Georgia State University, USA; Alexander Neiman, Ohio University, USA

Sunday, May 17

Coffee Break

11:00 AM-11:30 AM

Room:Golden Cliff

Welcome Remarks

11:30 AM-11:45 AM

Room:Ballroom

Sunday, May 17

IP1

Advances on the Control of Nonlinear Network Dynamics

11:45 AM-12:30 PM

Room:Ballroom

Chair: Louis M. Pecora, Naval Research Laboratory, USA

An increasing number of complex systems are now modeled as networks of coupled dynamical entities. Nonlinearity and high-dimensionality are hallmarks of the dynamics of such networks but have generally been regarded as obstacles to control. In this talk, I will discuss recent advances on mathematical and computational approaches to control high-dimensional nonlinear network dynamics under general constraints on the admissible interventions. I will present applications to the stabilization of power grids, identification of new therapeutic targets, mitigation of extinctions in food webs, and control of systemic failures in socio-economic systems. These examples will illustrate the potential and limitations of existing methods to address a broad class of problems, ranging from cascade control and transient stability to network reprogramming in general.

Adilson E. Motter
Northwestern University, USA

Lunch Break

12:30 PM-2:00 PM

Attendees on their own

Sunday, May 17

MT1

Network Dynamics

2:00 PM-4:00 PM

Room:Ballroom III

Chair: Louis M. Pecora, Naval Research Laboratory, USA

Over the last decade or more analysis of networks has developed into a topic all its own in mathematics and many sciences (physics, biology, sociology, neuroscience, etc.). Many journals have sections for papers on network analysis. This minitutorial will present the audience with an overview of network science including useful techniques and tools along with more abstract concepts. The speakers will also comment on new ideas and approaches that are beginning to surface.

From Structure to Dynamics in Complex Networks

Michelle Girvan, University of Maryland, USA

Networks, Dynamics, and the Ongoing Evolution

Mason A. Porter, University of Oxford, United Kingdom

Sunday, May 17

MS14

Featured Minisymposium: Applications of Algebraic Topology to Neuroscience

2:00 PM-4:00 PM

Room:Ballroom I

The varied subjects of study in neuroscience, from brain network dynamics to clinical diagnosis, provide an abundant source of fundamentally non-linear problems which emerging tools in computational algebraic topology are well-suited to address. Conversely, these new applications call for the development of new theoretical structure through which to interpret results and form hypotheses. This minisymposium showcases some recent applications and the directions in which the theory is evolving to accommodate them.

Organizer: Chad Giusti
University of Pennsylvania, USA

Organizer: Robert W. Ghrist
University of Pennsylvania, USA

Organizer: Danielle Bassett
University of Pennsylvania, USA

2:00-2:25 Topological Detection of Structure in Neural Activity Recordings

Chad Giusti, University of Pennsylvania, USA; Carina Curto and Vladimir Itskov, Pennsylvania State University, USA

2:30-2:55 An Algebro-Topological Perspective on Hierarchical Modularity of Networks

Kathryn Hess, École Polytechnique Fédérale de Lausanne, Switzerland

3:00-3:25 The Topology of Fragile X Syndrome

David Romano, Stanford University School of Medicine, USA

3:30-3:55 The Neural Ring: Using Algebraic Geometry to Analyze Neural Codes

Nora Youngs, Harvey Mudd College, USA

Sunday, May 17

MS15

Featured Minisymposium: Data Assimilation in the Life Sciences

2:00 PM-4:00 PM

Room:Ballroom II

Assimilation of data with models of physical and biological processes is a crucial component of modern scientific analysis. In recent years, nonlinear versions of Kalman filtering have been developed, in addition to methods that estimate model parameters in parallel with the system state. This minisymposium highlights the state of the art in applying these techniques to nonlinear dynamical systems in the life sciences to gain understanding from biological data. The talks will illustrate the use of data assimilation to analyze the dynamics of several prototypical systems, such as cardiac tissue, hippocampal neurons and neural cultures.

Organizer: Elizabeth M. Cherry
Cornell University, USA

Organizer: Timothy Sauer
George Mason University, USA

2:00-2:25 Intramural Forecasting of Cardiac Dynamics Using Data Assimilation

Matthew J. Hoffman, Rochester Institute of Technology, USA; Elizabeth M. Cherry, Cornell University, USA

2:30-2:55 Reconstructing Dynamics of Unmodeled Variables

Franz Hamilton and Timothy Sauer, George Mason University, USA

3:00-3:25 Modeling Excitable Dynamics of Cardiac Cells

Sebastian Berg, T.K. Shajahan, Jan Schumann-Bischoff, Ulrich Parlitz, and Stefan Luther, Max Planck Institute for Dynamics and Self-Organization, Germany

3:30-3:55 Tracking Neuronal Dynamics During Seizures and Alzheimer's Disease

Ghanim Ullah, University of South Florida, USA

Sunday, May 17

MS16

Featured Minisymposium: Data-Driven Modeling of Dynamical Processes in Spatially-Embedded Random Networks

2:00 PM-4:00 PM

Room:Maybird

Infrastructure, transportation, and brain networks are embedded in strongly heterogeneous spatial environments, posing formidable challenges in understanding the vulnerability or "plasticity" of these systems. There exists a large gap between some universal features of simplified dynamical processes on non-spatial complex networks and their applicability to real-world problems. This minisymposium will present recent progress by data-driven approaches in diverse areas. Topics will include the lack of self-averaging and predictability of cascading failures in power grids, optimization in smart grids, the applicability of scaling laws of human travel, and the impact of wiring constraints and weight-based heterogeneity in the cortical networks.

Organizer: Gyorgy Korniss
Rensselaer Polytechnic Institute, USA

2:00-2:25 Cascading Failures and Stochastic Methods for Mitigation in Spatially-Embedded Random Networks

Gyorgy Korniss, Rensselaer Polytechnic Institute, USA

2:30-2:55 Feasibility of Micro-Grid Adoptions in Spatially-Embedded Urban Networks

Marta Gonzalez, Massachusetts Institute of Technology, USA

3:00-3:25 Spatial Distribution of Population and Scaling in Human Travel

Zoltan Neda, Babes-Bolyai University, Romania; Geza Toth, Hungarian Central Statistical Office, Hungary; Andras Kovacs, Edutus College, Hungary; Istvan Papp and Levente Varga, Babes-Bolyai University, Romania

3:30-3:55 The Brain in Space

Zoltan Toroczkai, University of Notre Dame, USA; Maria Ercsey-Ravasz, Babes-Bolyai University, Romania; Kenneth Knoblauch and Henry Kennedy, Inserm, France

Sunday, May 17

MS17

Featured Minisymposium: Stochastic Delayed Networks

2:00 PM-4:00 PM

Room:Primrose A

Complex systems of the 21st century may exhibit rich dynamical behaviors due to complicated network structures, time delays and stochastic effects. Understanding the dynamics of such infinite dimensional dynamical systems requires new approaches and novel mathematical tools. This sections highlights the latest research result on the dynamics of networks where time delays arise due to finite-time information propagation between the nodes and stochasticity appears both in the state as well as in the time delays. Applications include neural networks, gene regulatory networks, and connected vehicle systems.

Organizer: Gabor Orosz
University of Michigan, Ann Arbor, USA

2:00-2:25 Dynamics with Stochastically Delayed Feedback: Designing Connected Vehicle Systems

Gabor Orosz and Wubing Qin, University of Michigan, Ann Arbor, USA

2:30-2:55 New Mechanisms for Patterns, Transitions, and Coherence Resonance for Systems with Delayed Feedback

Rachel Kuske and Chia Lee, University of British Columbia, Canada; Vivi Rottschaefer, Leiden University, Netherlands

3:00-3:25 Synchronization of Degrade-and-Fire Oscillations Via a Common Activator

William H. Mather, Virginia Tech, USA; Jeff Hasty and *Lev S. Tsimring*, University of California, San Diego, USA

3:30-3:55 On the Role of Stochastic Delays in Gene Regulatory Networks

Marcella Gomez and Matthew Bennett, Rice University, USA; Richard Murray, California Institute of Technology, USA

Sunday, May 17

MS18

Featured Minisymposium: Localized Pattern Formation in Reaction-diffusion Equations

2:00 PM-4:00 PM

Room:Primrose B

Spatially localized states have recently brought to the spotlight of mathematical analysis of nonlinear PDEs via analysis of models exhibiting free energy and/or conservation. The purpose of this minisymposium is to generalize and discuss the state of the art in localized pattern formation theory through the reaction diffusion framework that is related to applications across a range of problems in chemistry and biology. The focus will be devoted to recent theories and computations of spatially localized patterns that can result from a number of different mechanisms, such as sub-critical bifurcations, homoclinic snaking, singular perturbations and semi-strong interaction asymptotics.

Organizer: Arik Yochelis
Ben Gurion University Negev, Israel

2:00-2:25 The Origin of Finite Pulse Trains: Homoclinic Snaking in Excitable Media

Arik Yochelis, Ben Gurion University Negev, Israel; Edgar Knobloch, University of California, Berkeley, USA

2:30-2:55 Homoclinic Snaking Near a Codimension-two Turing-Hopf Bifurcation Point

Justin C. Tzou, Dalhousie University, Canada; Yiping Ma, University of Colorado Boulder, USA; Alvin Bayliss, Bernard J Matkowsky, and Vladimir A. Volpert, Northwestern University, USA

3:00-3:25 Slow Dynamics of Localized Spot Patterns for Reaction-Diffusion Systems on the Sphere

Philippe H. Trinh, Princeton University, USA; *Michael Ward*, University of British Columbia, Canada

3:30-3:55 Localised Solutions in a Non-Conservative Cell Polarization Model

Nicolas Verschueren Van Rees and Alan Champneys, University of Bristol, United Kingdom

Coffee Break

4:00 PM-4:30 PM

Room:Golden Cliff

Sunday, May 17

CP1

Topics in Reaction-Diffusion Systems

4:30 PM-6:30 PM

Room:Ballroom I

Chair: Petrus van Heijster, Queensland University of Technology, Australia

4:30-4:45 Defect Solutions in Reaction-Diffusion Equations

Peter van Heijster, Queensland University of Technology, Australia

4:50-5:05 Reaction-Diffusion Equations with Spatially Distributed Hysteresis in Higher Spatial Dimensions

Mark J. Curran, Free University of Berlin, Germany

5:10-5:25 Spatio-Temporal Dynamics of Heterogeneous Excitable Media

Thomas Lilienkamp, Ulrich Parlitz, and Stefan Luther, Max Planck Institute for Dynamics and Self-Organization, Germany

5:30-5:45 Existence of Periodic Solutions of the FitzHugh-Nagumo Equations for An Explicit Range of the Small Parameter

Aleksander Czechowski and Piotr Zgliczyński, Jagiellonian University, Poland

5:50-6:05 Morse-Floer Homology for Travelling Waves in Reaction-Diffusion Equations

Berry Bakker, Jan Bouwe Van Den Berg, and Robert van Der Vorst, VU University, Amsterdam, Netherlands

6:10-6:25 Low Dimensional Models of Diffusion and Reaction in Stratified Micro Flows

Jason R. Picardo and Subramaniam Pushpavanam, Indian Institute of Technology Madras, India

Sunday, May 17

CP2

Topics in Pattern Formation I

4:30 PM-6:30 PM

Room:Ballroom II

Chair: Jose Morales Morales, INRIA Rhone, France

4:30-4:45 Generalized Behavior of the Two-phase System in (1+1) D

David A. Ekrut and Nicholas Cogan, Florida State University, USA

4:50-5:05 Discrete Synchronization of Massively Connected Systems Using Hierarchical Couplings

Camille Poignard, Université de Nice, Sophia Antipolis, France

5:10-5:25 Nonlinear Dynamics of Two-Colored Filaments

Alexey Sukhinin and Alejandro Aceves, Southern Methodist University, USA

5:30-5:45 Scaling and Robustness of Two Component Morphogen Patterning Systems

Md. Shahriar Karim, Purdue University, USA; Hans G. Othmer, University of Minnesota, USA; David Umulis, Purdue University, USA

5:50-6:05 Solitary Waves in the Excitable Discrete Burridge-Knopoff Model

Jose Eduardo Morales Morales, Guillaume James, and Arnaud Tonnelier, INRIA Rhone, France

6:10-6:25 Aspects and Applications of Generalized Synchronization

Ulrich Parlitz, Max Planck Institute for Dynamics and Self-Organization, Germany

Sunday, May 17

CP3

Topics in Networks I

4:30 PM-6:10 PM

Room:Ballroom III

Chair: Christian Bick, Rice University, USA

4:30-4:45 Analysis of Connected Vehicle Networks with Nontrivial Connectivity, a Modal Decomposition Approach

Sergei S. Avedisov and Gabor Orosz, University of Michigan, Ann Arbor, USA

4:50-5:05 Phase Response Properties of Collective Rhythms in Networks of Coupled Dynamical Systems

Hiroya Nakao and Sho Yasui, Tokyo Institute of Technology, Japan

5:10-5:25 Heterogeneities in Temporal Networks Emerging from Adaptive Social Interactions

Takaaki Aoki, Kagawa University, Japan; Luis Rocha, Karolinska Institutet, Sweden; Thilo Gross, University of Bristol, United Kingdom

5:30-5:45 Simulating the Dynamics of College Drinking

Ben G. Fitzpatrick, Jason Martinez, and Elizabeth Polidan, Tempest Technologies LLC, USA

5:50-6:05 Integrating Hydrological and Waterborne Disease Network Models

Karly Jacobsen and Michael Kelly, The Ohio State University, USA; Faisal Hossain, University of Washington, USA; Joseph H. Tien, The Ohio State University, USA

Sunday, May 17

CP4

Topics in Computational Dynamical Systems I

4:30 PM-6:30 PM

Room:Magpie A

Chair: Dinesh Kasti, Florida Atlantic University, USA

4:30-4:45 Expanded Mixed Finite Element Method for Generalized Forchheimer Flows

Thinh T. Kieu, University of North Georgia, USA; Akif Ibraguimov, Texas Tech University, USA

4:50-5:05 An Algorithmic Approach to Computing Lattice Structures of Attractors

Dinesh Kasti and William D. Kalies, Florida Atlantic University, USA; Robertus Vandervorst, Vrije Universiteit Amsterdam, The Netherlands

5:10-5:25 Prediction in Projection

Joshua Garland and Elizabeth Bradley, University of Colorado Boulder, USA

5:30-5:45 A Method for Identification of Spatially-Varying Parameters Despite Missing Data with Application to Remote Sensing

Sean Kramer, Norwich University, USA; Erik Bollt, Clarkson University, USA

5:50-6:05 Bifold Visualization of Dynamic Networks

Yazhen Jiang, Joseph Skufca, and Jie Sun, Clarkson University, USA

6:10-6:25 Sparse Sensing Based Detection of Dynamical Phenomena and Flow Transitions

Piyush Grover, Mitsubishi Electric Research Laboratories, USA; Boris Kramer, Virginia Tech, USA; Petros Boufounos and Mouhacine Benosman, Mitsubishi Electric Research Laboratories, USA

Sunday, May 17

CP5

Topics in Biological Dynamics I

4:30 PM-6:10 PM

Room:Magpie B

Chair: Suma Ghosh, Pennsylvania State University, USA

4:30-4:45 A Mathematical Model for the Sexual Selection of Extravagant and Costly Mating Displays

Sara Clifton, Daniel Abrams, and Daniel Thomas, Northwestern University, USA

4:50-5:05 A Model for Mountain Pine Beetle Outbreaks in An Age Structured Forest: Approximating Severity and Outbreak-Recovery Cycle Period

Jacob P. Duncan, James Powell, and Luis Gordillo, Utah State University, USA; Joseph Eason, University of Utah, USA

5:10-5:25 Host-Mediated Responses on the Dynamics of Host-Parasite Interaction

Suma Ghosh and Matthew Ferrari, Pennsylvania State University, USA

5:30-5:45 Mathematical Models of Seasonally Migrating Populations

John G. Donohue and Petri T. Piiroinen, National University of Ireland, Galway, Ireland

5:50-6:05 Geometric Dissection of a Model for the Dynamics of Bipolar Disorders

Ilona Kosiuk, Max Planck Institute for Mathematics in the Sciences, Germany; Ekaterina Kutafina, AGH University of Science and Technology, Poland; Peter Szmolyan, Vienna University of Technology, Austria

Sunday, May 17

CP6

Topics in Bifurcation Theory

4:30 PM-6:30 PM

Room:Wasatch A

Chair: Shibabrat Naik, Virginia Tech, USA

4:30-4:45 Structuring and Stability of Solutions of the Static Cahn-Hilliard Equation

Santiago Madruga, Universidad Politécnica de Madrid, Spain; Fathi Bribesh, Zawia University, Libya; Uwe Thiele, University of Muenster, Germany

4:50-5:05 Sensitivity of the Dynamics of the General Rosenzweig-MacArthur Model to the Mathematical Form of the Functional Response: a Bifurcation Theory Approach

Gunog Seo, Colgate University, USA; Gail Wolkowicz, McMaster University, Canada

5:10-5:25 Continuation of Bifurcations in Physical Experiments

David A. Barton, University of Bristol, United Kingdom

5:30-5:45 Escape from Potential Wells in Multi-Degree of Freedom Systems: Phase Space Geometry and Partial Control

Shibabrat Naik and Shane D. Ross, Virginia Tech, USA

5:50-6:05 Experimental Verification of Criteria for Escape from a Potential Well in a Multi-degree of Freedom System

Shane D. Ross, Virginia Tech, USA; Amir BozorgMagham, University of Maryland, College Park, USA; Lawrence Virgin, Duke University, USA

6:10-6:25 Periodic Social Niche Construction

Philip Poon, University of Wisconsin, Madison, USA; David Krakauer and Jessica Flack, Wisconsin Institute for Discovery, USA

Sunday, May 17

CP7

Topics in Mechanical Systems

4:30 PM-6:10 PM

Room:Wasatch B

Chair: Thomas Ward, Iowa State University, USA

4:30-4:45 Numerical Simulations of Nonlinear Dynamics of Beams, Plates, and Shells

Timur Alexeev, University of California, Davis, USA

4:50-5:05 Global Attractors for Quasilinear Parabolic-Hyperbolic Equations Governing Longitudinal Motions of Nonlinearly Viscoelastic Rods

Suleyman Ulusoy, Zirve University, Turkey; Stuart S Antman, University of Maryland, USA

5:10-5:25 Revision on the Equation of Nonlinear Vibration of the Cable with Large Sag

Kun Wang, University of Macau, China

5:30-5:45 Control Strategies for Electrically Driven Flapping of a Flexible Cantilever Perturbed by Low Speed Wind

Thomas Ward, Iowa State University, USA

5:50-6:05 A New Mathematical Explanation of What Triggered the Catastrophic Torsional Mode of the Tacoma Narrows Bridge

Gianni Arioli, Politecnico di Milano, Italy

Sunday, May 17

CP8

Topics in Biological Dynamics II

4:30 PM-6:30 PM

Room:Maybird

Chair: Luis Mier-y-Teran, Johns Hopkins Bloomberg School of Public Health, USA

4:30-4:45 Coexistence of Multiannual Attractors in a Disease Interaction Model: Whooping Cough Revisited

Samit Bhattacharyya, Matthew Ferrari, and Ottar Bjornstad, Pennsylvania State University, USA

4:50-5:05 Order Reduction and Efficient Implementation of Nonlinear Nonlocal Cochlear Response Models

Maurice G. Filo, University of California, Santa Barbara, USA

5:10-5:25 Periodic Outbreaks in Models of Disease Transmission with a Behavioral Response

Winfried Just, Ohio University, USA; Joan Saldana, Universitat de Girona, Spain

5:30-5:45 Competition and Invasion of Dengue Viruses in Vaccinated Populations

Luis Mier-y-Teran and Isabel Rodriguez-Barraquer, Johns Hopkins Bloomberg School of Public Health, USA; Ira B. Schwartz, Naval Research Laboratory, USA; Derek Cummings, Johns Hopkins Bloomberg School of Public Health, USA

5:50-6:05 Examining Ebola Transmission Dynamics and Forecasting Using Identifiability and Parameter Estimation

Marisa Eisenberg, University of Michigan, USA

6:10-6:25 How Radiation-Induced Dedifferentation Influences Tumor Hierarchy

Kimberly Fessel, Mathematical Biosciences Institute, USA; John Lowengrub, University of California, Irvine, USA

Sunday, May 17

CP9

Non-smooth Dynamical Systems

4:30 PM-5:50 PM

Room:Superior A

Chair: John Hogan, Bristol Centre for Applied Nonlinear Mathematics and University of Bristol, United Kingdom

4:30-4:45 On the Use of Blow Up to Study Regularizations of Singularities of Piecewise Smooth Dynamical Systems

Kristian Uldall Kristiansen, Technical University of Denmark, Denmark; John Hogan, Bristol Centre for Applied Nonlinear Mathematics and University of Bristol, United Kingdom

4:50-5:05 C^∞ Regularisation of Local Singularities of Filippov Systems

Carles Bonet and Tere M. Seara-Alonso, Universitat Politecnica de Catalunya, Spain

5:10-5:25 Filippov Unplugged --- Part 1

John Hogan, Bristol Centre for Applied Nonlinear Mathematics and University of Bristol, United Kingdom; *Martin Homer*, Mike R. Jeffrey, and Robert Szalai, University of Bristol, United Kingdom

5:30-5:45 Filippov Unplugged - Part 2

John Hogan, Bristol Centre for Applied Nonlinear Mathematics and University of Bristol, United Kingdom; Martin Homer, Mike R. Jeffrey, and Robert Szalai, University of Bristol, United Kingdom

Sunday, May 17

CP10

Topics in Geometric and Nonlinear Dynamical Systems

4:30 PM-6:30 PM

Room:Superior B

Chair: Colin J. Grudzien, University of North Carolina at Chapel Hill, USA

4:30-4:45 Tensor of Green of Coupled Thermoelastodynamics

Bakhyt Alipova, University of Kentucky, USA

4:50-5:05 Geometric Phase in the Hopf Bundle and the Sability of Non-Linear Waves

Colin J. Grudzien and Christopher Krt Jones, University of North Carolina at Chapel Hill, USA

5:10-5:25 Error Assessment of the Local Statistical Linearization Method

Leo Dostal and Edwin Kreuzer, Hamburg University of Technology, Germany

5:30-5:45 Curve Evolution in Second-Order Lagrangian Systems

Ronald Adams and William D. Kalies, Florida Atlantic University, USA; R.C.A.M van Der Vorst, Vrije Universiteit Amsterdam, The Netherlands

5:50-6:05 Periodic Eigendecomposition and Its Application in Nonlinear Dynamics

Xiong Ding and Predrag Cvitanovic, Georgia Institute of Technology, USA

6:10-6:25 Computation of Cauchy-Green Strain Tensor Using Local Regression

Shane D. Kepley and Bill Kalies, Florida Atlantic University, USA

Sunday, May 17

CP11

Topics in Feedback/Control/ Optimization I

4:30 PM-6:30 PM

Room:White Pine

Chair: Kathrin Flaßkamp, Northwestern University, USA

4:30-4:45 Computing Bisimulation Functions Using SoS Optimization and δ-Decidability over the Reals

Abhishek Murthy, Philips Research North America, USA; Md. Ariful Islam and Scott Smolka, Stony Brook University, USA; Radu Grosu, Vienna University of Technology, Austria

4:50-5:05 Chaos in Biological Systems with Memory and Its Controllability

Mark Edelman, Stern College for Women and Courant Institute of Mathematical Sciences, New York University, USA

5:10-5:25 Odd-Number Limitation for Extended Time-Delayed Feedback Control

Andreas Amann and Edward Hooton, University College Cork, Ireland

5:30-5:45 Approximate Controllability of An Impulsive Neutral Fractional Stochastic Differential Equation With Deviated Argument and Infinite Delay

Sanjukta Das and Dwijendra Pandey, Indian Institute of Technology Roorkee, India

5:50-6:05 Mathematical Study of the Effects of Travel Costs on Optimal Dispersal in a Two-Patch Model

Theodore E. Galanthay, Ithaca College, USA

6:10-6:25 Discrete-Time Structure-Preserving Optimal Ergodic Control

Kathrin Flaßkamp and Todd Murphey, Northwestern University, USA

Sunday, May 17

CP12

Topics in Atmospheric/ Climate Dynamics and Related Themes

4:30 PM-6:10 PM

Room:Primrose A

Chair: Miklos Vincze, Hungarian Academy of Sciences, Hungary

4:30-4:45 Gradual and Abrupt Regime Shifts in Drylands

Yuval Zelnik, Ehud Meron, and Golan Bel, Ben-Gurion University of the Negev, Israel

4:50-5:05 Baroclinic Instability in An Initially Stratified Rotating Fluid

Miklos P. Vincze, Hungarian Academy of Sciences, Hungary; Patrice Le Gal, CNRS & Aix-Marseille Université, Marseille, France; Uwe Harlander, Brandenburg University of Technology, Germany

5:10-5:25 Modified Lorenz Equations for Rotating Convection

Jessica Layton, Jared P. Whitehead, and Shane McQuarrie, Brigham Young University, USA

5:30-5:45 Empirical Validation of Conceptual Climate Models

Charles D. Camp, Ryan Smith, and Andrew Gallatin, California Polytechnic State University, USA

5:50-6:05 On the Geometry of Attractors in Ageostrophic Flows with Viscoelastic-Type Reynolds Stress

Maleafisha Stephen Tladi, University of Limpopo, South Africa

Sunday, May 17

CP13

Topics in Nonlinear Oscillators

4:30 PM-6:10 PM

Room:Primrose B

Chair: Punit R. Gandhi, University of California, Berkeley, USA

4:30-4:45 Localized States in Periodically Forced Systems

Punit R. Gandhi, University of California, Berkeley, USA; Cedric Beaume, Imperial College London, United Kingdom; Edgar Knobloch, University of California, Berkeley, USA

4:50-5:05 Multicluster and Traveling Chimera States in Nonlocal Phase-Coupled Oscillators

Hsien-Ching Kao, Wolfram Research Inc., USA; Jianbo Xie and Edgar Knobloch, University of California, Berkeley, USA

5:10-5:25 Chimera States on the Route from Coherent State to a Rotating Wave

Tomasz Kapitaniak, Technical University of Lodz, Poland

5:30-5:45 Onset and Characterization of Chimera States in Coupled Nonlinear Oscillators

Lakshmanan Muthusamy, Bharathidasan University, India

5:50-6:05 Emergent Rhythmic Behavior of Mixed-Mode Oscillations in Pulse-Coupled Neurons

Avinash J. Karamchandani, James Graham, and Hermann Riecke, Northwestern University, USA

Dinner Break

6:30 PM-8:00 PM

Attendees on their own

DSWeb Editorial Board Meeting

6:30 PM-8:00 PM

Room: Boardroom

Sunday, May 17

Prize Presentations - Jürgen Moser and J. D. Crawford

8:00 PM-8:15 PM

Room:Ballroom

J. D. Crawford Prize Recipient:
Florin Diacu, University of Victoria, Canada

SP1

Jürgen Moser Lecture - Dynamics and Data

8:15 PM-9:00 PM

Room:Ballroom

Chair: Timothy Sauer, George Mason University, USA

This lecture highlights interdisciplinary interactions of dynamical systems theory. Experimental data and computer simulation have inspired mathematical discoveries, while resulting theory has made successful predictions and created new scientific perspectives. Nonlinear dynamics has unified diverse fields of science and revealed deep mathematical phenomena.

Examples involving

- One dimensional maps
- Numerical bifurcation analysis
- Multiple time scales
- Bursting and MMOs in neuroscience and chemistry
- Locomotion

are described, along with emerging areas having public impact.

John Guckenheimer, Cornell University, USA

Monday, May 18

Registration

8:00 AM-6:30 PM

Room:Ballroom Foyer

MS5

Structural and Functional Network Dynamics and Inference

8:30 AM-10:30 AM

Room:Magpie B

Complex systems are ubiquitous in nature, yet there often remains a disconnect between models and real-world systems. This discrepancy can be manifest as limited knowledge about the ordinary and/or partial differential equations, the network encoding which variables interact, or both. System identification such as the inference of "structural" and "functional networks" is thus an unavoidable hurdle for the realistic modeling of many complex systems. We will study structural and functional networks arising in biological and physical systems as well as explore various network analyses such as community detection and motif extraction.

Organizer: Dane Taylor
University of North Carolina at Chapel Hill, USA

8:30-8:55 Causal Network Inference by Optimal Causation Entropy

Jie Sun and Erik Bollt, Clarkson University, USA; Dane Taylor, University of North Carolina at Chapel Hill, USA

9:00-9:25 A Complex Networks Approach to Malaria's Genetic Recombination Dynamics

Daniel B. Larremore and Caroline Buckee, Harvard School of Public Health, USA; Aaron Clauset, University of Colorado Boulder, USA

9:30-9:55 Combined Effects of Connectivity and Inhibition in a Model of Breathing Rhythmogenesis

Kameron D. Harris, University of Washington, USA; Tatiana Dashevskiy, Seattle Children's Research Institute, USA; Eric Shea-Brown and Jan-Marino Ramirez, University of Washington, USA

10:00-10:25 Not-So-Random Graphs Through Wide Motifs

Pierre-Andre Noel, University of California, Davis, USA

Monday, May 18

MS19

Patterns in Partial Differential Equations - Part II of II

8:30 AM-10:30 AM

Room:Ballroom I

For Part 1 see MS1

Patterns play an important role in the dynamics of many dissipative and dispersive PDEs, posed on large or unbounded domains. This minisymposium will feature contributions that investigate intrinsically multi-dimensional aspects of the dynamics of patterns, including their existence, stability, instability, slow evolution, and interaction. Examples include interfaces between patterned and un-patterned state, point defects or vortices, and line defects. We expect to bring together researchers with a variety of backgrounds, employing a variety of techniques, such as diffusive and dispersive stability estimates, energy methods from the calculus of variations, or spatial dynamics and bifurcation methods.

Organizer: Keith Promislow
Michigan State University, USA

Organizer: Noa Kraitzman
Michigan State University, USA

8:30-8:55 Existence of Pearled Patterns in the Planar Functionalized Cahn-Hilliard Equation

Qiliang Wu, Michigan State University, USA

9:00-9:25 Stability in Spatially Localized Patterns

Elizabeth J. Makrides and Bjorn Sandstede, Brown University, USA

9:30-9:55 Reformulating Spectral Problems with the Krein Matrix

Todd Kapitula, Calvin College, USA

10:00-10:25 A Geometric Approach to Stationary Defect Solutions

Arjen Doelman, Leiden University, Netherlands; Peter van Heijster, Queensland University of Technology, Australia; Feng Xie, Leiden University, Netherlands

Monday, May 18

MS20

Structure-dynamics Relation in Networks of Coupled Dynamical Systems

8:30 AM-10:30 AM

Room:Ballroom II

A fundamental question in studying coupled dynamical systems concerns the dynamics-structure relation -- how do the characteristics of the interactions between dynamical units determine the dynamical behavior of the system? After more than a decade of research on the structure of real networks, the problem of understanding this relation has become a major topic of interest in the dynamical systems community. This minisymposium will address this timely topic, focusing on network-dynamical phenomena, such as synchronization patterns, sensitive dependence of dynamical stability, and homeostasis, and using a range of mathematical tools from graph theory, linear algebra, group theory, and optimization.

Organizer: Francesco Sorrentino
University of New Mexico, USA

Organizer: Takashi Nishikawa
Northwestern University, USA

8:30-8:55 Optimized Networks Have Cusp-like Dependence on Structural Parameters

Takashi Nishikawa and Adilson E. Motter, Northwestern University, USA

9:00-9:25 Symmetries, Cluster Synchronization, and Isolated Desynchronization in Complex Networks

Louis M. Pecora, Naval Research Laboratory, USA; Francesco Sorrentino, University of New Mexico, USA; Aaron M. Hagerstrom, University of Maryland, USA; Rajarshi Roy and Thomas E. Murphy, University of Maryland, College Park, USA

continued in next column

9:30-9:55 Symmetry Breaking and Synchronization Patterns in Networks of Coupled Oscillators

Francesco Sorrentino, University of New Mexico, USA; Aaron M. Hagerstrom, University of Maryland, USA; Louis M. Pecora, Naval Research Laboratory, USA; Thomas E. Murphy and Rajarshi Roy, University of Maryland, College Park, USA

10:00-10:25 Homeostasis As a Network Invariant

Martin Golubitsky, The Ohio State University, USA; Ian Stewart, University of Warwick, United Kingdom

Monday, May 18

MS21

Ocean-in-the-loop: Towards Real-Time Monitoring in Geophysical Flows - Part II of II

8:30 AM-10:30 AM

Room:Ballroom III

For Part 1 see MS3

Improved modeling and prediction of fluid dynamics is needed to better understand ocean and atmospheric transport along with associated applications including contaminant dispersion, environmental modeling, and underwater acoustic propagation. Major recent advances in closed-loop adaptive sampling, Lagrangian data assimilation, uncertainty quantification, and phase space transport are providing improved understanding of transport phenomena. The purpose of this minisymposium is to expose the audience to recent progress and developments, as well as to bring together researchers developing new mathematical methods and applications for use in understanding flow transport.

Organizer: Eric Forgoston
Montclair State University, USA

Organizer: Ani Hsieh
Drexel University, USA

8:30-8:55 Optimal Control in Lagrangian Data Assimilation

Damon Mcdougall, University of Texas at Austin, USA; Richard O. Moore, New Jersey Institute of Technology, USA

9:00-9:25 A Hybrid Particle-Ensemble Kalman Filter for High Dimensional Lagrangian Data Assimilation

Elaine Spiller, Marquette University, USA; Laura Slivinski, Woods Hole Oceanographic Institute, USA; Amit Apte, TIFR Centre, Bangalore, India

9:30-9:55 A Multi Agent Control Strategy for Sampling Uncertain Spatio-Temporally Varying Flow Fields

Axel Hackbarth and Edwin Kreuzer, Hamburg University of Technology, Germany

10:00-10:25 Bayesian Nonlinear Assimilation for Eulerian Fields and Lagrangian Trajectories

Pierre Lermusiaux, Massachusetts Institute of Technology, USA

Monday, May 18

MS22

Geometric Mechanics and Applications

8:30 AM-10:30 AM

Room:Magpie A

This minisymposium will focus on the application of geometric methods to dynamical systems originating in mechanicals. The geometric viewpoint provides a unified and systematic framework to address a broad range of problems, including control, numerical integration, and qualitative dynamics, for both finite- and infinite-dimensional systems. In particular, topics represented include the geometric optimal control of mechanical systems, stability analysis, variational principles, the use of momentum maps, and variational integrators. This minisymposium provides a unique opportunity for mathematicians, applied mathematicians, and engineers to come together and explore their common interest in the geometric approach to mechanics.

Organizer: Vakhtang Putkaradze
University of Alberta, Canada

8:30-8:55 The Geometry of the Toda Lattice Map

Anthony M. Bloch, University of Michigan, USA

9:00-9:25 Dynamics and Optimal Control of Flexible Solar Updraft Towers

Vakhtang Putkaradze, University of Alberta, Canada

9:30-9:55 Geodesic Finite Elements on Symmetric Spaces and Their Applications to Multisymplectic Variational Integrators

Phillip Grohs, ETH Zürich, Switzerland; *Melvin Leok*, Joe Salamon, and John Moody, University of California, San Diego, USA

10:00-10:25 Hamel's Formalism for Infinite-Dimensional Mechanical Systems

Dmitry Zenkov, North Carolina State University, USA

Monday, May 18

MS24

Nontwist Hamiltonian systems: Theory and Applications

8:30 AM-10:30 AM

Room:Wasatch A

In recent years, more and more physical systems have been found that can be modeled by Hamiltonians that locally violate a non-degeneracy condition leading to the appearance of so-called shearless invariant tori which act as particularly robust transport barriers in phase space. This minisymposium brings together researchers from physics and applied mathematics to present the latest developments and applications in the subject of nontwist Hamiltonian systems. Recent numerical studies of breakup and emergence of shearless tori and applications in plasma physics will be discussed.

Organizer: Alexander Wurm
Western New England University, USA

Organizer: P. J. Morrison
University of Texas at Austin, USA

8:30-8:55 Breakup of Shearless Tori and Reconnection in the Piecewise-Linear Standard Nontwist Map

Alexander Wurm, Western New England University, USA

9:00-9:25 Nontwist Worm Map

Caroline G. L. Martins and P. J. Morrison, University of Texas at Austin, USA; J. D. Szezech, Universidade Estadual de Ponta Grossa, Brazil; I. L. Caldas, Universidade de Sao Paulo, Brazil

9:30-9:55 Breakup of Tori in Multiharmonic Nontwist Standard Maps

Adam M. Fox, Western New England University, USA; James D. Meiss, University of Colorado Boulder, USA

10:00-10:25 Influence of Finite Larmor Radius on Critical Parameters for Invariant Curves Break Up in Area Preserving Maps Models of ExB Chaotic Transport

Julio Fonseca, University of Sao Paulo, Brazil; Diego Del-Castillo-Negrete, Oak Ridge National Laboratory, USA; *Iberê L. Caldas*, Universidade de Sao Paulo, Brazil

Monday, May 18

MS25

Rhythmic Dynamics of Minimal Neuronal Networks

8:30 AM-10:30 AM

Room:Wasatch B

Recent trends in mathematical and computational neuroscience have led to studies of increasingly larger networks. However, there are still many fundamental questions related to the dynamics of rhythmic networks that are best suited to be addressed in the context of small and minimal models. Speakers in this minisymposium will focus on questions that involve multiple time scales, the detection of synchrony and the coordination of neural activity in the context of central pattern generators and more general brain networks. A primary goal is to use mathematical modeling to identify biological mechanisms that underlie the existence and control of rhythms. Because of the minimal nature of the models considered, mathematical findings can fairly clearly be correlated to biological mechanisms.

Organizer: Amitabha Bose
New Jersey Institute of Technology, USA

8:30-8:55 The Role of Voltage-Dependent Electrical Coupling in the Control of Oscillations

Christina Mouser, William Patterson University, USA; Farzan Nadim and *Amitabha Bose*, New Jersey Institute of Technology, USA

9:00-9:25 Understanding and Distinguishing Multiple Time Scale Oscillations

Yangyang Wang and Jonathan E. Rubin, University of Pittsburgh, USA

9:30-9:55 The Essential Role of Phase Delayed Inhibition in Decoding Synchronized Oscillations

Badal Joshi, California State University, San Marcos, USA; Mainak Patel, College of William & Mary, USA

10:00-10:25 Neural Mechanisms of Limb Coordination in Crustacean Swimming

Tim Lewis, University of California, Davis, USA

Monday, May 18

MS26

Experiments on Transport in Multi-scale Fluid Systems

8:30 AM-10:30 AM

Room:Maybird

Transport in fluid systems is mainly investigated by theoretical and numerical methods. Experimental studies lag behind yet are crucial both for validation purposes and for investigation of phenomena that are beyond theory and simulations. The aims of these investigations range from validation of fundamental transport phenomena to bridging the gap from dynamical-systems concepts to (industrial) applications. This mini-symposium highlights the essential role of laboratory experiments in comprehensive transport studies of multi-scale systems, which are almost the only class of flows that allows analytical description and presents a natural meeting point for experiments, simulations and theory.

Organizer: Michel Speetjens
Eindhoven University of Technology, Netherlands

Organizer: Dmitri Vainchtein
Temple University, USA

8:30-8:55 Chaotic Mixing and Transport Barriers

Thomas H. Solomon, Bucknell University, USA

9:00-9:25 How Small a Thought: Design of Mixing and Separation Processes with Dynamical Systems

Guy Metcalfe, CSIRO, Australia

9:30-9:55 3D Chaotic Advection in Langmuir Cells

Larry Pratt and Irina Rypina, Woods Hole Oceanographic Institute, USA

10:00-10:25 Experimental Investigation of Fundamental Lagrangian Transport Phenomena

Michel Speetjens, Eindhoven University of Technology, Netherlands

Monday, May 18

MS27

Analysis of Network Dynamical Systems

8:30 AM-10:30 AM

Room:Superior A

Many real world dynamical systems admit a nontrivial network structure. This special structure often makes these systems behave in an unexpected way. Networks can for example synchronise, support anomalous bifurcations, admit robust heteroclinic cycles, display chimera states, etc. In other words: dynamical behaviour that is classically considered “degenerate” and hence “irrelevant”, turns out to be generic in the context of networks, and can thus be important for applications. In this minisymposium, we present a number of recent insights in the analysis of networks that may be used to understand and predict their dynamical behaviour.

Organizer: Bob Rink
VU University, Amsterdam, Netherlands

Organizer: Eddie Nijholt
VU University, Amsterdam, Netherlands

8:30-8:55 Classifying Bifurcations in Coupled Cell Networks

Eddie Nijholt, Bob Rink, and Jan Sanders, VU University, Amsterdam, Netherlands

9:00-9:25 Pulse Bifurcations in Stochastic Neural Fields

Zachary Kilpatrick, University of Houston, USA; Gregory Faye, École des Hautes Etudes en Sciences Sociales, France

9:30-9:55 Dynamics of Asynchronous Networks

Christian Bick, Rice University, USA; Michael Field, Imperial College London, United Kingdom; Anushaya Mohapatra, Oregon State University, USA

10:00-10:25 Dynamics of Heterogeneous Networks: Reductions and Coherent Behaviour

Tiago Pereira, Universidade de Sao Paulo, Brazil; Matteo Tanzi and Sebastian van Strien, Imperial College London, United Kingdom

Monday, May 18

MS28

Simple Systems with Complex Dynamics

8:30 AM-10:30 AM

Room:Superior B

Lab experiments can often be very costly as they may require expensive equipment. However, research in dynamical systems can still be done using simple table top experiments at low cost. Many of these systems may seem extremely simple and mundane in set up, yet they can be very rich in their dynamics. In this mini-symposium, we present four table top experiments involving mechanical, chemical and electrical oscillators and show how they can produce complex phenomena such as synchronization, period doubling bifurcation and chaos. We also demonstrate how these systems can be studied mathematically and numerically.

Organizer: Andrea J. Welsh
Georgia Institute of Technology, USA

8:30-8:55 Period Doubling in the Saline Oscillator

Diandian Diana Chen and Flavio Fenton, Georgia Institute of Technology, USA

9:00-9:25 Oscillatory Dynamics of the Candelator

Greg A. Byrne, Mary Elizabeth Lee, and Flavio Fenton, Georgia Institute of Technology, USA

9:30-9:55 Synchronization Patterns in Simple Networks of Optoelectronic Oscillators

Briana Mork, Gustavus Adolphus College, USA; Kate Coppess, University of Michigan, Ann Arbor, USA; Caitlin R. S. Williams, Washington and Lee University, USA; Aaron M. Hagerstrom and Joseph Hart, University of Maryland, USA; Thomas E. Murphy, University of Maryland, College Park, USA; *Rajarshi Roy*, University of Maryland, USA

10:00-10:25 Noise-Induced Transitions in Bistable Tunnel Diode Circuits

Stephen Teitsworth, Yuriy Bomze, Steven Jones, and Ryan McGeehan, Duke University, USA

Monday, May 18

MS29

Multiscale Models to Understand the Social and Physical World - Part II of II

8:30 AM-10:30 AM

Room:White Pine

For Part 1 see MS11

The scientific community has developed a rich and diverse library of mathematical models capable of capturing complex processes and interactions over a broad range of scales in space and time. In this session, we feature a variety of researchers exploring the application of mathematical models to the social and physical world. The topics of this session cover several scales, from interacting particles to population models to PDEs, and include both stochastic and deterministic models. Talks will address applications such as earthquakes, swimming microorganisms, and human crowd dynamics.

Organizer: Alethea Barbaro
Case Western Reserve University, USA

Organizer: Brittany Erickson
Portland State University, USA

8:30-8:55 Population Models Applied to Model the Pregnancy to Labor Transition

Douglas Brubaker, Alethea Barbaro, Mark Chance, and Sam Mesiano, Case Western Reserve University, USA

9:00-9:25 Stochastic Fluctuations in Suspensions of Swimming Microorganisms

Peter R. Kramer, Yuzhou Qian, and Patrick Underhill, Rensselaer Polytechnic Institute, USA

9:30-9:55 A Model for Riot Dynamics: Shocks, Diffusion and Thresholds

Nancy Rodriguez-Bunn, University of North Carolina at Chapel Hill, USA; Henri Berestycki and Jean-Pierre Nadal, CNRS, France

10:00-10:25 Crowd Modeling: How Can People Respond to Fear

Jesus Rosado Linares, Universidad de Buenos Aires, Argentina; Alethea Barbaro, Case Western Reserve University, USA; Andrea L. Bertozzi, University of California, Los Angeles, USA

Monday, May 18

MS30

Network Synchronization in Mechanical Systems and Beyond - Part II of II

8:30 AM-10:30 AM

Room:Primrose A

For Part 1 see MS12

This minisymposium focuses on the role of synchronization, coordination, and dynamical consensus in mechanical systems and beyond. Examples range from bridges and mechanical pendula to self-organizing networks of moving agents, with application in robotics and animal behavior. This minisymposium aims at various theoretical and experimental aspects of synchrony-induced phenomena and their control and brings together applied mathematicians and mechanical engineers.

Organizer: Igor Belykh
Georgia State University, USA

Organizer: Maurizio Porfiri
Polytechnic Institute of New York University, USA

8:30-8:55 Synchronization in Dynamical Networks of Noisy Nonlinear Oscillators, Or Collective Behavior of Zebrafish

Violet Mwaffo and Ross Anderson, New York University Polytechnic, USA; *Maurizio Porfiri*, Polytechnic Institute of New York University, USA

9:00-9:25 Synchronization of a Nonlinear Beam Coupled with Deformable Substrates

Davide Spinello, University of Ottawa, Canada

9:30-9:55 A Self-Organising Distributed Strategy for Optimal Synchronisation of Networked Mechanical Systems

Louis Kempton, Guido Hermann, and Mario Di Bernardo, University of Bristol, United Kingdom

10:00-10:25 Synchronization Control of Electrochemical Oscillator Assemblies by External Inputs

Anatoly Zlotnik, Los Alamos National Laboratory, USA; Istvan Z. Kiss and Raphael Nagao, Saint Louis University, USA; Jr-Shin Li, Washington University, St. Louis, USA

Monday, May 18

MS31

Extreme Events: Modeling, Analysis, Prediction, and Control

8:30 AM-10:30 AM

Room:Primrose B

Extreme events are considered to be rare events characterized by a large impact on a particular system which is measured in terms of some observable or order parameter. The aim of this minisymposium is to discuss the mechanisms of generation of extreme events as well as their prediction and control in different system classes which are relevant to different applications in nature. The system classes covered by this minisymposium are excitable population dynamical systems, coupled systems, stochastic multistable systems as well as small-world networks of excitable units of FitzHugh Nagumo type.

Organizer: Ulrike Feudel
University of Oldenburg, Germany

Organizer: Klaus Lehnertz
University of Bonn, Germany

8:30-8:55 Extreme Events in Nature: Harmful Algal Blooms

Ulrike Feudel, University of Oldenburg, Germany; Subhendu Chakraborty, DTU Aqua, Denmark; Cornelius Steinbrink, Rajat Karnatak, and Helmut Hillebrand, University of Oldenburg, Germany

9:00-9:25 Extreme Events on Small-World Networks of Excitable Units

Gerrit Ansmann and Klaus Lehnertz, University of Bonn, Germany; Ulrike Feudel, University of Oldenburg, Germany

9:30-9:55 Extreme Events in Stochastic Multistable Systems

Alexander N. Pisarchik, Technical University of Madrid, Spain; Ricardo Sevilla-Escoboza, Guillermo Huerta-Cuellar, and Rider Jaimes-Reátegui, Universidad de Guadalajara, Mexico

10:00-10:25 Forecasting and Controlling Dragon-King Events in Coupled Dynamical Systems

Daniel J. Gauthier, Duke University, USA; Hugo Cavalcante and Marcos Oria, Universidade Federal da Paraiba, Brazil; Didier Sornette, ETH Zürich, Switzerland; Ed Ott, University of Maryland, USA

Coffee Break

10:30 AM-11:00 AM

Room:Golden Cliff

Monday, May 18

IP2

Mathematics of Crime

11:00 AM-11:45 AM

Room:Ballroom

Chair: Michelle Girvan, University of Maryland, USA

There is an extensive applied mathematics literature developed for problems in the biological and physical sciences. Our understanding of social science problems from a mathematical standpoint is less developed, but also presents some very interesting problems, especially for young researchers. This lecture uses crime as a case study for using applied mathematical techniques in a social science application and covers a variety of mathematical methods that are applicable to such problems. We will review recent work on agent based models, methods in linear and nonlinear partial differential equations, variational methods for inverse problems and statistical point process models. From an application standpoint we will look at problems in residential burglaries and gang crimes. Examples will consider both “bottom up' and ‘top down' approaches to understanding the mathematics of crime, and how the two approaches could converge to a unifying theory.

Andrea L. Bertozzi
University of California, Los Angeles, USA

Lunch Break

11:45 AM-1:15 PM

Attendees on their own

Monday, May 18

MS32

Energy Transfer and Harvesting in Nonlinear Systems - Part I of II

1:15 PM-3:15 PM

Room:Ballroom I

For Part 2 see MS45

The minisymposium will focus on recent developments and challenges related to energy transfer and harvesting in nonlinear systems. Special attention will be paid to rapidly developing research field of nonsmooth systems. Topics will include, but will not be limited to:

- New results in the classical problem of divergent vs convergent heat conduction in models of atomic lattices;
- Description of wave initiation, propagation and mitigation in granular systems;
- Nonlinear targeted energy transfer in systems with strongly nonlinear attachments
- Applications of strong and non-smooth nonlinearities for efficient energy harvesting.

Organizer: Oleg Gendelman
Technion Israel Institute of Technology, Israel

Organizer: Alexander Vakakis
University of Illinois, USA

1:15-1:40 Convergent Heat Conduction in One-Dimensional Lattices with Dissociation

Oleg Gendelman, Technion Israel Institute of Technology, Israel; Alexander Savin, Institute of Chemical Physics, Moscow, Russia

1:45-2:10 Stochastic Closure Schemes for Bi-stable Energy Harvesters Excited by Colored Noise

Themistoklis Sapsis and Han Kyul Joo, Massachusetts Institute of Technology, USA

2:15-2:40 Bistable Nonlinear Energy Sink Coupled System for Energy Absorption and Harvesting

Francesco Romeo, University of Rome La Sapienza, Italy; Giuseppe Habib, University of Liege, Belgium

2:45-3:10 Acceleration of Charged Particles in the Presence of Fluctuations

Africa Ruiz Mora and *Dmitri Vainchtein*, Temple University, USA

Monday, May 18

MS33

Rare Events in Stochastic Systems

1:15 PM-3:15 PM

Room:Ballroom II

A pivotal goal in the analysis of dynamical systems is the prediction and qualitative description of long-term behavior. In deterministic systems, this is often accomplished via bifurcation analysis and the identification of invariant motions, usually considering the behavior of orbits. Most practical systems however are noisy, and even in the presence of small noise a stochastic system will exhibit events that cannot be described by deterministic dynamics alone. The rarity of such events necessitates specialized tools and approaches to study them. This minisymposium will focus on recent advancements in the methods to investigate rare events as well as intriguing applications of these methods.

Organizer: Christoffer R. Heckman
University of Colorado Boulder, USA

Organizer: Ira B. Schwartz
Naval Research Laboratory, USA

1:15-1:40 Rare Events in Stochastic Dynamical Systems with Delay: From Random Switching to Extinctions

Ira B. Schwartz, Naval Research Laboratory, USA; Thomas W. Carr, Southern Methodist University, USA; Lora Billings, Montclair State University, USA; Mark Dykman, Michigan State University, USA

1:45-2:10 Rare Event Extinction on Stochastic Networks

Leah Shaw, College of William & Mary, USA; Brandon S. Lindley and Ira B. Schwartz, Naval Research Laboratory, USA

2:15-2:40 Influence of Periodic Modulation in Extreme Optical Pulses

Cristina Masoller, Universitat Politecnica de Catalunya, Spain

2:45-3:10 Models of Large Deviations and Rare Events for Optical Pulses

William Kath, Northwestern University, USA

Monday, May 18

MS34

Mathematical Models of Cancer Development and Treatment

1:15 PM-3:15 PM

Room:Ballroom III

Cancer develops in stages from incipience to metastasis, often followed by the emergence of drug resistance and evasion of the immune response. Understanding cancer progression and interaction with treatments will lead to insights into cancer therapy by aiding the design of innovative strategies that include and combine chemotherapy, virotherapy, immunotherapy, and other approaches. Current mathematical models seek to understand cancer deterministically and stochastically from the level of populations to individual cells. This minisymposium will bring together speakers who are applying a variety of mathematical and computational approaches to consider various stages of cancer development and treatment.

Organizer: Joanna Wares
University of Richmond, USA

Organizer: Peter S. Kim
University of Sydney, Australia

1:15-1:40 How Much and How Often? Mathematical Models of Cancer Vaccine Delivery

Ami Radunskaya, Pomona College, USA

1:45-2:10 A Mathematical Model of Cancer Stem Cell Lineage Population Dynamics with Mutation Accumulation and Telomere Length Hierarchies

Georgi Kapitanov, University of Iowa, USA

2:15-2:40 A Cell Population Model Structured by Cell Age Incorporating Cell-cell Adhesion

Glenn Webb, Vanderbilt University, USA

2:45-3:10 Mathematical Models of the Treatment of Chronic Lymphocytic Leukemia with Ibrutinib and the Development of Drug Resistance

Dominik Wodarz, University of California, Irvine, USA

Monday, May 18

MS35

Dynamics of Inertial Particles in Flows

1:15 PM-3:15 PM

Room:Magpie A

The dynamics of particles in fluid flows is of fundamental importance in a wide range of scientific problems. Heavy particles respond in intricate ways to fluid-velocity fluctuations. Recently there has been substantial progress in understanding the dynamics of such particles by analysing simplified mathematical models. Most models neglect the effect of fluid inertia although it can have a substantial effect in certain cases. The goal of this minisymposium is to discuss recent developments in understanding the role of fluid inertia upon the motion of particles suspended in steady and in turbulent flows.

Organizer: Bernhard Mehlig
University of Gothenburg, Sweden

1:15-1:40 The Effect of Particle and Fluid Inertia on the Dynamics of Particles in Flows

Bernhard Mehlig, University of Gothenburg, Sweden

1:45-2:10 Effect of Fluid and Particle Inertia on the Dynamics and Scaling of Ellipsoidal Particles in Shear Flow

Tomas Rosen, KTH Royal Institute of Technology, Sweden; Yusuke Kotsubo, Tokyo University, Japan; Cyrus Aidun, Georgia Institute of Technology, USA; *Fredrik Lundell*, KTH Stockholm, Sweden

2:15-2:40 Inertia Effects in the Dynamics of Spherical and Non-Spherical Objects at Low Reynolds Number

Fabien Candelier, Aix-Marseille Université, France

2:45-3:10 Influence of the History Force on Inertial Particle Advection: Gravitational Effects and Horizontal Diffusion

Ksenia Guseva and Ulrike Feudel, University of Oldenburg, Germany; Tamas Tel, Eötvös Loránd University, Hungary

Monday, May 18

MS36

Theory and Applications of Nonsmooth Dynamics in Physical Systems - Part I of II

1:15 PM-3:15 PM

Room:Magpie B

For Part 2 see MS49

This minisymposium will provide a mix of talks featuring theoretical developments in nonsmooth systems as well as talks featuring applications with nonsmooth dynamics. In either case, physical applications provide the motivation for mathematical exploration. Additionally, the minisymposium will blend talks appropriate for a broad audiences and talks geared at experts. To that point, the minisymposium will begin with the very general “How nonsmooth are the Earth sciences?” which will set the stage for the rest of the speakers. Other talks will discuss issues such as generalized bifurcations, canard phenomena, synchronization, and the new area of resilience.

Organizer: Andrew Roberts
Cornell University, USA

Organizer: Esther Widiasih
University of Hawaii, West Oahu, USA

1:15-1:40 How Nonsmooth Are the Earth Sciences?

Chris Budd and Tim J. Dodwell, University of Bath, United Kingdom

1:45-2:10 The Search for Glacial Cycles: A Quasiperiodically Forced Nonsmooth System in a Conceptual Climate Model

Esther Widiasih, University of Hawaii, West Oahu, USA; James Walsh, Oberlin College, USA; Richard McGehee and Jonathan Hahn, University of Minnesota, USA

2:15-2:40 Analysis of an Arctic Sea Ice Model in a Nonsmooth Limit

Kaitlin Hill and Mary Silber, Northwestern University, USA

2:45-3:10 Mathematical Quantifications of Resilience

Alanna Hoyer-Leitzel, Bowdoin College, USA

Monday, May 18

MS37

Guided Approaches to Ocean Data Assimilation Incorporating Uncertainty and Observability

1:15 PM-3:15 PM

Room:Wasatch A

Ocean dynamics strongly drive transport and ecological balances at all spatiotemporal scales, influencing seasonal and operational forecasts for commerce and defense. Prediction of ocean dynamics is challenging due to sparsity and inhomogeneity of observations, as well as nonlinearity of dynamics and model errors contributing to uncertainty. These challenges may be met through data assimilation techniques that properly incorporate uncertainty, along with the use of distributed sampling platforms for in situ sampling. This session focuses on guided data assimilation for incorporating uncertainty into observing system design. To improve overall forecast skill, we address questions related to observability, identification of coherent flow structures, and desirable sampling trajectories.

Organizer: Derek A. Paley
University of Maryland, USA

1:15-1:40 A Quantitative Measure of Observability for Data Assimilations

Wei Kang, Naval Postgraduate School, USA; Sarah King and Liang Xu, Naval Research Laboratory, USA

1:45-2:10 Probabilistic Approach to Deployment Strategy in Lagrangian Data Assimilation

Kayo Ide, University of Maryland, College Park, USA

2:15-2:40 Multivehicle Motion Planning in the Presence of Ocean Eddies

Frank D. Lagor and Derek A. Paley, University of Maryland, USA

2:45-3:10 Bayesian Nonlinear Smoothing and Mutual Information for Adaptive Sampling

Tapovan Lolla and Pierre Lermusiaux, Massachusetts Institute of Technology, USA

Monday, May 18

MS38

Spatial Organization of Biochemical Dynamics Within and Between Cells

1:15 PM-3:15 PM

Room:Wasatch B

Recent advances in imaging of biochemical processes has revealed spatial organization of the underlying processes, which were previously assumed homogenous or well-mixed. We explore modeling methods to describe the spatial organization of these processes within and between cells. Approaches include PDE and ODE based models, matched asymptotic expansions, dominant balance analysis, and agent based modeling. The symposium includes a range of applications: improved efficiency of metabolic reactions through cellular spatial organization, quorum sensing in biofilms, cell-fate decisions due to signaling gradients, and the effect of the micro environment on drug resistance in cancer cells.

Organizer: Niall M. Mangan
Massachusetts Institute of Technology, USA

1:15-1:40 Organization of Metabolic Reactions for Improved Efficiency: Carbon Fixation and Bioengineering Applications

Niall M. Mangan, Massachusetts Institute of Technology, USA

1:45-2:10 A 3D Model of Cell Signal Transduction

David Iron, Dalhousie University, Canada

2:15-2:40 Synthetic Genetic Circuits for Spatial Patterning

Paul Steiner, University of California, San Diego, USA

2:45-3:10 An Spatial Model of Anti-Cancer Drug Resistance: the Role of the Micro-Environment

Kerri-Ann Norton, Johns Hopkins University, USA; Kasia Rejniak, H. Lee Moffitt Cancer Center & Research Institute, USA; Jana Gevertz, The College of New Jersey, USA; Judith Pérez-Velázquez, Helmholtz Zentrum München, Germany; Zahra Aminzare, Rutgers University, USA; Alexandria Volkening, Brown University, USA

Monday, May 18

MS39

Reduced Dynamical Models and Their Applications - Part I of II

1:15 PM-3:15 PM

Room:Maybird

For Part 2 see MS52

The purpose is to present a cross-section of leading-edge research on the development, analysis, numerical solution, visualization and applications of reduced dynamical systems models. These models may arise via simplification of form of infinite-dimensional systems, reduction in cardinality of the dimension, possibly by restriction to invariant submanifolds, and ad hoc techniques based upon focusing on certain combinations of variables. Among the reductions to be discussed are simplified infinite-dimensional models for granular flows, reduced dimensional models via extensions of the zero derivative principle, discrete dynamical systems reductions for logical circuits and ecological models, and discrete integrable reductions of continuum models.

Organizer: Denis Blackmore
New Jersey Institute of Technology, USA

Organizer: Anthony Rosato
New Jersey Institute of Technology, USA

1:15-1:40 Reduced Models for Granular and Ecological Dynamics

Denis Blackmore, Anthony Rosato, and Hao Wu, New Jersey Institute of Technology, USA

1:45-2:10 On the Calogero Type Integrable Discretization of Nonlinear Dynamical Systems

Anatolij Prykarpatski, AGH University of Science and Technology, Poland

2:15-2:40 A Scheme for Modeling and Analyzing the Dynamics of Logical Circuits

Aminur Rahman, New Jersey Institute of Technology, USA

2:45-3:10 Collective Coordinates as Model Reduction for Nonlinear Wave Interactions

Ivan C. Christov, Los Alamos National Laboratory, USA

Monday, May 18

MS40

The Behavior of Autonomous Agents in Diverse Applications

1:15 PM-3:15 PM

Room:Superior A

Many different applications, such as the swarming of insects, the interaction of cells, and the flow of traffic, when studied mathematically, naturally take the form of agent-based models. The diversity of perspectives on the behavior of autonomous agents across these fields provides an opportunity for a cross-fertilization of ideas and techniques. The goal of this minisymposium is to capitalize on the differences between these applications, in the context of agent-based models and their analyses, to ignite more ideas and better answer the questions that arise in many fields.

Organizer: Paul A. Carter
Brown University, USA

Organizer: Alexandria Volkening
Brown University, USA

1:15-1:40 Modeling Stripe Formation in Zebrafish

Alexandria Volkening and Bjorn Sandstede, Brown University, USA

1:45-2:10 Predator-Swarm Interactions

Theodore Kolokolnikov, Dalhousie University, Canada

2:15-2:40 Non-Standard Travelling Waves in Traffic and Pedestrian Flow Models

Paul Carter, Brown University, USA; Peter Leth Christiansen, Technical University of Denmark, Denmark; Yuri Gaididei, Bogolyubov Institute for Theoretical Physics, Ukraine; Carlos Gorria, University of the Basque Country, Spain; Christian Marschler, Technical University of Denmark, Denmark; Bjorn Sandstede, Brown University, USA; Mads Peter Soerensen and *Jens Starke,* Technical University of Denmark, Denmark

2:45-3:10 Topological Data Analysis of Biological Aggregation Models

Chad M. Topaz, Lori Ziegelmeier, and Tom Halverson, Macalester College, USA

Monday, May 18

MS41

Renewable Energy and Power Grids: Their Mathematical Characterizations - Part I of II

1:15 PM-3:15 PM

Room:Superior B

For Part 2 see MS54

It is our social demand to introduce more renewable energy resources into power grids. However, because renewable energy outputs fluctuate according to weather conditions, we need to control and/or optimize power grids so that we can keep the voltage and frequency as constant and stable. Here we put together some recent advances to achieve this need mathematically. This need for more renewables makes us to combine several fields of mathematics together such as dynamical systems theory, control theory and complex network theory. This need also brings us into new research directions, which will turn our mathematical tools more practical.

Organizer: Yoshito Hirata
University of Tokyo, Japan

Organizer: Jun-ichi Imura
Tokyo Institute of Technology, Japan

Organizer: Juergen Kurths
Potsdam Institute for Climate Impact Research and Humboldt University Berlin, Germany

1:15-1:40 Time Series Prediction for Renewable Energy Resources

Yoshito Hirata, University of Tokyo, Japan; Kazuyuki Aihara, JST/University of Tokyo, Japan; Hideyuki Suzuki, University of Tokyo, Japan

1:45-2:10 Analysis of Systems in Buildings Using Koopman Operator Methods

Michael Georgescu, University of California, Santa Barbara, USA

continued on next page

2:15-2:40 Hierarchical Subsystem Clustering for Distributed Control of Networked Systems

Tomonori Sadamoto, Takayuki Ishizaki, and *Jun-ichi Imura*, Tokyo Institute of Technology, Japan

2:45-3:10 Stability of Power Grid: Dynamical Systems Perspective

Andrej Gajduk, Macedonian Academy of Sciences and Arts, Macedonia; Mirko Todorovski, Saints Cyril and Methodius University of Skopje, Macedonia; *Lasko Basnarkov*, Macedonian Academy of Sciences and Arts, Macedonia; Ljupco Kocarev, University of California, San Diego, USA

Monday, May 18

MS42

Extensions and Applications of Dynamic Mode Decomposition - Part I of II

1:15 PM-3:15 PM

Room:White Pine

For Part 2 see MS55

Dynamic mode decomposition (DMD) is a powerful method that identifies spatial-temporal coherent structures in high-dimensional datasets. Introduced less than a decade ago, it has quickly gained a wide following due to its ease of implementation and broad applicability. In this minisymposium, we present exciting new extensions and applications of DMD. These include theoretical advances in rigorously defining DMD and its connections to Koopman operator theory, as well as applications in fluid mechanics, neuroscience, and epidemiology. We also introduce algorithmic enhancements that account for the effects of control inputs, correct for noise, and enable ever-larger computations, for instance using compressive sensing.

Organizer: Jonathan H. Tu

University of California, Berkeley, USA

Organizer: Steven Brunton

University of Washington, USA

1:15-1:40 A Rigorous Definition and Theory of Dynamic Mode Decomposition

Jonathan H. Tu, University of California, Berkeley, USA; Clarence Rowley, Princeton University, USA

1:45-2:10 On the Relationship Between Koopman Mode Decomposition and Dynamic Mode Decomposition

Hassan Arbabi and Igor Mezic, University of California, Santa Barbara, USA

2:15-2:40 Dynamic Mode Decomposition with Control with a Special Focus on Epidemiological Applications

Joshua L. Proctor, Intellectual Ventures, USA

2:45-3:10 Extracting Spatial-Temporal Coherent Patterns in Large-Scale Neural Recordings Using Dynamic Mode Decomposition

Bing W. Brunton, University of Washington, USA

Monday, May 18

MS43

Applications of Exactly Solvable Chaos

1:15 PM-3:15 PM

Room:Primrose A

Recent work on certain hybrid dynamical systems, containing linear continuous-time differential equations coupled to a discrete-time switching condition, revealed a new class of chaos that exhibits a quasi-linear nature. These systems generate chaotic waveforms as typical solutions that have an exact analytic description as a linear convolution of a fixed basis function and a symbolic dynamics. As a consequence, for the first time, chaotic waveforms could be dissected and analyzed using the tools of linear analysis. This minisymposium explores physical and technological applications of exactly solvable chaotic oscillators.

Organizer: Lucas Illing

Reed College, USA

Organizer: Ned J. Corron

US Army RDECOM, USA

1:15-1:40 Communication Waveforms and Exactly Solvable Chaos

Ned J. Corron and Jonathan N. Blakely, US Army RDECOM, USA

1:45-2:10 A Pseudo-Matched Filter for Solvable Chaos

Seth D. Cohen, Miltec Corp., USA

2:15-2:40 Methods for Implementing Exactly Solvable Chaos in Electronic Circuits

Aubrey N. Beal and Robert Dean, Auburn University, USA

2:45-3:10 Exactly Solvable Chaos in An Electromechanical Oscillator

Lucas Illing, Reed College, USA

Monday, May 18

MS44

Recent Advances in Ergodic Theory with an Eye to Applications

1:15 PM-3:15 PM

Room:Primrose B

Many modelling approaches in applied dynamical systems rely either directly, or indirectly on theoretical results from ergodic theory. Ergodic theory can provide a framework for the modelling process by guiding us to make productive simplifications to the model and/or can suggest directions in which to study a given model (e.g. invariants, exponents, correlations, and their rates of decay, almost invariant states and so-on) or more directly, through numerical implementation of theoretical results, either in an experimental or a rigorous context. This minisymposium will provide a sample from the range of recent contributions to applications and theoretical advances in the field, the latter, 'with an eye to applications'.

Organizer: Chris Bose
University of Victoria, Canada

1:15-1:40 Rigorous Numerical Approximation of Invariant Measures -- History and Recent Progress

Chris Bose, University of Victoria, Canada

1:45-2:10 A Measurable Perspective on Finite Time Coherence

Erik Bollt and Tian Ma, Clarkson University, USA

2:15-2:40 Non-Autonomous Dynamical Systems, Multiplicative Ergodic Theorems and Applications

Cecilia Gonzalez Tokman and Gary Froyland, University of New South Wales, Australia; Anthony Quas, University of Victoria, Canada

2:45-3:10 On Triangularization of Matrix Cocycles in the Multiplicative Ergodic Theorem

Joseph Horan, University of Victoria, Canada

Coffee Break

3:15 PM-3:45 PM

Room:Golden Cliff

Monday, May 18

CP14

Topics in Fluids

3:45 PM-4:45 PM

Room:Ballroom I

Chair: Robert E. Ecke, Los Alamos National Laboratory, USA

3:45-4:00 Reduced Modeling of Exact Coherent States in Shear Flow

Cedric Beaume, Imperial College London, United Kingdom; Greg Chini, University of New Hampshire, USA; Keith Julien, University of Colorado Boulder, USA; Edgar Knobloch, University of California, Berkeley, USA

4:05-4:20 Effects of Fluid Dynamics on Experiments with Compressed/ Expanded Surfactant Monolayers

Maria Higuera, Jose Perales, and Jose Vega, Universidad Politécnica de Madrid, Spain

4:25-4:40 Stratified Shear Turbulence Experiments

Robert E. Ecke, Los Alamos National Laboratory, USA; Philippe Odier, ENS Lyon, France

Monday, May 18

CP15

Topics in Noisy/Stochastic/ Random Dynamical Systems

3:45 PM-5:45 PM

Room:Ballroom II

Chair: Kevin Lin, University of Arizona, USA

3:45-4:00 Embedology for Control and Random Dynamical Systems

Boumediene Hamzi, Imperial College London, United Kingdom; Jake Bouvrie, Massachusetts Institute of Technology, USA

4:05-4:20 Noise Shaping and Pattern Discrimination in Recurrent Spiking Neuronal Networks

Hermann Riecke, Tom Zhao, and Siu Fai Chow, Northwestern University, USA

4:25-4:40 Faster Sensitivity Estimates for Stochastic Differential Equations

Kevin K. Lin, University of Arizona, USA; Jonathan C. Mattingly, Duke University, USA

4:45-5:00 Zero Density of Open Paths in the Lorentz Mirror Model for Arbitrary Mirror Probability

David P. Sanders, National University of Mexico, Mexico; Atahualpa Kraemer, Heinrich-Heine Universitaet Duesseldorf, Germany

5:05-5:20 Power System Stochastic Modeling

Mathew Titus, Yue Zhang, and Eduardo Cotilla-Sanchez, Oregon State University, USA

5:25-5:40 Noisy-Bar Problem

Korana Burke, University of California, Davis, USA

Monday, May 18

CP16

Topics in Networks II

3:45 PM-5:25 PM

Room:Ballroom III

Chair: Renate A. Wackerbauer, University of Alaska, Fairbanks, USA

3:45-4:00 Control of Stochastic and Induced Switching in Biophysical Complex Networks

Daniel Wells, William Kath, and Adilson E. Motter, Northwestern University, USA

4:05-4:20 Effects of Network Structure on the Synchronization of Hamiltonian Systems

Yogesh Virkar, Juan G. Restrepo, and James D. Meiss, University of Colorado Boulder, USA

4:25-4:40 Transient Spatiotemporal Chaos in a Network of Coupled Morris-Lecar Neurons

Renate A. Wackerbauer and Jacopo Lafranceschina, University of Alaska, Fairbanks, USA

4:45-5:00 Studies of Stable Manifolds of a Spatially Extended Lattice Kuramoto Model

Andrea J. Welsh and Flavio Fenton, Georgia Institute of Technology, USA

5:05-5:20 Consequence of Symmetry Breaking in Two Coupled Kuramoto Networks

Scott T. Watson, Ernest Barreto, Bernard Cotton, and Paul So, George Mason University, USA

Monday, May 18

CP17

Topics in Computational Dynamical Systems II

3:45 PM-5:45 PM

Room:Magpie A

Chair: James D. Meiss, University of Colorado Boulder, USA

3:45-4:00 The Existence of Horseshoe Dynamics in Three Dimensional Lotka-Volterra Systems

Rizgar Salih and Colin Christopher, Plymouth University, United Kingdom

4:05-4:20 Invariant Manifolds and Space Mission Design in the Restricted Four-Body Problem

Kaori Onozaki and Hiroaki Yoshimura, Waseda University, Japan

4:25-4:40 Efficient Kernel Algorithm for the Dynamic Mode Decomposition of Observed Data

Wataru Kurebayashi, Sho Shirasaka, and Hiroya Nakao, Tokyo Institute of Technology, Japan

4:45-5:00 Perturbing the Cat Map: Mixed Elliptic and Hyperbolic Dynamics

James D. Meiss, University of Colorado Boulder, USA; Lev Lerman, Lobachevsky State University of Nizhny Novgorod, Russia

5:05-5:20 Classification of Critical Sets and Images for Quadratic Maps of the Plane

Bruce B. Peckham, University of Minnesota, Duluth, USA; Chia-Hsing Nien, Providence University, Taiwan; Richard McGehee, University of Minnesota, Duluth, USA; Bernd Krauskopf and Hinke M. Osinga, University of Auckland, New Zealand

5:25-5:40 Mixing on a Hemisphere

Paul Park, Paul Umbanhowar, Julio Ottino, and Richard M. Lueptow, Northwestern University, USA

Monday, May 18

CP18

Topics in Complex Systems

3:45 PM-5:45 PM

Room:Magpie B

Chair: Steven H. Strogatz, Cornell University, USA

3:45-4:00 Dynamics of Correlated Novelties

Steven H. Strogatz, Cornell University, USA

4:05-4:20 Hysteresis Effects in Pedestrian Flows

Poul G. Hjorth and Jens Starke, Technical University of Denmark, Denmark

4:25-4:40 Robustness of Nonlinear Models

Fabio Della Rossa, Alessandro Colombo, Fabio Dercole, and Carlo Piccardi, Politecnico di Milano, Italy

4:45-5:00 Systems with Hidden Slow Fast Dynamics

Peter Szmolyan, Vienna University of Technology, Austria

5:05-5:20 A New Filter for State Estimation in Neural Mass Models

Dean R. Freestone, University of Melbourne, Melbourne, Australia & Columbia University, New York, USA; Philippa Karoly, Dragan Nesic, Mark Cook, and David Grayden, University of Melbourne, Australia

5:25-5:40 Inferring Causal Structures in Complex Systems Via Causation Entropy

Carlo Cafaro, Warren Lord, Jie Sun, and Erik Bollt, Clarkson University, USA

Monday, May 18

CP19

Topics in Classical Dynamical Systems

3:45 PM-5:45 PM

Room:Wasatch A

Chair: Kelum D. Gajamannage, Clarkson University, USA

3:45-4:00 New Asymptotics of Homoclinic Orbits Near Bogdanov-Takens Bifurcation Point

Bashir M. Al-Hdaibat and Willy Govaerts, Ghent University, Belgium; Yuri Kuznetsov, University of Twente, Netherlands; Hil Meijer, Twente University, Netherlands

4:05-4:20 Metric Invariance Entropy and Conditionally Invariant Measures

Fritz Colonius, University of Augsburg, Germany

4:25-4:40 Periodic Orbit Theory of Continuous Media

Nazmi Burak Budanur and Predrag Cvitanovic, Georgia Institute of Technology, USA

4:45-5:00 A Dynamical and Algebraic Study of a Family of Lienard Equations Transformable to Riccati Equations

Primitivo B. Acosta-Humanez, Jorge Rodriguez-Contreras, and Alberto Reyes-Linero, Universidad del Atlantico, Colombia

5:05-5:20 Dimensionality Reduction of Collective Motion by Principal Manifolds

Kelum D. Gajamannage, Clarkson University, USA; Sachit Butail, Indraprastha Institute of Information Technology Delhi, India; Maurizio Porfiri, Polytechnic Institute of New York University, USA; Erik Bollt, Clarkson University, USA

5:25-5:40 A Fast Explicit Method for Computing Invariant Solutions of High-Dimensional Dynamical Systems with Continuous Symmetries

Mohammad Farazmand and Predrag Cvitanovic, Georgia Institute of Technology, USA

Monday, May 18

CP20

Topics in Computational Dynamical Systems & Pattern Formation

3:45 PM-5:25 PM

Room:Wasatch B

Chair: Mikheil Tutberidze, Ilia State University, Georgia

3:45-4:00 Nonlinear Behaviors As Well As Bifurcation Mechanism in Switched Dynamical Systems

Yu V. Wang, City College of New York, USA

4:05-4:20 Gpu-Based Computational Studies of the Interaction Between Reentry Waves and Gap Junctional Uncoupling in Cardiac Tissues

Zhihui Zhang, Florida State University, USA

4:25-4:40 On the Numerical Integration of One Nonlinear Parabolic Equation

Mikheil Tutberidze, Ilia State University, Georgia

4:45-5:00 A Continuous Model for the Pathfinding Problem with Self-Recovery Property

Kei-Ichi Ueda, University of Toyama, Japan; Masaaki Yadome and Yasumasa Nishiura, Tohoku University, Japan

5:05-5:20 Patterns on Curved Backgrounds: the Influence of Local Curvature on Pattern Formation

Frits Veerman and Philip K. Maini, University of Oxford, United Kingdom

Monday, May 18

CP21

Topics in Biological Dynamics III

3:45 PM-5:25 PM

Room:Maybird

Chair: Vladimir E. Bondarenko, Georgia State University, USA

3:45-4:00 A Model of Heart Rate Dynamics for Changes in Exercise Intensity

Michael J. Mazzoleni, Duke University, USA; Claudio Battaglini, University of North Carolina at Chapel Hill, USA; Brian Mann, Duke University, USA

4:05-4:20 The Evolutionary Dynamics of Gamete Recognition Genes

David Mcavity and Mottet Geneva, Evergreen State College, USA

4:25-4:40 B-Adrenergic Regulation of Action Potential and Calcium Dynamics in a Model of Mouse Ventricular Myocytes

Vladimir E. Bondarenko, Georgia State University, USA

4:45-5:00 Spike Time Dependent Plasticity in a Spiking Neural Network

Anushaya Mohapatra, Oregon State University, USA; Mike Field and Chris Bick, Rice University, USA

5:05-5:20 A Mathematical Model for Frog Population Dynamics with Batrachochydrium Dendrobatidis (Bd) Infection

Baoling Ma, University of Louisiana, Lafayette, USA

Monday, May 18

CP22

Delay Dynamical Systems & Time Series Analysis

3:45 PM-5:05 PM

Room:Superior A

Chair: Sue Ann Campbell, University of Waterloo, Canada

3:45-4:00 Plankton Models with Time Delay

Sue Ann Campbell, Matt Kloosterman, and Francis Poulin, University of Waterloo, Canada

4:05-4:20 Stochastic Delay in Gene Regulation: Exact Stability Analysis

Mehdi Sadeghpour and Gabor Orosz, University of Michigan, Ann Arbor, USA

4:25-4:40 Computational Topology Techniques for Characterizing Time Series Data

Elizabeth Bradley, James D. Meiss, and Joshua T. Garland, University of Colorado Boulder, USA; Nicole Sanderson, University of Colorado, USA

4:45-5:00 Noise, Chaos and Entropy Generation in a Time-Delayed Dynamical System

Aaron M. Hagerstrom and Rajarshi Roy, University of Maryland, USA; Thomas E. Murphy, University of Maryland, College Park, USA

Monday, May 18

CP23

Topics in Optical and Related Systems

3:45 PM-5:45 PM

Room:Superior B

Chair: Estathios Charalampidis, University of Massachusetts, USA

3:45-4:00 Control of Extreme Events in the Bubbling Onset of Wave Turbulence in the Forced and Damped Non-Linear Schrödinger Equation

Paulo Galuzio, Ricardo L. Viana, and Sergio R. Lopes, Federal University of Paraná, Brazil

4:05-4:20 Vector Rogue Waves and Dark-Bright Boomeronic Solitons in Autonomous and Non-Autonomous Settings

Efstathios Charalampidis, University of Massachusetts, Amherst, USA; R. BABU Mareeswaran and T. Kanna, Bishop Heber College, India; Panayotis Kevrekidis, University of Massachusetts, USA; Dimitri Frantzeskakis, University of Athens, Greece

4:25-4:40 Reducibility of One-dimensional Quasi-periodic Schrödinger Equations

Jiansheng Geng, Nanjing University, China

4:45-5:00 Numerical Continuation of Invariant Solutions of the Complex Ginzburg-Landau Equation

Vanessa Lopez, IBM T.J. Watson Research Center, USA

5:05-5:20 Nonlinear Oscillations and Bifurcations in Silicon Photonic Resonators

Alexander Slawik and Daniel Abrams, Northwestern University, USA

5:25-5:40 Noise and Determinism of Stimulated Brillouin Scattering Dynamics in Optical Fiber

Diana A. Arroyo-Almanza, Rafael Setra, and Zetian Ni, University of Maryland, USA; Thomas E. Murphy, University of Maryland, College Park, USA; Rajarshi Roy, University of Maryland, USA

Monday, May 18

CP24

Topics in Wave Dynamics

3:45 PM-5:25 PM

Room:Primrose A

Chair: Ibrahim Fatkullin, University of Arizona, USA

3:45-4:00 Coupled Parametrically Forced Oscillators and Modulated Cross-Waves

Jeff Porter, Pablo Salgado Sanchez, Ignacio Tinao, and Ana Laveron-Simavilla, Universidad Politécnica de Madrid, Spain

4:05-4:20 Finding the Stokes Wave: From Low Steepness to Almost Limiting Wave

Sergey Dyachenko, University of Arizona, USA

4:25-4:40 Singularities of the Stokes' Wave: Numerical Simulation

Alexander O. Korotkevich, University of New Mexico, USA

4:45-5:00 Branch Cut Singularity of Stokes Wave

Pavel M. Lushnikov, University of New Mexico, USA

5:05-5:20 Blow-Ups in Nonlinear Pdes, Composite Grid-Particle Methods, and Stochastic Particle Systems

Ibrahim Fatkullin, University of Arizona, USA

Monday, May 18

CP25

Topics in Classical and Fluid Dynamical Systems

3:45 PM-5:25 PM

Room:Primrose B

Chair: To Be Determined

3:45-4:00 Experiments on a Pinball-Like Oscillator

Lawrie N. Virgin, Duke University, USA

4:05-4:20 Jetting-BubblingTransition in Microflows

Dipin S. Pillai and S. Pushpavanam, Indian Institute of Technology Madras, India

4:25-4:40 Exploring the Hyperbolicity of Chaotic Rayleigh-Bénard Convection

Mu Xu and Mark Paul, Virginia Tech, USA

4:45-5:00 Snakes on An Invariant Plane: Coupled Translational-Rotational Dynamics of Flying Snakes

Isaac Yeaton, Hodjat Pendar, Jake Socha, and Shane D. Ross, Virginia Tech, USA

5:05-5:20 Finding Model Parameters Without Prior Knowledge of Solve-Able Regions: A Solar Thermochemistry Case-Study

Karl Schmitt, Luke Venstrom, William D. Arloff, and Leandro Jaime, Valparaiso University, USA

Intermission

5:45 PM-6:00 PM

Monday, May 18

IP3

Filtering Partially Observed Chaotic Deterministic Dynamical Systems

6:00 PM-6:45 PM

Room:Ballroom

Chair: Bjorn Sandstede, Brown University, USA

This talk is concerned with determining the state of a chaotic dynamical system, for which the initial condition is only known probabilisticlly, given partial and noisy observations. In particular it is of interest to study this problem in the limit of a large number of such observations, over a long time interval. A key question is to determine which observations are sufficient in order to accurately recover the signal, and thereby overcome the lack of predictability caused by sensitive dependence on initial conditions. A canonical application is the development of probabilistic weather forecasts. In order to study this problem concretely, we will focus on a wide class of dissipative differential equations with quadratic energy-conserving nonlinearity, including the Navier-Stokes equation on a two dimensional torus. The work presented is contained in the paper D. Sanz-Alonso and A.M.Stuart, “Long-time asymptotics of the filtering distribution for partially observed chaotic deterministic dynamical systems” (http://arxiv.org/abs/1411.6510); see also the paper K.J.H. Law, A. Shukla and A.M. Stuart, “Analysis of the 3DVAR filter for the partially observed Lorenz ‘63 model,’” Discrete and Continuous Dynamical Systems A, 34(2014), and the book K.J.H. Law, A.M.Stuart and K. Zygalalkis, “Data Assimilation: A Mathematical Introduction” (in preparation, 2015) for further background references.

Andrew Stuart
University of Warwick, United Kingdom

Intermission

6:45 PM-7:00 PM

Monday, May 18

PD1

Journal Editors Panel and Reception (*pizza and light refreshments available*)

7:00 PM-8:00 PM

Room:Ballroom

Chair: Lora Billings, Montclair State University, USA

Wondering where to submit your next manuscript? What is the optimal journal for publishing work? How does the editorial process work? In this panel, editors of the leading journals in the area of dynamical systems will be making short presentations to inform potential authors and readers. Editors will describe the subject areas covered by their journals, describe their acceptance criteria and the editorial process they use to evaluate manuscripts, and will also present vital statistics for their journals. As a collection, journals in the field span a broad spectrum with a tremendous variation in authors, audiences, traditions, and editorial practices. One goal of this panel, a first of its kind, is to scope the publication landscape in dynamical systems. The presentations will be followed by a reception sponsored by the publishing companies. In this informal setting, editors will be available answer questions. Pizza and light refreshments will be served.

Panelists:

Eli Ben-Naim

Los Alamos National Laboratory, USA - Physical Review E, American Physical Society

David Campbell

Boston University, USA - Chaos, American Institute of Physics

Serena Dalena

Physical Review Letters, American Physical Society, USA

Charles Doering

University of Michigan, USA - Physics Letters A, Elsevier

Edgar Knobloch

University of California, Berkeley, USA - Nonlinearity, Institute of Physics

Joceline Lega

University of Arizona, USA - Physica D, Elsevier

Bjorn Sandstede

Brown University, USA - SIAM Journal on Applied Dynamical Systems (SIADS)

Monday, May 18

SIAG/DS Business Meeting

8:30 PM-9:30 PM

Room:Ballroom

Complimentary wine and beer will be served.

Tuesday, May 19

Registration

8:00 AM-4:30 PM

Room:Ballroom Foyer

Tuesday, May 19

MS45

Energy Transfer and Harvesting in Nonlinear Systems - Part II of II

8:30 AM-10:30 AM

Room:Ballroom I

For Part 1 see MS32

The minisymposium will focus on recent developments and challenges related to energy transfer and harvesting in nonlinear systems. Special attention will be paid to rapidly developing research field of nonsmooth systems. Topics will include, but will not be limited to:

- New results in the classical problem of divergent vs convergent heat conduction in models of atomic lattices;
- Description of wave initiation, propagation and mitigation in granular systems;
- Nonlinear targeted energy transfer in systems with strongly nonlinear attachments
- Applications of strong and non-smooth nonlinearities for efficient energy harvesting.

Organizer: Oleg Gendelman

Technion Israel Institute of Technology, Israel

Organizer: Alexander Vakakis

University of Illinois, USA

8:30-8:55 Non-Linearizable Wave Equation: Nonlinear Sonic Vacuum

Leonid Manevich, Russian Academy of Sciences, Russia; *Alexander Vakakis*, University of Illinois, USA

9:00-9:25 Vibration Energy Harvesting Based on Nonlinear Targeted Energy Transfer

Kevin Remick, University of Illinois at Urbana-Champaign, USA; D Dane Quinn, University of Akron, USA; D. Michael McFarland, University of Illinois, USA; *Lawrence Bergman*, University of Illinois at Urbana-Champaign, USA; Alexander Vakakis, University of Illinois, USA

9:30-9:55 Nonlinear Energy Harvesting in Granular Media

Christopher Chong, ETH Zürich, Switzerland

10:00-10:25 2D Energy Channeling in the Locally Resonant Acoustic Metamaterials

Yuli Starosvetsky and Kirill Vorotnikov, Technion - Israel Institute of Technology, Israel

Tuesday, May 19

MS46

Cellular Decision Making Under Noise

8:30 AM-10:30 AM

Room:Ballroom II

Understanding how living cells make decisions based on environmental inputs is one of the keys to understanding all living systems. In the past decade, the behavior of genetic circuits has been studied in great detail, both theoretically and experimentally. While most studies focused on the role of intrinsic noise, extrinsic noise has remained largely unexplored, even though it may dramatically affect the behavior of these systems. Understanding the combined influence of intrinsic and extrinsic noise on the stochastic dynamics of gene expression should give us insight on how biochemical networks have evolved to both control and exploit their fluctuating environment.

Organizer: Michael Assaf

Hebrew University of Jerusalem, Israel

8:30-8:55 The Effect of Extrinsic Noise on Gene Regulation

Michael Assaf, Hebrew University of Jerusalem, Israel

9:00-9:25 Fundamental Limits to the Precision of Multicellular Sensing

Andrew Mugler, Purdue University, USA; Matthew Brennan, Johns Hopkins University, USA; Andre Levchenko, Yale University, USA; Ilya Nemenman, Emory University, USA

9:30-9:55 Inferring Predictive Signal-Activated Gene Regulation Models from Noisy Single-Cell Data

Brian Munsky, Colorado State University, USA

10:00-10:25 Coarse-Graining Biochemical Networks

Nikolai Sinitsyn, Los Alamos National Laboratory, USA

Tuesday, May 19

MS47

Koopman Operator Techniques in Dynamical Systems: Theory and Practice - Part I of II

8:30 AM-10:30 AM

Room:Ballroom III

For Part 2 see MS60

Koopman operator is a linear infinite-dimensional composition operator that can be defined for arbitrary nonlinear dynamical systems. It retains the full information of the nonlinear state-space dynamics. Study of its spectral properties provides an alternate framework for dynamical systems analysis. Recently, the spectral theory of Koopman operator has been extended to dissipative systems. This enabled numerous applications based on the so-called Koopman Mode Expansion in fields as diverse as fluid mechanics, image processing and power grid engineering. In this minisymposium, we aim to present and discuss the current status of Koopman operator techniques in theory and practice of dynamical systems.

Organizer: Igor Mezic

University of California, Santa Barbara, USA

Organizer: Yoshihiko Susuki

Kyoto University, Japan

8:30-8:55 Koopman Mode Expansion in Theory and Practice

Igor Mezic, University of California, Santa Barbara, USA

9:00-9:25 What Can the Koopman Operator Do for Dynamical Systems?

Rainer Nagel, University of Tübingen, Germany

9:30-9:55 Generalized Laplace Analysis and Spaces of Observables for the Koopman Operator

Ryan Mohr, University of California, Santa Barbara, USA

10:00-10:25 Computation of the Koopman Eigenfunctions Is a Systematic Method for Global Stability Analysis

Alexandre Mauroy, University of Liege, Belgium; Igor Mezic, University of California, Santa Barbara, USA

Tuesday, May 19

MS48

Bridging the Gap Between Observations and Idealized Modeling: A Comprehensive Approach to Weather and Climate Predictability

8:30 AM-10:30 AM

Room:Magpie A

Many important climate and weather phenomenon are difficult to predict because of abrupt transitions in behavior due to noise and nonlinearity. Determining whether noise and nonlinearity manifest themselves as an organizing or random forcing has important consequences for model choice and subsequent mechanistic understanding and predictability. This minisymposium is centered on a two-fold approach to addressing this issue. First, observational data is used as a tool to identify the relevant physical processes that are at the core of complex atmospheric systems. Second, the insights gained from observations are leveraged to create simple, but physically unabridged representations of real-world atmospheric phenomenon.

Organizer: Juliana Dias

NOAA Earth System Research Laboratory

8:30-8:55 An Observational Basis for Sudden Stratospheric Warmings As Bifurcations in Planetary Wave Amplitude

John R. Albers, University of Colorado, USA

9:00-9:25 The Role of Noise in Bifurcations in Fluids and the Atmosphere

Yuzuru Sato, Hokkaido University, Japan; David J. Albers, Columbia University, USA

9:30-9:55 Tropical-Extratropical Wave Interactions in the Atmosphere

Juliana Dias, NOAA Earth System Research Laboratory

10:00-10:25 The Use of Green Functions of the Shallow Water Model for Understanding Climate Anomalies

Pedro Leite da Silva Dias, University of Sao Paulo, Brazil

Tuesday, May 19

MS49

Theory and Applications of Nonsmooth Dynamics in Physical Systems - Part II of II

8:30 AM-10:00 AM

Room:Magpie B

For Part 1 see MS36

This minisymposium will provide a mix of talks featuring theoretical developments in nonsmooth systems as well as talks featuring applications with nonsmooth dynamics. In either case, physical applications provide the motivation for mathematical exploration. Additionally, the minisymposium will blend talks appropriate for a broad audiences and talks geared at experts. To that point, the minisymposium will begin with the very general "How nonsmooth are the Earth sciences?" which will set the stage for the rest of the speakers. Other talks will discuss issues such as generalized bifurcations, canard phenomena, synchronization, and the new area of resilience.

Organizer: Andrew Roberts
Cornell University, USA

Organizer: Esther Widiasih
University of Hawaii, West Oahu, USA

8:30-8:55 Canard Phenomena in Nonsmooth Systems

Andrew Roberts, Cornell University, USA

9:00-9:25 Generalized Hopf Bifurcation in a Nonsmooth Climte Model

Julie Leifeld, University of Minnesota, USA

9:30-9:55 Dangerous Border Collision Bifurcation in Piecewise Smooth Maps

Soumitro Banerjee and Arindam Saha, Indian Institute for Science Education and Research, Kolkata, India; Viktor Avrutin, University of Stuttgart, Germany; Laura Gardini, University of Urbino, Italy

Tuesday, May 19

MS50

Multistability in Biological Circuits: Theory and Applications

8:30 AM-10:00 AM

Room:Wasatch A

Complex networks facilitate the existence of multiple coexisting stable states in the network dynamics. This is most prominent in biological, gene, and neural networks that derive their functional flexibility from a high multiplicity of operational modes. Robustness and multiplicity as well as the transition dynamics is determined by network symmetry, structure and node dynamics. The struggle of understanding such complex network dynamics has inspired novel mathematical approaches and continues to uncover fascinating mechanisms of real network function. The speakers in this session will present novel mathematical problems of understanding dynamical transitions on complex biological networks.

Organizer: Marcos Rodriguez
Centro Universitario De La Defensa Zaragoza, Spain

Organizer: Justus T. Schwabedal
Georgia State University, USA

8:30-8:55 From Andronov-Hopf to Z_3 Heteroclinic Bifurcations in Cpgs

Marcos Rodriguez, Centro Universitario De La Defensa Zaragoza, Spain; Roberto Barrio and Sergio Serrano, University of Zaragoza, Spain; Andrey Shilnikov, Georgia State University, USA

9:00-9:25 Intrinsic Mechanisms for Pattern Generation in Three-Node Networks

Jarod Collens, Aaron Kelley, Deniz Alacam, Tingli Xing, Drake Knapper, Justus T. Schwabedal, and Andrey Shilnikov, Georgia State University, USA

9:30-9:55 Key Bifurcations of Bursting Polyrhythms in 3-Cell Central Pattern Generators

Jeremy Wojcik, Applied Technology Associates, USA; Robert Clewley, Justus T. Schwabedal, and Andrey Shilnikov, Georgia State University, USA

Tuesday, May 19

MS51

Mechanisms for Computations in Neuronal Networks

8:30 AM-10:30 AM

Room:Wasatch B

Our speakers address a range of neural network mechanisms in order to understand their impact on specific computations, including: synchrony detection through phase-delayed inhibition, olfactory coding using time-varying oscillations, and transfer of correlations through convergent network motifs.

Organizer: Andrea K. Barreiro
Southern Methodist University, USA

Organizer: Pamela B. Fuller
Rensselaer Polytechnic Institute, USA

8:30-8:55 Impact of Single-Neuron Dynamics on Transfer of Correlations from Common Input

Andrea K. Barreiro, Southern Methodist University, USA

9:00-9:25 Integrate-and-Fire Model of Insect Olfaction

Pamela B. Fuller and Gregor Kovacic, Rensselaer Polytechnic Institute, USA; David Cai, Shanghai Jiao Tong University, China and Courant Institute of Mathematical Sciences, New York University, USA

9:30-9:55 A Network of Excitatory and Inhibitory Neurons with Gap Junctions

Jennifer Kile and Gregor Kovacic, Rensselaer Polytechnic Institute, USA; David Cai, Shanghai Jiao Tong University, China and Courant Institute of Mathematical Sciences, New York University, USA

10:00-10:25 Phase Delayed Inhibition and the Representation of Whisker Deflection Velocity in the Rodent Barrel Cortex

Mainak Patel, College of William & Mary, USA; Runjing Liu, Duke University, USA; Badal Joshi, California State University, San Marcos, USA

Tuesday, May 19

MS52

Reduced Dynamical Models and Their Applications - Part II of II

8:30 AM-10:30 AM

Room:Maybird

For Part 1 see MS39

The purpose is to present a cross-section of leading-edge research on the development, analysis, numerical solution, visualization and applications of reduced dynamical systems models. These models may arise via simplification of form of infinite-dimensional systems, reduction in cardinality of the dimension, possibly by restriction to invariant submanifolds, and ad hoc techniques based upon focusing on certain combinations of variables. Among the reductions to be discussed are simplified infinite-dimensional models for granular flows, reduced dimensional models via extensions of the zero derivative principle, discrete dynamical systems reductions for logical circuits and ecological models, and discrete integrable reductions of continuum models.

Organizer: Denis Blackmore
New Jersey Institute of Technology, USA

Organizer: Anthony Rosato
New Jersey Institute of Technology, USA

8:30-8:55 Idealized Models for Vortex Shedding and Fluid-Body Interactions

Scott D. Kelly, University of Illinois at Urbana-Champaign, USA

9:00-9:25 A Novel Semidiscete Scheme for a Reduced Continuum Flow Model

Hao Wu and Denis Blackmore, New Jersey Institute of Technology, USA

9:30-9:55 Visualization of Reduced Granular Dynamics

Xavier M. Tricoche, Purdue University, USA

10:00-10:25 Extending the Zero Derivative Principle

Morten Brons, Technical University of Denmark, Denmark; Eric Benoît, Universitè de la Rochelle, France; Mathieu Desroches and Maciej Krupa, INRIA Paris-Rocquencourt, France

Tuesday, May 19

MS53

Ostwald Ripening, Aggregate Growth and Precipitation

8:30 AM-10:30 AM

Room:Superior A

The minisymposium will address new developments on the impact of fluctuations of the environment on aggregate growth and the emergence of precipitation. There will comprise two times two talks. There will be two talks addressing recent theoretical progress focusing on Ostwald ripening and the crossover to a runaway growth leading to precipitation, respectively. Another two talks, will address recent advances in applications, nanoparticle synthesis and steel production.

Organizer: Jürgen Vollmer
Max Planck Institute for Dynamics and Self-Organization, Germany

8:30-8:55 Episodic Precipitaton

Jürgen Vollmer, Max Planck Institute for Dynamics and Self-Organization, Germany

9:00-9:25 Ostwald Ripening and Nanoparticle Growth

Martin Rohloff, Max Planck Institute for Dynamics and Self-Organization, Germany

9:30-9:55 Aggregate Growth in Optimizing Steel Production

Nikolas Rimbert, Université de Lorraine, France

10:00-10:25 Initiation of Rain and Inertial Particles

Markus Abel, University of Potsdam, Germany

Tuesday, May 19

MS54

Renewable Energy and Power Grids: Their Mathematical Characterizations - Part II of II

8:30 AM-10:00 AM

Room:Superior B

For Part 1 see MS41

It is our social demand to introduce more renewable energy resources into power grids. However, because renewable energy outputs fluctuate according to weather conditions, we need to control and/or optimize power grids so that we can keep the voltage and frequency as constant and stable. Here we put together some recent advances to achieve this need mathematically. This need for more renewables makes us to combine several fields of mathematics together such as dynamical systems theory, control theory and complex network theory. This need also brings us into new research directions, which will turn our mathematical tools more practical.

Organizer: Yoshito Hirata
University of Tokyo, Japan

Organizer: Jun-ichi Imura
Tokyo Institute of Technology, Japan

Organizer: Juergen Kurths
Potsdam Institute for Climate Impact Research and Humboldt University Berlin, Germany

8:30-8:55 Basin Stability for Evaluating Large Perturbations in Power Grids

Juergen Kurths, Potsdam Institute for Climate Impact Research and Humboldt University Berlin, Germany

9:00-9:25 Model Free Tuning of Wind Farms for Maximizing Power Production

Mohd Ashraf Ahmad, Shun-Ichi Azuma, and Toshiharu Sugie, Kyoto University, Japan

9:30-9:55 Predicting Critical Links in Complex Supply Networks

Marc Timme, Max-Planck-Institute for Dynamics and Self-Organization, Germany; Dirk Witthaut, Forschungszentrum Jülich, Germany; Martin Rohden, University of Bremen, Germany; Xiaozhu Zhang and Sarah Hallerberg, Max Planck Institute for Dynamics and Self-Organization, Germany

Tuesday, May 19

MS55

Extensions and Applications of Dynamic Mode Decomposition - Part II of II

8:30 AM-10:30 AM

Room:White Pine

For Part 1 see MS42

Dynamic mode decomposition (DMD) is a powerful method that identifies spatial-temporal coherent structures in high-dimensional datasets. Introduced less than a decade ago, it has quickly gained a wide following due to its ease of implementation and broad applicability. In this minisymposium, we present exciting new extensions and applications of DMD. These include theoretical advances in rigorously defining DMD and its connections to Koopman operator theory, as well as applications in fluid mechanics, neuroscience, and epidemiology. We also introduce algorithmic enhancements that account for the effects of control inputs, correct for noise, and enable ever-larger computations, for instance using compressive sensing.

Organizer: Jonathan H. Tu
University of California, Berkeley, USA

Organizer: Steven Brunton
University of Washington, USA

8:30-8:55 Using Dynamic Mode Decomposition to Extract Linear Global Modes from Nonlinear Fluid Flow Solvers

Kunihiko Taira and Aditya Nair, Florida State University, USA; Shervin Bagheri, KTH Royal Institute of Technology, Sweden

9:00-9:25 Improving the Accuracy of Dynamic Mode Decomposition in the Presence of Noise

Scott Dawson, Maziar S. Hemati, Matthew O. Williams, and Clarence Rowley, Princeton University, USA

9:30-9:55 Parallel Qr Algorithm for Data-Driven Decompositions, in Particular Dynamic Mode Decomposition

Taraneh Sayadi, University of Illinois at Urbana-Champaign, USA; Peter Schmid, Imperial College London, United Kingdom

10:00-10:25 Compressive Sensing and Dynamic Mode Decomposition

Steven Brunton, University of Washington, USA

Tuesday, May 19

MS56

Topology and Computation in Dynamics

8:30 AM-10:30 AM

Room:Primrose A

Classical Morse theory provides a direct link between the topology of a manifold and gradient dynamics on it. Extensions of Morse-theoretic ideas due to Conley (in the finite dimensional setting) and Floer (in the infinite dimensional cases) are powerful topological tools in applied dynamical systems. In particular, the associated homology provides computable invariants of dynamical systems. This homology is thus well-suited for numerical approaches to understanding global dynamics. This minisymposium explores recent advances in finite and infinite dimensional dynamical systems using Morse-Conley-Floer index techniques, rigorous computational dynamics, 'database' explorations based on Conley-Morse graphs, and topological reconstruction from data.

Organizer: Jan Bouwe Van Den Berg
VU University, Amsterdam, Netherlands

Organizer: Robert Vandervorst
VU University, Amsterdam, Netherlands

8:30-8:55 Rigorous Computing in Strongly Indefinite Problems

Jean-Philippe Lessard, Université Laval, Canada; Jan Bouwe Van Den Berg and Robert Vandervorst, VU University, Amsterdam, Netherlands; Marcio Gameiro, University of Sao Paulo, Brazil

9:00-9:25 Computing Conley-Morse Databases

Shaun Harker, Rutgers University, USA

9:30-9:55 Reconstructing Functions from Dense Samples

Vidit Nanda, University of Pennsylvania, USA

10:00-10:25 Morse Homology on Spaces of Braids

Patrick Hafkenscheid, VU University, Amsterdam, Netherlands

Tuesday, May 19

MS57

Chaos and Strange Attractors

8:30 AM-10:30 AM

Room:Primrose B

The purpose of this minisymposium is to discuss the state of the art in the modern chaos theory and applications of the theory to problems in biology, chemistry, mechanics etc.

Organizer: Ivan Ovsyannikov
University of Bremen, Germany

8:30-8:55 Global Invariant Manifolds Unravelling Shilnikov Chaos

Pablo Aguirre, Universidad Técnica Federico Santa María, Chile; Bernd Krauskopf and Hinke M. Osinga, University of Auckland, New Zealand

9:00-9:25 Analytic Proof of Lorenz Attractors in Flows and Maps

Ivan Ovsyannikov, University of Bremen, Germany

9:30-9:55 The Lorenz System Near the Loss of the Foliation Condition

Jennifer L. Creaser, Bernd Krauskopf, and Hinke M. Osinga, University of Auckland, New Zealand

10:00-10:25 The Many Facets of Chaos

Evelyn Sander, George Mason University, USA

Coffee Break

10:30 AM-11:00 AM

Room:Golden Cliff

Tuesday, May 19

IP4

Fields of Dreams: Modeling and Analysis of Large Scale Activity in the Brain

11:00 AM-11:45 AM

Room:Ballroom

Chair: Michael Ward, University of British Columbia, Canada

With the advent of optogenetics and the ability to record large numbers of neurons with high temporal resolution, there is now a great deal of interest in both the temporal and spatial activity of neurons in the brain. In this talk, I will discuss a number of old and new developments in the study of these nonlinear integro-differential equations and how they apply to some new biological findings. Topics that I will discuss include the role of noise on spatio-temporal activity, the interaction between extrinsic and intrinsic activity, interactions between multiple spatial networks, and finally some recent applications of Filippov theory to discontinuous neural field models.

Bard Ermentrout
University of Pittsburgh, USA

Lunch Break

11:45 AM-1:30 PM

Attendees on their own

Tuesday, May 19

PD2

Funding Agency Panel

12:00 PM-1:00 PM

Room:Ballroom

Chair: Igor Mezic, University of California, Santa Barbara, USA

A panel of representatives from federal funding agencies will discuss trends and opportunities for research funding in the area of dynamical systems. Each will describe their funding guidelines and deadlines, and provide information about the their particular funding interests.

Panelists:

Fariba Fahroo
Air Force Office of Scientific Research, USA

Predrag Neskovic
Office of Naval Research, USA

Massimo Ruzzene
National Science Foundation, Directorate for Engineering, USA

Samuel Stanton
Army Research Office, USA

Henry Warchall
National Science Foundation, Division of Mathematical Sciences, USA

Tuesday, May 19

MS58

Snapshot and Pullback Attractors, a Framework for Understanding Nonautonomous Dissipative Dynamics

1:30 PM-3:30 PM

Room:Ballroom I

Snapshot attractors generalize strange attractors from autonomous to nonautonomous dynamics. A snapshot attractor is a time-dependent object in the phase space of an open system that is the asymptotic locus of trajectories initialized in the remote past. Pullback attractors in the deterministic setting and random attractors in the stochastic setting provide a solid mathematical foundation to this loose definition. Random dynamical systems theory encompasses both deterministic and random forcing. The minisymposium will clarify the connections between snapshot and pullback attractors, and shed further light on their invariant measures as generalized SRB measures. Applications will include climate dynamics and coupled oscillators.

Organizer: Michael Ghil
Ecole Normale Superieure de Paris, France, and University of California, Los Angeles, USA

Organizer: Tamas Tel
Eötvös Loránd University, Hungary

1:30-1:55 Random Attractors and How They Help Understand Climate Change and Variability

Michael Ghil, Ecole Normale Superieure de Paris, France, and University of California, Los Angeles, USA

2:00-2:25 SRB Measures for Time-Dependent and Random Attractors

Lai-Sang Young, Courant Institute of Mathematical Sciences, New York University, USA

2:30-2:55 Snapshot Attractors and the Transition to Extensive Chaos in Large Systems of Mean-Field Coupled Oscillators

Edward Ott, Wai Lim Ku, and Michelle Girvan, University of Maryland, USA

continued on next page

3:00-3:25 The Quantification of the Nonergodic Property Via Snapshot Attractors: An Application to a Conceptual Climate Model

Gabor Drotos, Hungarian Academy of Sciences, Hungary; Tamas Bodai, Universitat Hamburg, Germany; Tamas Tel, Eötvös Loránd University, Hungary

Tuesday, May 19

MS59

Synchronization of Chaos and its Applications - Part I of II

1:30 PM-3:30 PM

Room:Ballroom II

For Part 2 see MS72

Many fundamental processes in nature are based on synchronization of chaos. This phenomenon is universal, robust and it may also involve large population of active elements distributed over extensive spatial regions. In this minisymposium theoretical and application issues related to this phenomenon will be considered. In particular, we address the fundamental role that this phenomenon has in the organization of the collective movement, in neuroscience and in the development of scenarios that lead to coexistence of ordered and disordered states.

Organizer: Elbert E. Macau

Laboratory for Computing and Applied Mathematics and Brazilian Institute for Space Research, Brazil

Organizer: Epaminondas Rosa

Illinois State University, USA

1:30-1:55 Chimeras in Networks of Identically Coupled Mechanical Oscillators

Rosangela Follmann, Daniel Abrams, and Adilson E. Motter, Northwestern University, USA

2:00-2:25 Dynamics of Clustering in Networks with Repulsive Interaction

Michael A. Zaks, University of Potsdam, Germany

2:30-2:55 Synchronization Properties Related to Neighborhood Similarity in a Complex Network of Non-Identical Oscillators

Elbert E. Macau, Laboratory for Computing and Applied Mathematics and Brazilian Institute for Space Research, Brazil; Celso Bernardo Freitas, Instituto Nacional de Pesquisas Espaciais, Brazil; Ricardo L. Viana, Federal University of Paraná, Brazil

3:00-3:25 Chimera States in Networks with Symmetry-Breaking Coupling

Anna Zakharova, Institute of Theoretical Physics, Berlin, Germany; Marie Kapeller, Berlin Institute of Technology, Germany; Eckehard Schöll, Technische Universität Berlin, Germany

Tuesday, May 19

MS60

Koopman Operator Techniques in Dynamical Systems: Theory and Practice - Part II of II

1:30 PM-3:30 PM

Room:Ballroom III

For Part 1 see MS47

Koopman operator is a linear infinite-dimensional composition operator that can be defined for arbitrary nonlinear dynamical systems. It retains the full information of the nonlinear state-space dynamics. Study of its spectral properties provides an alternate framework for dynamical systems analysis. Recently, the spectral theory of Koopman operator has been extended to dissipative systems. This enabled numerous applications based on the so-called Koopman Mode Expansion in fields as diverse as fluid mechanics, image processing and power grid engineering. In this minisymposium, we aim to present and discuss the current status of Koopman operator techniques in theory and practice of dynamical systems.

Organizer: Igor Mezic

University of California, Santa Barbara, USA

Organizer: Yoshihiko Susuki

Kyoto University, Japan

1:30-1:55 Approximating the Koopman Operator Using Extended Dynamic Mode Decomposition

Clarence Rowley and Matthew O. Williams, Princeton University, USA

2:00-2:25 Machine Learning and the Koopman Operator: Algorithms and Applications

Matthew O. Williams, Princeton University, USA

2:30-2:55 Dynamic Mode Decomposition for Multi-Resolution Analysis

J. Nathan Kutz, University of Washington, USA

3:00-3:25 Koopman Operator Techniques in Power Grid Analysis

Yoshihiko Susuki, Kyoto University, Japan

Tuesday, May 19

MS61

State and Parameter Estimation for Complex Dynamical Systems

1:30 PM-3:30 PM

Room:Magpie A

Using mathematical models to analyze and predict real world dynamical processes meets with the difficulty that often not all state variables are easy to observe, and adequate values of model parameters may be (partly) unknown. To estimate unobserved variables and model parameters, various identification methods have been devised, aiming to match the model output to some observed time. This may be considered a form of data assimilation, a term which refers to incorporating observed data into computer models of the observed system. The presentations of this minisymposium will address theoretical issues, new concepts, and applications of state and parameter estimation techniques.

Organizer: Ulrich Parlitz
Max Planck Institute for Dynamics and Self-Organization, Germany

Organizer: Henry D. Abarbanel
University of California, San Diego, USA

Organizer: Jochen Bröcker
University of Reading, United Kingdom

1:30-1:55 What Is the Right Functional for Variational Data Assimilation?
Jochen Bröcker, University of Reading, United Kingdom

2:00-2:25 Filtering Unstable Quadratic Dissipative Systems
Kody Law, King Abdullah University of Science & Technology (KAUST), Saudi Arabia; Abhishek Shukla, *Daniel Sanz-Alonso*, and Andrew Stuart, University of Warwick, United Kingdom

2:30-2:55 Time Delay Methods for Variational Data Assimilation
Uriel I. Morone, University of California, San Diego, USA

3:00-3:25 Observability of Chaotic Lorenz-96 Systems
Jan Schumann-Bischoff, Stefan Luther, and Ulrich Parlitz, Max Planck Institute for Dynamics and Self-Organization, Germany

Tuesday, May 19

MS62

Dynamics of Nanoelectromechanical Systems (NEMS)

1:30 PM-3:00 PM

Room:Magpie B

Nanoelectromechanical systems (NEMS) are the latest step in miniaturizing electro-mechanical devices. Due to their scale, we can now study new physical regimes as well as develop novel technologies. The minisymposium presents an overview of their rich nonlinear and pattern formation dynamics alongside new theoretical and experimental advances. The talks will address systems consisting of single NEMS devices as well as NEMS networks.

Organizer: Korana Burke
University of California, Davis, USA

1:30-1:55 Intrinsic Computation in NEMS
Russell Hawkins, University of California, Davis, USA

2:00-2:25 Control of Complex Diffusion in Networks of NEMS
Jeff Emenheiser, University of California, Davis, USA; Mehran Mesbahi, University of Washington, USA; Raissa D'Souza, University of California, Davis, USA

2:30-2:55 Phase Synchronization Between Nanoelectromechanical Oscillators
Matt Matheny, California Institute of Technology, USA

Tuesday, May 19

MS63

Applications of Ensemble Data Assimilation Methods to Climate Processes

1:30 PM-3:30 PM

Room:Wasatch A

Data assimilation methods seek to improve estimates from a predictive model by combining them with observed data. Most realistic applications, such as those used in climate modeling, involve an underlying dynamical system which is nonlinear. Many ensemble methods have been designed to handle this nonlinearity, and additionally, often provide an estimate of the uncertainty in the prediction via the ensemble spread. This session will include applications of ensemble data assimilation methods to several aspects of the climate, including oceans, sea ice, and the ionosphere.

Organizer: Laura Slivinski
Woods Hole Oceanographic Institute, USA

1:30-1:55 An Application of Lagrangian Data Assimilation to Katama Bay, Ma
Laura Slivinski, Larry Pratt, and Irina Rypina, Woods Hole Oceanographic Institute, USA

2:00-2:25 Ensemble Inflation by Shadowing Techniques
Thomas Bellsky, University of Maine, USA; Lewis Mitchell, University of Adelaide, Australia

2:30-2:55 Ionospheric Weather Forecasting Using the Letkf Scheme
Juan Durazo, Arizona State University, USA

3:00-3:25 Predicting Flow Reversals in a Cfd Simulated Thermosyphon Using Data Assimilation
Andrew Reagan, University of Vermont, USA

Tuesday, May 19

MS64

Excitation Waves in Heterogeneous Cardiac Tissue: Theory and Experiments

1:30 PM-3:30 PM

Room:Wasatch B

In this minisymposium we plan to bring together experimentalists and theorist interested on the initiation and control of spiral waves in the cardiac system. From the dynamical system perspective cardiac tissue can be considered as an excitable medium. Indeed, experiments have shown that dynamics of cardiac excitation waves during fibrillation is similar to dynamics of spiral waves in excitable media. This perspective is already bearing fruits in understanding cardiac arrhythmias and its management. For example new defibrillation methods have been proposed using low energy pulses to eliminate spiral waves from heterogeneities in the cardiac tissue. This minisymposium will discuss some of the underlying theoretical issues and experimental challenges.

Organizer: Shajahan Thamara Kunnathu

Max Planck Institute for Dynamics and Self-Organization, Germany

1:30-1:55 Controlling Spiral Wave Dynamics in Cardiac Monolayers Using Far Field Pulses

Shajahan Thamara Kunnathu, Sebastian Berg, Valentin Krinsky, and Stefan Luther, Max Planck Institute for Dynamics and Self-Organization, Germany

2:00-2:25 A Mechanism of Spiral Wave Unpinning and Its Implications for the Treatment of Cardiac Arrhythmias with Periodic Far-Field Pacing

Philip Bittihn, University of California, San Diego, USA; Anna Behrend and Stefan Luther, Max Planck Institute for Dynamics and Self-Organization, Germany

2:30-2:55 The Effects of Cardiac Fibroblasts on Wave Propagation in Ventricular Tissue: Insights from Numerical Studies of Mathematical Models

Alok R. Nayak and Rahul Pandit, Indian Institute of Science, Bangalore, India

3:00-3:25 How to Control Spiral Waves Using Weak Signals: A Few Suggestions

S Sridhar, Ghent University, Belgium

Tuesday, May 19

MS65

Spiral and Scroll Waves Dynamics in Experiment and Simulations - Part I of II

1:30 PM-3:30 PM

Room:Maybird

For Part 2 see MS73

Spiral and scroll waves are nonlinear dissipative patterns occurring in 2- and 3-dimensional excitable and oscillatory media, where they act as organizing centers. Important motivation to study spiral and scroll waves dynamics is better control of cardiac re-entry underlying dangerous arrhythmias and fatal fibrillation. Though, the vortices become of increasing interest of their own as regimes of self-organisation and transition to chaos. Recent advances in experimental, theoretical and computer simulation techniques brought the studies closer to practical applications than ever before. This minisymposium provides a sampling of the current state of experimental and computer simulation research in this field.

Organizer: Irina Biktasheva

University of Liverpool, United Kingdom

1:30-1:55 Anatomy Induced Drift of Reentrant Waves in Human Atrium

Irina Biktasheva, University of Liverpool, United Kingdom; Vadim N. Biktashev and Sanjay R. Kharche, University of Exeter, United Kingdom; Gunnar Seemann, Karlsruhe Institute of Technology, Germany; Henggui Zhang, The University of Manchester, UK

2:00-2:25 Stabilized Wave Segments in An Excitable Medium with a Phase Wave at the Wave Back

Eberhard Bodenschatz and Vladimir Zykov, Max-Planck-Institute for Dynamics and Self-Organization, Germany

2:30-2:55 Use of Delay-Differential Equations in Cardiac Models

Elizabeth M. Cherry, Cornell University, USA; Ryan Thompson, Rochester Institute of Technology, USA

3:00-3:25 Spiral Wave Activity in a Mixture of Resting and Oscillating Cardiomyocytes: Limitations on Biopacemaker Development

Philippe Comtois, Université de Montréal, Canada

Tuesday, May 19

MS66

Stochastic and Nonlinear Dynamics of Neuronal Networks - Part I of II

1:30 PM-3:30 PM

Room:Superior A

For Part 2 see MS74

Coherent neural activity patterns have been implicated as a substrate of short term memory, spatial navigation, sensation, and motor skills. Understanding the mechanisms that underlie this activity requires using sophisticated mathematical methods to analyze nonlinear models of neuronal networks. Recent advances along these lines address the effects of stochasticity, spatial heterogeneity, delays, and modular structure on the dynamics of neuronal networks. This session will feature talks on cutting-edge methods for analyzing stochastic neural field equations, balanced networks, and mean field theories for spiking networks.

Organizer: Zachary Kilpatrick

University of Houston, USA

Organizer: Jonathan D. Touboul

Collège de France, France

Organizer: Bard Ermentrout

University of Pittsburgh, USA

1:30-1:55 Finite Size Effects in Networks of Theta Neurons

Siwei Qiu and Carson C. Chow, National Institutes of Health, USA

2:00-2:25 Optimal Decision-Making in a Changing Environment

Alan Veliz-Cuba, University of Houston and Rice University, USA; Zachary Kilpatrick and Krešimir Josic, University of Houston, USA

2:30-2:55 A Computational Model of the Influence of Depolarization Block on Initiation of Seizure-like Activity

Duane Nykamp, University of Minnesota, USA

3:00-3:25 Traveling Waves in a Laminar Neural Field Model of Visual Cortex

Samuel R. Carroll, University of Utah, USA; Paul C. Bressloff, University of Utah, USA and University of Oxford, United Kingdom

Tuesday, May 19

MS67

Evolutionary Dynamics and Constraints of Quickly Mutating Pathogens

1:30 PM-3:30 PM

Room:Superior B

Understanding the evolution of pathogens is an important topic in science. High reproduction rates, large populations, high mutation and recombination rates, etc. are but some of the strategies pathogens adopt to escape selection pressure (immune response, drugs/therapies, etc.). Fast paced technological advances are allowing more and more high throughput experimental investigations, thus uncovering novel biological phenomena and providing large high-quality datasets. The aim of this minisymposium is to gather experts in the field of application of dynamical systems to theoretical evolutionary biology to assess determinants and constraints of rapidly evolving organisms in complex environments.

Organizer: Simone Bianco
IBM Research, USA

1:30-1:55 Costs and Benefits of Mutational Robustness in Rna Viruses

Simone Bianco, IBM Research, USA

2:00-2:25 Thermodynamics and Statistical Mechanics of Viral Evolution

Barbara Jones and James Kaufman, IBM Research, USA; Justin Lessler, Johns Hopkins Bloomberg School of Public Health, USA

2:30-2:55 The Acceleration of Evolutionary Spread by Long-Range Dispersal

Oskar Hallatschek, University of California, Berkeley, USA

3:00-3:25 Evolutionary Dynamics of Mutator Phenotypes in Changing Environments

Oana Carja, University of Pennsylvania, USA

Tuesday, May 19

MS68

The Structure and Dynamics of Multilayer Networks

1:30 PM-3:30 PM

Room:White Pine

Up until recently, network theory was almost exclusively limited to networks in which all components were treated on equivalent footing. Only in the last years, taking advantage of the enhanced resolution in real data sets, network scientists have directed their interest to the multiplex character of real-world systems, and explicitly considered the time-varying and multilayer nature of networks. We offer a series of talks on both structural and dynamical organization of graphs made of diverse relationships (layers) between its constituents, and cover several relevant issues, from a full redefinition of the basic structural measures, to understanding how the multilayer nature of the network affects processes and dynamics.

Organizer: Stefano Boccaletti
CNR, Italy

Organizer: Regino Criado
Universidad Rey Juan Carlos, Spain

Organizer: Charo I. del Genio
University of Warwick, United Kingdom

Organizer: Irene Sendina Nadal
Universidad Rey Juan Carlos, Spain

Organizer: Miguel Romance
Universidad Rey Juan Carlos, Spain

Organizer: Zhen Wang
Kyushu University, Japan

1:30-1:55 Characterizing the Structure of Multilayer Networks

Regino Criado and Miguel Romance, Universidad Rey Juan Carlos, Spain

2:00-2:25 Game and Diffusion Dynamics in Multilayer Networks

Zhen Wang, Kyushu University, Japan

2:30-2:55 Synchronization in Time Varying Networks: the Non Commutative Case

Charo I. del Genio, University of Warwick, United Kingdom

continued in next column

3:00-3:25 Synchronization and the problem of Targeting in Multilayer Networks

Ricardo Gutierrez, Weizmann Institute of Science, Israel; *Irene Sendina Nadal*, Universidad Rey Juan Carlos, Spain; Massimiliano Zanin, Technical University of Madrid, Spain; David Papo, Universidad Politécnica de Madrid, Spain; Stefano Boccaletti, CNR, Italy

Tuesday, May 19

MS69

Applications of Chaotic, Stochastic and Multiscale Dynamics

1:30 PM-3:30 PM

Room:Primrose A

Chaotic, stochastic and multiscale processes are common in many areas of contemporary scientific applications, such as modeling in neuroscience, nonlinear optics, and geosciences, among others. Key topics of modeling for complex systems will be brought together in this interdisciplinary session. Two speakers will communicate their recent work in multiscale modeling for neuroscience and nonlinear optics. Two other participants will report their new findings in coarse-graining and response to stochastic perturbations of more general nonlinear systems.

Organizer: Rafail Abramov
University of Illinois, Chicago, USA

Organizer: Ibrahim Fatkullin
University of Arizona, USA

1:30-1:55 The Response of Statistical Averages to Small Stochastic Forcing

Rafail Abramov, University of Illinois, Chicago, USA

2:00-2:25 Is Our Sensing Compressed?

Gregor Kovacic, Rensselaer Polytechnic Institute, USA

2:30-2:55 A Multiscale Method for Optical Responses of Nano Structures

Di Liu, Michigan State University, USA

3:00-3:25 Parareal Methods for Highly Oscillatory Dynamical Systems

Richard Tsai, University of Texas, Houston, USA

Tuesday, May 19

MS70

Recent Applications of Singular Perturbation Theory - Part I of II

1:30 PM-3:30 PM

Room:Primrose B

For Part 2 see MS77

Singularly perturbed dynamical systems arise in many applications; for example, whenever there is a natural separation of time scales or a bifurcation that changes the underlying structure of a system. Many techniques have been developed to study such systems. Geometric singular perturbation methods use properties of "geometric" dynamical objects such as invariant manifolds and foliations. On the other hand, spectral techniques have been used to study transitions between linear operators that are posed on different spaces but are nevertheless "close". This minisymposium presents recent theoretical results for which singular perturbation theory plays a key role in the analysis.

Organizer: Kelly Mcquighan
Boston University, USA

Organizer: Hermen Jan Hupkes
University of Leiden, The Netherlands

Organizer: Peter van Heijster
Queensland University of Technology, Australia

1:30-1:55 Travelling Waves for Fully Discretized Bistable Reaction-Diffusion Problems

Hermen Jan Hupkes, University of Leiden, The Netherlands

2:00-2:25 Oscillatory Pulses in FitzHugh-Nagumo

Paul A. Carter and Bjorn Sandstede, Brown University, USA

2:30-2:55 Invariant Manifolds of Multi Interior Spike States for the Cahn-Hilliard Equation

Peter W. Bates, Michigan State University, USA

3:00-3:25 Slow-Fast Factorization of the Evans Function Via the Riccati Transformation in the Semi-Strong Regime

Björn De Rijk and Arjen Doelman, Leiden University, Netherlands; Jens Rademacher, University of Bremen, Germany

Coffee Break

3:30 PM-4:00 PM

Room:Golden Cliff

Tuesday, May 19

MS71

Emerging Collective Patterns in Dynamic Swarms

4:00 PM-6:00 PM

Room:Ballroom I

Swarming dynamics are characterized by the emergence of complex motion patterns from simple interactions between individual agents. Understanding the mechanisms which drive the formation of these highly coherent motion pattern can lead to key insights into many processes in biology, such as the growth and development in multi-cellular organisms, and the collective motion of animal groups. Such an understanding should prove valuable for the development of algorithms to generate collective motions in engineered systems. This minisymposium will focus on recent advancements in biological swarming dynamics, as well as the application of these methods to swarming systems in engineering.

Organizer: Klementyna Szwaykowska
Naval Research Laboratory, USA

Organizer: Luis Mier-y-Teran
Johns Hopkins Bloomberg School of Public Health, USA

4:00-4:25 Nonlocal Aggregation Models: A Primer of Swarm Equilibria

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

4:30-4:55 Fire Ants Build, Morph, and Repair to Survive Floods

David Hu, Georgia Institute of Technology, USA

5:00-5:25 Quantifying Collective Cell Migration During Cancer Progression

Rachel Lee, University of Maryland, College Park, USA; Haicen Yue and Wouter-Jan Rappel, University of California, San Diego, USA; Wolfgang Losert, University of Maryland, College Park, USA

5:30-5:55 Aggregate Behaviors of Heterogeneous, Delay-Coupled Agents

Klementyna Szwaykowska, Naval Research Laboratory, USA; Christoffer R. Heckman, University of Colorado Boulder, USA; Luis Mier-y-Teran, Johns Hopkins Bloomberg School of Public Health, USA; Ira B. Schwartz, Naval Research Laboratory, USA

Tuesday, May 19

MS72

Synchronization of Chaos, Chimera and Neurosciences - Part II of II

4:00 PM-6:00 PM

Room:Ballroom II

For Part 1 see MS59

Many fundamental processes in nature are based on synchronization of chaos. This phenomenon is universal, robust and it may also involve large population of active elements distributed over extensive spatial regions. In this minisymposium theoretical and application issues related to this phenomenon will be considered. In particular, we address the fundamental role that this phenomenon has in the organization of the collective movement, in neuroscience and in the development of scenarios that lead to coexistence of ordered and disordered states.

Organizer: Elbert E. Macau
Laboratory for Computing and Applied Mathematics and Brazilian Institute for Space Research, Brazil

Organizer: Epaminondas Rosa
Illinois State University, USA

4:00-4:25 Nontrivial Collective Dynamics in Networks of Pulse Coupled Oscillators

Antonio Politi and Ekkehard Ullner, University of Aberdeen, United Kingdom

4:30-4:55 Effects of Reciprocal Inhibitory Coupling in Synchronous Neurons

Epaminondas Rosa, Illinois State University, USA

5:00-5:25 Clustering, Malleability and Synchronization of Hodgkin-Huxley-Type Neurons

Sergio R. Lopes, Thiago de L. Prado, Ricardo L. Viana, and José C. P. Coninck, Federal University of Paraná, Brazil; Juergen Kurths, Potsdam Institute for Climate Impact Research and Humboldt University Berlin, Germany

5:30-5:55 Synchronization in a Cortical Multilayered Computational Model: A Simulation Study

Antonio C. Roque, Renan O. Shimoura, and Rodrigo F. O. Pena, University of Sao Paulo, Brazil

Tuesday, May 19

MS73

Spiral and Scroll Waves Dynamics in Experiment and Simulations - Part II of II

4:00 PM-6:00 PM

Room:Maybird

For Part 1 see MS65

Spiral and scroll waves are nonlinear dissipative patterns occurring in 2- and 3-dimensional excitable and oscillatory media, where they act as organizing centers. Important motivation to study spiral and scroll waves dynamics is better control of cardiac re-entry underlying dangerous arrhythmias and fatal fibrillation. Though, the vortices become of increasing interest of their own as regimes of self-organisation and transition to chaos. Recent advances in experimental, theoretical and computer simulation techniques brought the studies closer to practical applications than ever before. This minisymposium provides a sampling of the current state of experimental and computer simulation research in this field.

Organizer: Irina Biktasheva
University of Liverpool, United Kingdom

4:00-4:25 Crossover Collisions of Scroll Waves

Dennis Kupitz and *Marcus Hauser*, Otto-von-Guericke University, Magdenburg, Germany

4:30-4:55 Role of Small Sized Heterogeneities in the Onset and Perpetuation of Arrhythmias

Alexander Panfilov, Arne Defauw, Nele Vandersickel, and Peter Dawyndt, Ghent University, Belgium

5:00-5:25 Effects of Substrate Geometry on Spiral Wave Chirality

Thomas D. Quail, Alvin Shrier, and Leon Glass, McGill University, Canada

5:30-5:55 Scroll Waves in Viscous Systems with Stokes Flow: Writing Filaments and Other New Tricks

Oliver Steinbock, Florida State University, USA

Tuesday, May 19

MS74

Stochastic and Nonlinear Dynamics of Neuronal Networks - Part II of II

4:00 PM-6:00 PM

Room:Superior A

For Part 1 see MS66

Coherent neural activity patterns have been implicated as a substrate of short term memory, spatial navigation, sensation, and motor skills. Understanding the mechanisms that underlie this activity requires using sophisticated mathematical methods to analyze nonlinear models of neuronal networks. Recent advances along these lines address the effects of stochasticity, spatial heterogeneity, delays, and modular structure on the dynamics of neuronal networks. This session will feature talks on cutting-edge methods for analyzing stochastic neural field equations, balanced networks, and mean field theories for spiking networks.

Organizer: Zachary Kilpatrick
University of Houston, USA

Organizer: Jonathan D. Touboul
Collège de France, France

Organizer: Bard Ermentrout
University of Pittsburgh, USA

4:00-4:25 Oscillations in Neuronal Networks

Stefanos Folias, University of Alaska, Anchorage, USA

4:30-4:55 Dynamics of Networks with Partially Symmetric Connectivity Matrices

Nicolas Brunel, University of Chicago, USA

5:00-5:25 Assembling Collective Activity in Neural Circuits

Eric Shea-Brown, University of Washington, USA

5:30-5:55 On a Kinetic Fitzhugh-Nagumo Equation

Cristobal Quininao, Laboratoire Jacques-Louis Lions, France

Tuesday, May 19

MS75

Between Order and Chaos: Entropy and Information Processing in Complex Dynamics

4:00 PM-6:00 PM

Room:Superior B

Complex systems often exhibit a fine balance between order and chaos. On one hand, high-dimensional deterministic dynamical systems can show sensitive dependence on initial conditions wile on the other, identifying sensible macroscopic physical observables relies on emergent coherent coarse-grained structures. The recent years have seen the application of information-theoretic aspects to a variety of complex dynamics, ranging from stochastic thermodynamics to neuroscience. In this symposium, we review some of these aspects and discuss relations between notions of entropy and information arising in various dynamical descriptions used in complexity science.

Organizer: Bernhard Altaner
Max Planck Institute for Dynamics and Self-Organization, Germany

Organizer: Guillaume Lajoie
University of Washington, USA

4:00-4:25 Entropy, Dissipation and Information Processing in Models of Complex Systems

Bernhard Altaner, Max Planck Institute for Dynamics and Self-Organization, Germany

4:30-4:55 Deconstructing Maxwell's Demon

Dibyendu Mandal, University of California, Berkeley, USA

5:00-5:25 Degrees of Information Processing in Chaotic Dynamical Systems

Ryan G. James, University of California, Davis, USA

5:30-5:55 Time-Dependent Chaotic Attractors Shape Information Content in Neural Networks

Guillaume Lajoie, University of Washington, USA

Tuesday, May 19

MS76

Networks of Chemical Oscillators

4:00 PM-6:00 PM

Room:Primrose A

Chemical oscillations, which are a remarkable nonequilibrium phenomenon, can be observed in chemical engineering applications and are ubiquitous in biological systems. The realization of networks of coupled chemical oscillators with control over the coupling function and topology is a challenging experimental task, even for small and intermediate network sizes. In this workshop we report on recent experiments in which the coupling between the oscillatory chemical reactions is realized via microfluid arrays, optical feedback or wired connections in electrochemical arrays. The experiments demonstrate the connection between the rich dynamical behavior and the network topology.

Organizer: Ralf Toenjes
Potsdam University, Germany

4:00-4:25 Synchronization and Network Topology of Electrochemical Micro-Oscillators in On-Chip Integrated Flow Cells

Istvan Z. Kiss, Yanxin Jia, Yifan Liu, and Jasmine Coleman, Saint Louis University, USA

4:30-4:55 Microfluidic Networks of Belousov-Zhabotinsky Drops

Seth Fraden, Brandeis University, USA

5:00-5:25 Synchronization in Networks of Coupled Chemical Oscillators

Kenneth Showalter, West Virginia University, USA

5:30-5:55 Long Transients to Synchronization in Random Networks of Electrochemical Oscillators

Ralf Toenjes, Potsdam University, Germany; Michael Sebek and Istvan Z. Kiss, Saint Louis University, USA

Tuesday, May 19

MS77

Recent Applications of Singular Perturbation Theory - Part II of II

4:00 PM-6:00 PM

Room:Primrose B

For Part 1 see MS70

Singularly perturbed dynamical systems arise in many applications; for example, whenever there is a natural separation of time scales or a bifurcation that changes the underlying structure of a system. Many techniques have been developed to study such systems. Geometric singular perturbation methods use properties of "geometric" dynamical objects such as invariant manifolds and foliations. On the other hand, spectral techniques have been used to study transitions between linear operators that are posed on different spaces but are nevertheless "close''. This minisymposium presents recent theoretical results for which singular perturbation theory plays a key role in the analysis.

Organizer: Kelly Mcquighan
Boston University, USA

Organizer: Hermen Jan Hupkes
University of Leiden, The Netherlands

Organizer: Peter van Heijster
Queensland University of Technology, Australia

4:00-4:25 Pinning and Unpinning in Nonlocal Equations

Taylor Anderson, Mount Holyoke College, USA; Gregory Faye, École des Hautes Etudes en Sciences Sociales, France; *Arnd Scheel*, University of Minnesota, Minneapolis, USA; David Stauffer, Cornell University, USA

4:30-4:55 Singularities in Front Bifurcations with Scale Separation

Jens Rademacher, University of Bremen, Germany

5:00-5:25 Travelling Waves and Canards in a Model of Wound Healing Angiogenesis

Kristen Harley and Peter van Heijster, Queensland University of Technology, Australia; Robert Marangell, University of Sydney, Australia; Graeme Pettet, Queensland University of Technology, Australia; Martin Wechselberger, University of Sydney, Australia

5:30-5:55 Canard Supersonique

Martin Wechselberger, University of Sydney, Australia

Tuesday, May 19

MS97

Dynamical Models in Drug Delivery

4:00 PM-6:00 PM

Room:Ballroom III

Mathematical modeling of drug delivery has been attracting great attention of scientists for years. It provides an adequate quantitative description of physical, chemical and biological processes that determine the performance of drug delivery systems. The goal of this minisymposium is to present recent advances in modeling basic types of drug delivery, including systems based on fluid flows, swelling and deswelling gels, liquid films, nanoparticles and lipid membranes, as well as transdermal drug delivery systems.

Organizer: Alexander Nepomnyashchy
Technion - Israel Institute of Technology, Israel

Organizer: Vladimir Volper
Northwestern University, USA

4:00-4:25 Cyclic Drug Delivery Devices and Monotone Dynamical Systems

Maria-Carme Calderer, University of Minnesota, USA

4:30-4:55 Evaluation of the Diffusion Coefficient of Nanoparticles Using Mathematical Simulation

Giora Enden and Amnon Sintov, Ben-Gurion University of the Negev, Israel

5:00-5:25 Fluid Flow and Drug Delivery in a Brain Tumor

Ranadhir Roy and Daniel Riahi, University of Texas - Pan American, USA

5:30-5:55 Viscoelastic Effects in Drug Delivery

Alexander Nepomnyashchy, Technion - Israel Institute of Technology, Israel; Vladimir A. Volpert, Northwestern University, USA; Yulia Kanevsky, Technion - Israel Institute of Technology, Israel

Tuesday, May 19

CP26

Topics in Financial Dynamical Systems and Related Themes

4:00 PM-5:00 PM

Room:Magpie A

Chair: To Be Determined

4:00-4:15 Constant Rebalanced Portfolio Strategy Is Rational in a Multi-Group Asset Trading Model

Mark DeSantis, Chapman University, USA; David Swigon, University of Pittsburgh, USA

4:20-4:35 How Monetary Policy Can Cause Forecasting Uncertainty

James M. Haley, Point Park University, USA

4:40-4:55 Non-Smooth Dynamics and Bifurcations in a Model of Electricity Market

Gerard Olivar Tost and Johnny Valencia Calvo, Universidad Nacional de Colombia, Colombia

Tuesday, May 19

CP27

Topics in Biological Dynamics IV

4:00 PM-6:00 PM

Room:Magpie B

Chair: Linda Sommerlade, University of Aberdeen, United Kingdom

4:00-4:15 Analysis of Cholera Epidemics with Bacterial Growth and Spatial Movement

Xueying Wang, Washington State University, USA

4:20-4:35 Optogenetic Stimulation of a Meso-Scale Human Cortical Model

Prashanth Selvaraj and Andrew J. Szeri, University of California, Berkeley, USA; James W. Sleigh, University of Auckland, New Zealand; Heidi E. Kirsch, University of California, San Francisco, USA

4:40-4:55 Growth Dynamics for Pomacea Maculata

Lihong Zhao and Karyn L. Sutton, University of Louisiana, Lafayette, USA; Jacoby Carter, USGS National Wetlands Research Center, USA

5:00-5:15 Assessing the Strength of Directed Influences Among Neural Signals

Linda Sommerlade and Marco Thiel, University of Aberdeen, United Kingdom; Claude Wischik, TauRx Therapeutics Ltd., Singapore; Bjoern Schelter, University of Aberdeen, United Kingdom

5:20-5:35 Benefits of Noise in Synaptic Vesicle Release

Calvin Zhang and Charles S. Peskin, Courant Institute of Mathematical Sciences, New York University, USA

5:40-5:55 Towards Understanding Mechanisms of Pain Transmission: a Systems Theoretic Approach

Pierre Sacré and Sridevi Sarma, Johns Hopkins University, USA

Tuesday, May 19

CP28

Topics in Feedback/Control/ Optimization II

4:00 PM-5:00 PM

Room:Wasatch A

Chair: Raya Horesh, IBM T.J. Watson Research Center, USA

4:00-4:15 Towards a Structural Theory of Controllability of Binary Networks

Afroza Shirin, University of New Mexico, USA

4:20-4:35 Optimal Treatment Strategies for HIV-TB Co-Infected Individuals

Abhishek Mallela, University of Missouri, Kansas City, USA; Suzanne M. Lenhart, University of Tennessee, USA; Naveen K. Vaidya, University of Missouri, Kansas City, USA

4:40-4:55 Optimal Control of Building's Hvac System with on-Site Energy Storage and Generation System

Raya Horesh, Young M. Lee, and Leo Liberti, IBM T.J. Watson Research Center, USA; Young Tae Chae, Hyundai Engineering & Construction Co., Ltd, Korea; Rui Zhang, IBM T.J. Watson Research Center, USA

Tuesday, May 19

CP29

Topics in Pattern Formation II

4:00 PM-5:20 PM

Room:Wasatch B

Chair: Víctor Brena-Medina, University of Bristol, United Kingdom

4:00-4:15 Symmetry Groups and Dynamics of Time-Fractional Diffusion Equation

Muhammad D. Khan, Institute of Business Management, Pakistan

4:20-4:35 Polynomial Mixing Rates of Particle Systems

Yao Li, Courant Institute of Mathematical Sciences, New York University, USA

4:40-4:55 Stripe to Spot Transition in a Plant Root Hair Initiation Model

Victor F. Brena-Medina, University of Bristol, United Kingdom; Daniele Avitabile, University of Nottingham, United Kingdom; Alan R. Champneys, University of Bristol, United Kingdom; Michael Ward, University of British Columbia, Canada

5:00-5:15 Onset of Singularities in the Pattern of Fluctuational Paths of a Nonequilibrium System

Oleg B. Kogan, Cornell University, USA; Mark I. Dykman, Michigan State University, USA

Dinner Break

6:00 PM-8:30 PM

Attendees on their own

SIADS Editorial Board Meeting

6:30 PM-8:30 PM

Room: Summit Room

Tuesday, May 19

PP1

Poster Session and Dessert Reception

8:30 PM-10:30 PM

Room:Ballroom

The Breakup of Invariant Tori in 4-D Maps Using the Slater's Criterion

Celso Abud and Ibere L. Caldas, University of Sao Paulo, Brazil

Theta Model for Quartic Integrate-and-Fire Neuron Model

Akihiko Akao and Yutaro Ogawa, University of Tokyo, Japan; Bard Ermentrout, University of Pittsburgh, USA; Yasuhiko Jimbo and Kiyoshi Kotani, University of Tokyo, Japan

A Solution of Linear Programming Problems with Interval Coefficients

Ibraheem Alolyan, King Saud University, Saudia Arabia

Developing a Model Approximation Method and Parameter Estimates for a Solar Thermochemistry Application

William D. Arloff, Karl Schmitt, Luke Venstrom, and Leandro Jaime, Valparaiso University, USA

Hamiltonian Hopf Bifurcations in Schrödinger Trimers

Casayndra H. Basarab and Roy Goodman, New Jersey Institute of Technology, USA

Computing the Optimal Path in Stochastic Dynamical Systems

Martha Bauver, Lora Billings, and Eric Forgoston, Montclair State University, USA

Effects of Quasi-Steady-State Reduction on Biophysical Models with Oscillations

Sebastian D. Boie, Vivien Kirk, and James Sneyd, University of Auckland, New Zealand

Analyzing Cycling Dynamics in Stochastic Systems

Pralhad Burli, Lora Billings, and Eric Forgoston, Montclair State University, USA

Limit Cycles in a Simplified Basal Ganglia Model

Michael Caiola and Mark Holmes, Rensselaer Polytechnic Institute, USA

continued on next page

Tuesday, May 19

PP1

Poster Session and Dessert Reception

8:30 PM-10:30 PM

Room:Ballroom

cont.

Mathematical Modelling of Spatial Sorting and Evolution in a Host-Parasite System

Matthew H. Chan, Gregory Brown, Richard Shine, and Peter S. Kim, University of Sydney, Australia

New Computational Tools for Non-Smooth Dynamical Systems

Antonio S. Chong and Marian Wiercigroch, University of Aberdeen, United Kingdom

Polyrhythmic Synchronization in Modular Networks

Jarod Collens, Justus T. Schwabedal, Andrey Shilnikov, and *Drake Knapper*, Georgia State University, USA

Modeling the Lymphocytic Choriomeningitis Virus: Insights into Understanding Its Epidemiology in the Wild

Christy Contreras, Arizona State University, USA

Causal Relationships Between Time Series: Generalizing Takens' Theorem to a Dynamical Network

Bree Cummins and Tomas Gedeon, Montana State University, USA; Kelly Spendlove, Rutgers University, USA

Regular Acceleration from Low Initial Energies in a Magnetized Relativistic System

Meirielen C. De Sousa and Iberê L. Caldas, Universidade de Sao Paulo, Brazil; Fernanda Steffens, Deutsches Elektronen-Synchrotron, Germany; Renato Pakter and Felipe Rizzato, Universidade Federal do Rio Grande do Sul, Brazil

Estimating the L^∞-Norm of Linear Solutions of Cahn-Hilliard

Philipp Düren, Universität Augsburg, Germany

Spike Adding in Transient Dynamics

Saeed Farjami, Hinke M. Osinga, and Vivien Kirk, University of Auckland, New Zealand

Front-Dynamics and Pattern Selection in the Wake of Triggered Instabilities

Ryan Goh and Arnd Scheel, University of Minnesota, USA

Pattern Sequences as Early-warning Signs of Critical Transition in Models of Dryland Vegetation

Karna V. Gowda, Yuxin Chen, Sarah Iams, and Mary Silber, Northwestern University, USA

Rigorous Computation of Radially Symmetric Stationary Solutions of Pdes

Chris M. Groothedde, VU University, Amsterdam, Netherlands

Dynamics of Register Transitions in Human Vocal Fold Modeling

Jesse Haas, Grenoble University, France

A Mathematical Model of Saliva Secretion and Calcium Dynamics

Jung Min Han, James Sneyd, and Vivien Kirk, University of Auckland, New Zealand

Mixed-Mode Oscillations and Twin Canards

Ragheb Hasan, Hinke M. Osinga, and Bernd Krauskopf, University of Auckland, New Zealand

A Dynamical Analysis of Steam Supply Network Based on Invariant Manifold

Hikaru Hoshino and Yoshihiko Susuki, Kyoto University, Japan

Defects in Spatially Extended Systems

Gabriela Jaramillo, University of Minnesota, USA; Arnd Scheel, University of Minnesota, Minneapolis, USA

Delayed Feedback Model of Axonal Length Sensing

Bhargav R. Karamched, University of Utah, USA; Paul C. Bressloff, University of Utah, USA and University of Oxford, United Kingdom

Nonlinear Dynamical Systems in Finance

Deniz K. Kiliç, Middle East Technical University, Turkey

continued in next column

Discriminating Chaotic and Stochastic Dynamics Through the Permutation Spectrum Test

Christopher W. Kulp, Lycoming College, USA; Luciano Zunino, Centro de Investigaciones en Optica, Mexico

Coupling Methods As a Tool for Sensitivity Analysis of Stochastic Differential Equations

Andrew Leach, University of Arizona, USA

Transient Dynamics in Ensemble of Inhibitory Coupled Rulkov Maps

Tatiana A. Levanova and Grigory Osipov, Lobachevsky State University of Nizhny Novgorod, Russia

Complex Collective Behavior in a Network of Theta Neurons is Suppressed by Synaptic Diversity

Lucas Lin, Thomas Jefferson High School of Science and Techonology, USA; Paul So and Ernest Barreto, George Mason University, USA

Shape Coherence and Finite-Time Curvature Evolution in Time-Dependent Dynamical Systems

Tian Ma and Erik Bollt, Clarkson University, USA

Snaking on Networks: From Local Solutions to Turing Patterns

Nick McCullen, University of Bath, United Kingdom; Matthias Wolfrum, Weierstrass Institute for Applied Analysis and Stochastics, Germany; Thomas Wagenknecht, University of Leeds, United Kingdom

Fractal Boundaries in the Parameters Space of Deterministic Dynamical Systems

Everton S. Medeiros, University of Sao Paulo, Brazil; Iberê L. Caldas, Universidade de Sao Paulo, Brazil; Murilo Baptista, University of Aberdeen, United Kingdom

A Biophysical Model for the Role of Network Topology in Regulating a Two-Phase Breathing Rhythm

Joshua Mendoza, Kameron Decker Harris, and Eric Shea-Brown, University of Washington, USA; Jan Ramirez and Tatiana Dashevskiy, Seattle Children's Research Institute, USA

Modeling Effects of Drugs of Abuse on Hiv-Specific Antibody Responses

Jones M. Mutua, Anil Kumar, and Naveen K. Vaidya, University of Missouri, Kansas City, USA

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Time-Delayed Model of Immune Response in Plants

Giannis Neofytou and Konstantin Blyuss, University of Sussex, United Kingdom

Analysis and Control of Pre-Extinction Dynamics in Stochastic Populations

Garrett Nieddu, Lora Billings, and Eric Forgoston, Montclair State University, USA

An Explicit Formula for R_0 of Tick-Borne Relapsing Fever

Cody Palmer, University of Montana, USA

Title Not Available

Youngmin Park, University of Pittsburgh, USA

Stochastic Motion of Bumps in Planar Neural Fields

Daniel Poll and Zachary Kilpatrick, University of Houston, USA

Automatically Proving Periodic Solutions to Polynomial ODEs

Elena Queirolo, Vrije Universiteit Amsterdam, The Netherlands

Repulsive Inhibition Promotes Synchrony in Excitatory Networks of Bursting Neurons

Reimbay Reimbayev and Igor Belykh, Georgia State University, USA

Quasipatterns in Two and Three Dimensions

Alastair M. Rucklidge, University of Leeds, United Kingdom

Rigorous Computations for BVPs with Chebyshev-series

Ray Sheombarsing, VU University, Amsterdam, Netherlands

Central Configurations of Symmetrically Restricted Five-Body Problem

Anoop Sivasankaran, Khalifa University of Science, Technology and Research, United Arab Emirates; Muhammad Shoaib and Abdulrehman Kashif, University of Hail, Saudi Arabia

Finite Time Diagnostics and Transport Barriers in Non Twist Systems

Jose D. Szezech Jr, Ponta Grossa State University, Brazil; Ibere L. Caldas, University of Sao Paulo, Brazil; Sergio R. Lopes and Ricardo L. Viana, Federal University of Paraná, Brazil; Philip Morrison, University of Texas at Austin, USA

continued in next column

Robust Pulse Generators in An Excitable Medium

Takashi Teramoto, Asahikawa Medical University, Japan

Dynamical Building Blocks in Turbulent Two-Dimensional Channel Flow

Toshiki Teramura and Sadayoshi Toh, Kyoto University, Japan

Phase Models and Oscillators with Time Delayed All-to-All Coupling

Zhen Wang, University of Waterloo, Canada

Efficient Design of Navigable Networks

B.M. Shandeepa D. Wickramasinghe and Jie Sun, Clarkson University, USA

Instability of Certain Equilibrium Solutions of the Euler Fluid Equations

Joachim Worthington, Holger R. Dullin, and Robby Marangell, University of Sydney, Australia

A Symbolic Method in Chua's Circuit

Tingli Xing and Andrey Shilnikov, Georgia State University, USA

Interactions of Solitary Modes in Models of Bacterial Chemotaxis

Glenn S. Young, Hanna Salman, Bard Ermentrout, and Jonathan Rubin, University of Pittsburgh, USA

The Spread of Activity with Refractory Periods over Directed Networks

Daniel R. Zavitz and Alla Borisyuk, University of Utah, USA

Using Tangles to Quantify Topological Mixing of Fluids

Qianting Chen, Sulimon Sattari, and Kevin A. Mitchell, University of California, Merced, USA

Computing Chaotic Transport Properties in a Mixed Phase Space with Periodic Orbits

Sulimon Sattari and Kevin A. Mitchell, University of California, Merced, USA

Wednesday, May 20

Registration

8:00 AM-4:30 PM

Room:Ballroom Foyer

MS78

Dynamics of Moreau Sweeping Processes - Part I of II

8:30 AM-10:30 AM

Room:Ballroom I

For Part 2 see MS91

A sweeping process describes the motion of a particle which is governed by a differential equation on the one hand and which is constrained by a moving convex set on the other hand. Such a configuration leads to a differential inclusion with unbounded right-hand-terms (Clarke normal cones). Building upon the discrete approximation scheme proposed my Moreau in 70th the theory of sweeping processes is now able to analyse the existence, continuous dependence, periodicity and (Lyapunov) stability of solutions.
This minisymposium accumulates current achievements aiming to approach the structural stability and to understand how the dynamics changes under varying parameters (control).

Organizer: Oleg Makarenkov
University of Texas at Dallas, USA

8:30-8:55 On the Response of Sweeping Processes to Perturbation

Mikhail Kamenski, Voronezh State University, Russia; *Oleg Makarenkov*, University of Texas at Dallas, USA

9:00-9:25 Dynamics of Sweeping Processes with Jumps in the Driving Term

Vincenzo Recupero, Politecnico di Torino, Italy

9:30-9:55 Control of Moreau's Sweeping Process: Some Results and Open Problems

Giovanni Colombo, University of Padova, Italy

10:00-10:25 Estimation and Control Problems in Systems with Moreau's Sweeping Process

Aneel Tanwani, University of Kaiserslautern, Germany

Wednesday, May 20

MS79

Topological Fluid and Mass Dynamics - Part I of II

8:30 AM-10:30 AM

Room:Ballroom II

For Part 2 see MS92

Topological and geometrical methods provide powerful tools for predicting and interpreting the dynamics of fluid flows and interacting masses. This minisymposium will explore recent developments in the use of these methods for considering relative equilibria, modeling interaction dynamics on surfaces, and characterizing structure and transport in complex flows. This minisymposium is dedicated to Konrad Bajer (1956-2014), who made many contributions in this area.

Organizer: Stefanella Boatto
Universidade Federal do Rio De Janeiro, Brazil

Organizer: Mark A. Stremler
Virginia Tech, USA

8:30-8:55 Eulerian Geometric Integration of Fluids for Computer Graphics

Mathieu Desbrun, California Institute of Technology, USA; Dmitry Pavlov, Imperial College London, United Kingdom; Evan S. Gawlik, Stanford University, USA; Yiying Tong, Michigan State University, USA; Gemma Mason, California Institute of Technology, USA; Eva Kanso, University of Southern California, USA

9:00-9:25 Poincare-Birkhoff Normal Forms for Hamiltonian Relative Equilibria

Cristina Stoica, Wilfrid Laurier University, Canada

9:30-9:55 The Dynamics of Vortices and Masses over Surfaces of Revolution

Stefanella Boatto and Gladston Duarte, Universidade Federal de Rio de Janeiro, Brazil; David G. Dritschel, University of St. Andrews, United Kingdom; Teresa J. Stuchi, Universidade Federal de Rio de Janeiro, Brazil; Carles Simo, Universitat de Barcelona, Spain; Rodrigo Schaefer, Universitat Politecnica de Catalunya, Spain

10:00-10:25 Studies on Dynamics of Vortices on a Flat Torus

Humberto H. de Barros Viglioni, Universidade Federal de Sergipe, Brazil

Wednesday, May 20

MS80

Theoretical Aspects of Spiral and Scroll Wave Dynamics - Part I of II

8:30 AM-10:30 AM

Room:Ballroom III

For Part 2 see MS93

Spiral and scroll waves are the most common types of solutions characterizing the dynamics of 2- and 3-dimensional excitable media such as the cardiac tissue. This minisymposium presents a sampling of recent analytical and numerical studies focusing on the interaction of scroll and spiral waves with perturbations such as structural heterogeneities and external stimuli as well as self-interactions and interaction of different spiral/scroll waves with each other.

Organizer: Roman Grigoriev
Georgia Institute of Technology, USA

Organizer: Vadim N. Biktashev
University of Exeter, United Kingdom

8:30-8:55 Drift of Scroll Waves in Thin Layers Caused by Thickness Features

Irina Biktasheva, University of Liverpool, United Kingdom; Hans Dierckx, Ghent University, Belgium; *Vadim N. Biktashev*, University of Exeter, United Kingdom

9:00-9:25 Spiral Pinballs

Jacob Langham and Dwight Barkley, University of Warwick, United Kingdom

9:30-9:55 Tidal Forces Act on Cardiac Filaments

Hans Dierckx, Ghent University, Belgium

10:00-10:25 Computation of Unstable Solutions of Cardiac Models on Static and Evolving Domains

Christopher Marcotte and Roman Grigoriev, Georgia Institute of Technology, USA

Wednesday, May 20

MS81

First Passage Times in Discrete and Continuous Systems - Part I of II

8:30 AM-10:30 AM

Room:Magpie A

For Part 2 see MS94

Numerous problems in nature are formulated in terms of Mean First Passage Time (MFPT) of Brownian particles in the presence of traps. For example, cells are regulated by chemical reactions involving signaling molecules that have to find their targets in a complex and crowded environment. The study of MFPT touches upon many topics and utilizes diverse tools including PDEs, stochastic differential equations, complex variables, generating functions and many others. This mini-session will bring together experts in this active field of research. Directions that will be considered include: search-and-rescue, mobile traps, narrow escape problems on bounded domains, connections to spike solutions of PDEs, and applications in biology and physics.

Organizer: Alan E. Lindsay
University of Notre Dame, USA

Organizer: Justin C. Tzou
Dalhousie University, Canada

8:30-8:55 First Passage Times in Biological Self-Assembly

Maria D'Orsogna, California State University, Northridge, USA; Tom Chou, University of California, Los Angeles, USA

9:00-9:25 Asymptotic Analysis of Narrow Escape Problems in Non-Spherical 3D Domains

Alexei F. Cheviakov, University of Saskatchewan, Canada; Daniel Gomez, University of British Columbia, Canada

9:30-9:55 Signal Focusing Through Active Transport

Aljaz Godec and Ralf Metzler, Universität Potsdam, Germany

10:00-10:25 First-Passage Times of Random Walks in Confined Geometries

Olivier Benichou, Université Pierre et Marie Curie, France

Wednesday, May 20

MS82

Control of Multiscale Dynamics - Part I of II

8:30 AM-10:30 AM

Room:Magpie B

For Part 2 see MS95

The control of dynamical systems has been extensively studied in the past century, which led to significant applications such as space mission, aerocraft design, or nanoelectromechanical systems. Multiscale simulation and modeling, on the other hand, has become an active field in recent years, due to the multiscale nature of complex systems ubiquitous in practical applications. We consider it an emerging direction to go further and control multiscale systems, which was not possible without contemporary multiscale methods and computational architectures. The proposed minisymposium gathers researchers working on frontiers of related fields, with goals of shaping this new direction and contributing to important applications.

Organizer: Molei Tao

Georgia Institute of Technology, USA

8:30-8:55 Control of Multiscale Dynamical Systems

Richard D. Braatz, Massachusetts Institute of Technology, USA

9:00-9:25 Some Results on the Backward Stability of Singular Perturbation Approximations of Linear and Nonlinear Stochastic Control Systems

Carsten Hartmann, Free University Amsterdam, Netherlands

9:30-9:55 Variational Integrators for Multiscale Dynamics

Sina Ober-Bloebaum, University of Paderborn, Germany; Sigrid Leyendecker, University of Erlangen-Nuremberg, Germany

10:00-10:25 Control of Oscillators, Temporal Homogenization, and Energy Harvest by Super-Parametric Resonance

Molei Tao, Georgia Institute of Technology, USA

Wednesday, May 20

MS83

Wave Propagation in Highly Nonlinear Dispersive Media - Part I of II

8:30 AM-10:30 AM

Room:Wasatch A

For Part 2 see MS96

Wave propagation in highly nonlinear dispersive media has recently attracted considerable attention of the interdisciplinary community that includes applied mathematicians, physicists and engineers. In particular, dynamics of granular crystals has been a subject of intensive theoretical and experimental research because of their unique, adaptive dynamical properties. Strongly nonlinear dispersive media may exhibit quite intriguing phenomena such as broadband absorption, high-rate wave attenuation and strong energy localization, rendering them highly attractive for multiple engineering applications. In this minisymposium, leading experts dealing with this class of dynamical systems will come together for a creative exchange of ideas involving fundamental and applied research.

Organizer: Anna Vainchtein

University of Pittsburgh, USA

Organizer: Yuli Starosvetsky

Technion - Israel Institute of Technology, Israel

8:30-8:55 Granular Acoustic Switches and Logic Elements

Jinkyu Yang and Feng Li, University of Washington, USA; Paul Anzel, California Institute of Technology, USA; Panayotis Kevrekidis, University of Massachusetts, USA; Chiara Daraio, ETH Zürich, Switzerland and California Institute of Technology, USA

9:00-9:25 Nonlinear Waves in Microsphere-Based Metamaterials

Nicholas Boechler, University of Washington, USA

9:30-9:55 Multiscale Analysis of Strongly Localized Waves

Guillaume James, Université de Grenoble and CNRS, France

10:00-10:25 Standing Waves on Tadpole Graphs

Dmitry Pelinovsky, McMaster University, Canada

Wednesday, May 20

MS84

Dynamics of Neural Networks with General Connectivity and Nonlinearity

8:30 AM-10:30 AM

Room:Wasatch B

The dynamics of a neural field model can be analyzed using a nonlinear integro-differential equation. Two basic components in this model are the integral kernel, which models the network connectivity, and the nonlinear gain function. Many previous results are obtained under rather restrictive assumptions on the connectivity and the gain. In this minisymposium, we will present some recent theoretical as well as experimental works for more general types of connectivity functions and gain functions. The talks will discuss analytical tools for and dynamical consequences of generalizations such as anisotropy/inhomogeneity in the connectivity functions and non-monotonicity in the gain functions.

Organizer: Dennis Yang

Drexel University, USA

8:30-8:55 Asymmetric Stationary Bumps in Neural Field Models

Dennis Yang, Drexel University, USA

9:00-9:25 Homogenization Theory for Neural Field Models

John Wyller, Norwegian University of Life Sciences, Norway

9:30-9:55 Traveling Patterns in Lateral Inhibition Neural Networks

Yixin Guo and Aijun Zhang, Drexel University, USA

10:00-10:25 Modulating Synaptic Plasticity Within In Vitro Hippocampal Networks

Rhonda Dzakpasu, Georgetown University, USA

Wednesday, May 20

MS85

Advances in Viral Infection Modeling - Part I of II

8:30 AM-10:30 AM

Room:Maybird

For Part 2 see MS98

Viral infections, be they acute, like influenza or ebola, or chronic, like HIV, pose a continuing threat to daily life. In recent years mathematical modeling has become an important tool in investigating these infections, and novel methods are rapidly emerging. The primary goal of this minisymposium is to provide a platform for discussion of mathematical advances in viral infection modeling and resulting insights into viral infections, at both the within-host and between-hosts (epidemiological) scales.

Organizer: Jessica M. Conway
Pennsylvania State University, USA

Organizer: Naveen K. Vaidya
University of Missouri, Kansas City, USA

8:30-8:55 A Multi-Scale Model of Multiple Exposures to a Pathogen

Jane Heffernan and Redouane Qesmi, York University, Canada; Jianhong Wu, York University, Canada

9:00-9:25 Contact Network Models for Immunizing Infections

Shweta Bansal, Georgetown University, USA

9:30-9:55 Evaluation of Combined Strategies for Controlling Dengue Fever

Alun Lloyd, North Carolina State University, USA

10:00-10:25 Mathematical Models of the Spatial and Evolutionary Dynamics of Influenza A

Julia R. Gog, University of Cambridge, United Kingdom

Wednesday, May 20

MS86

Front Propagation in Advection-Reaction-Diffusion Systems - Part I of II

8:30 AM-10:30 AM

Room:Superior A

For Part 2 see MS99

Autocatalytic reactions in a spatially-extended system are characterized by the propagation of reaction fronts separating the species. The front dynamics is generally well-understood for reaction-diffusion systems in the absence of substrate flow. The effects of fluid motion on fronts in the general advection-reaction-diffusion (ARD) case have only recently received significant attention, despite the wide applicability of ARD, including microfluidic chemical reactors, plasmas, ecosystem dynamics in the oceans (e.g., plankton blooms), cellular- and embryonic-scale biological processes. This minisymposium brings together groups studying ARD systems from a variety of perspectives, including experiments, dynamical systems theory, numerical PDEs, and analytics.

Organizer: Kevin A. Mitchell
University of California, Merced, USA

Organizer: Thomas H. Solomon
Bucknell University, USA

Organizer: John R. Mahoney
University of California, Merced, USA

8:30-8:55 Front Pinning in Single Vortex Flows

John R. Mahoney and Kevin A. Mitchell, University of California, Merced, USA

9:00-9:25 Front Propagation in Cellular Flows for Fast Reaction and Small Diffusivity

Alexandra Tzella, University of Birmingham, United Kingdom; Jacques Vanneste, University of Edinburgh, United Kingdom

9:30-9:55 Experimental Studies of Burning Invariant Manifolds as Barriers to Reaction Fronts

Savannah Gowen, Mount Holyoke College, USA; Tom Solomon, Bucknell University, USA

10:00-10:25 Propagation of An Autocatalytic Reaction Front in Heterogeneous Porous Media

Laurent Talon, Université Paris-Sud, France; Dominique Salin, University of Pittsburgh School of Medicine, USA

Wednesday, May 20

MS87

Nonsmooth Dynamical Systems: Theory and Applications - Part I of II

8:30 AM-10:30 AM

Room:Superior B

For Part 2 see MS100

Many physical systems involve abrupt events, such as switches, impacts or thresholds, and are well-modelled by equations that are nonsmooth. This minisymposium will discuss novel applications of nonsmooth systems in ecology, optics and neuroscience, as well as describe new developments in the theory of nonsmooth systems. Overall the talks will highlight the various nuances of nonsmooth systems and show how these relate to the dynamical behaviour of the physical systems being modelled.

Organizer: David J. Simpson
Massey University, New Zealand

8:30-8:55 Infinitely Many Coexisting Attractors in the Border-Collision Normal Form

David J. Simpson, Massey University, New Zealand

9:00-9:25 Geometric Optics and Piecewise Linear Systems

Paul Glendinning, University of Manchester, United Kingdom

9:30-9:55 Analysis of Traveling Pulses and Fronts in a Nonsmooth Neural Mass Model

Jeremy D. Harris, University of Pittsburgh, USA

10:00-10:25 Are Plankton Discontinuous, Smooth Or Slow-Fast (and Furious)?

Sofia Piltz, University of Oxford, United Kingdom

Wednesday, May 20

MS88

Emergent Phenomena from Many-player Dynamics in Biological and Social Systems

8:30 AM-10:30 AM

Room:White Pine

Systems wherein the behavior of individual organisms is controlled by simple interaction rules, such as from discrete games, can lead to organized large scale dynamics. The global behavior can depend heavily on small nuances in the underlying interaction rules, as well as the network and/or structure on which these organisms reside. In this minisymposium, we will explore the dynamics that arise from various biological and social interactions within systems comprised of large numbers of agents.

Organizer: Scott Mccalla
Montana State University, USA

Organizer: Martin Short
Georgia Institute of Technology, USA

8:30-8:55 Hotspots in a Non-Local Crime Model

Scott Mccalla, Montana State University, USA; Jonah Breslau, Pomona College, USA; Sorathan Chaturapruek, Harvey Mudd College, USA; Theodore Kolokolnikov, Dalhousie University, Canada; Daniel Yazdi, University of California, Los Angeles, USA

9:00-9:25 Co-Dimension One Self Assembly

James von Brecht, California State University, Long Beach, USA; Scott Mccalla, Montana State University, USA; David T. Uminsky, University of San Francisco, USA

9:30-9:55 Swarming of Self-propelled Particles in Fluids

Yaoli Chuang and Maria D'Orsogna, California State University, Northridge, USA

10:00-10:25 Origin and Structure of Dynamic Social Networks Based on Cooperative Actions

Christoph Hauert and Lucas Wardil, University of British Columbia, Canada

Wednesday, May 20

MS89

Complex Network Theory Based Approaches in the Analyses of Complex Systems and Data - Part I of II

8:30 AM-10:30 AM

Room:Primrose A

For Part 2 see MS102

Analysis of network data obtained from a complex system is often a challenging task. In this minisymposium we will be discussing few novel approaches for obtaining insights into the structural and functional properties of empirical networks and networks inferred from data. One of our focus areas will be to employ simulation of variety of dynamical processes on networks to study properties of empirical networks. We will also discuss methodologies to overcome problems in the analysis of empirical networks due to spurious or missing links. Dynamical system based approaches for transforming data into a network representing will also be presented.

Organizer: Nishant Malik
University of North Carolina at Chapel Hill, USA

8:30-8:55 Role of Netwok Topology in Collective Opinion Formation

Nishant Malik, University of North Carolina at Chapel Hill, USA

9:00-9:25 Network Reliability As a Tool for Using Dynamics to Probe Network Structure

Stephen Eubank, Yasamin Khorramzadeh, Mina Youssef, Shahir Mowlaei, and Madhurima Nath, Virginia Tech, USA

9:30-9:55 Linear Dynamics on Brain Networks: A Tool for Understanding Cognition

Danielle Bassett, University of Pennsylvania, USA and *Fabio Pasqualetti,* University of California, Riverside, USA

10:00-10:25 Dynamical Macro-Prudential Stress Testing Using Network Theory

Dror Y. Kenett, Boston University, USA

Wednesday, May 20

MS90

Sensitivity Methods with Applications

8:30 AM-10:30 AM

Room:Primrose B

Sensitivity and uncertainty analysis are used to understand the role of variability inherent in the physical experimentation, mathematical interpretation and mathematical analysis. We are interested in biological applications where uncertainty arises in each aspect of the joint experimental and theoretical studies. For example, immune response to bacterial challenge has stochastic elements. Additionally all experiments have limited precision in measuring the data, making parameter estimation challenging. Finally, model analysis typically requires approximation such as perturbation or numerical methods. We focus on methods for quantifying uncertainty in biological processes, the sensitivity of the model with respect to parameters and data assimilation methods.

Organizer: Nick Cogan
Florida State University, USA

8:30-8:55 Using Sensitivity Analysis to Understand S. aureus Infections

Angela M. Jarrett, Nick Cogan, and M Yousuff Hussaini, Florida State University, USA

9:00-9:25 Computational Aspects of Stochastic Collocation with Multi-Fidelity Models

Xueyu Zhu and Dongbin Xiu, University of Utah, USA

9:30-9:55 The Dynamics of Alopecia Areata

Atanaska Dobreva, Florida State University, USA; Ralf Paus, University of Manchester, United Kingdom and University of Münster, Germany; Nicholas Cogan, Florida State University, USA

10:00-10:25 Epistemic Uncertainty Quantification Using Fuzzy Set Theory

YanYan He and Dongbin Xiu, University of Utah, USA

Coffee Break

10:30 AM-11:00 AM

Room:Golden Cliff

Wednesday, May 20

IP5

Cooperation, Cheating, and Collapse in Biological Populations

11:00 AM-11:45 AM

Room:Ballroom

Chair: Jan Medlock, Oregon State University, USA

Natural populations can suffer catastrophic collapse in response to small changes in environmental conditions as a result of a bifurcation in the dynamics of the system. We have used laboratory microbial ecosystems to directly measure theoretically proposed early warning signals of impending population collapse based on critical slowing down. Our experimental yeast populations cooperatively break down sugar, meaning that below a critical size the population cannot sustain itself. The cooperative nature of yeast growth on sucrose makes the population susceptible to "cheater" cells, which do not contribute to the public good and reduce the resilience of the population.

Jeff Gore
Massachusetts Institute of Technology, USA

Lunch Break

11:45 AM-1:30 PM

Attendees on their own

Wednesday, May 20

MS91

Dynamics of Moreau Sweeping Processes - Part II of II

1:30 PM-3:30 PM

Room:Ballroom I

For Part 1 see MS78

A sweeping process describes the motion of a particle which is governed by a differential equation on the one hand and which is constrained by a moving convex set on the other hand. Such a configuration leads to a differential inclusion with unbounded right-hand-terms (Clarke normal cones). Building upon the discrete approximation scheme proposed my Moreau in 70th the theory of sweeping processes is now able to analyse the existence, continuous dependence, periodicity and (Lyapunov) stability of solutions. This minisymposium accumulates current achievements aiming to approach the structural stability and to understand how the dynamics changes under varying parameters (control).

Organizer: Oleg Makarenkov
University of Texas at Dallas, USA

1:30-1:55 Sweeping Process and Congestion Models for Crowd Motion

Juliette Venel, Universite Lille-Nord de France, France

2:00-2:25 Evolution Equations Governed by Sweeping Processes and Applications in Heat Equations with Controlled Obstacles

Hoang Nguyen, University of Technical Federical Santa Maria, Chile

2:30-2:55 Periodic Solutions of Moreau Sweeping Processes and Applications

Ivan Gudoshnikov, University of Texas at Dallas, USA

3:00-3:25 Moreau Sweeping Processes on Banach Spaces

Messaoud Bounkhel, King Saud University, Saudia Arabia

Wednesday, May 20

MS92

Topological Fluid and Mass Dynamics - Part II of II

1:30 PM-3:30 PM

Room:Ballroom II

For Part 1 see MS79

Topological and geometrical methods provide powerful tools for predicting and interpreting the dynamics of fluid flows and interacting masses. This minisymposium will explore recent developments in the use of these methods for considering relative equilibria, modeling interaction dynamics on surfaces, and characterizing structure and transport in complex flows. This minisymposium is dedicated to Konrad Bajer (1956-2014), who made many contributions in this area.

Organizer: Stefanella Boatto
Universidade Federal do Rio De Janeiro, Brazil

Organizer: Mark A. Stremler
Virginia Tech, USA

1:30-1:55 Braid Dynamics, Self-organized Criticality, and Solar Coronal Heating

Mitchell Berger, University of Exeter, United Kingdom

2:00-2:25 Topological Shocks in Burgers Turbulence

Kostantin Khanin, University of Toronto, Canada

2:30-2:55 Topology of Vortex Trajectories in Wake-Like Flows

Mark A. Stremler, Virginia Tech, USA

3:00-3:25 Characterizing Complexity of Aperiodic Braids of Trajectories

Marko Budisic and Jean-Luc Thiffeault, University of Wisconsin, Madison, USA

Wednesday, May 20

MS93

Theoretical Aspects of Spiral and Scroll Wave Dynamics - Part II of II

1:30 PM-3:30 PM

Room:Ballroom III

For Part 1 see MS80

Spiral and scroll waves are the most common types of solutions characterizing the dynamics of 2- and 3-dimensional excitable media such as the cardiac tissue. This minisymposium presents a sampling of recent analytical and numerical studies focusing on the interaction of scroll and spiral waves with perturbations such as structural heterogeneities and external stimuli as well as self-interactions and interaction of different spiral/scroll waves with each other.

Organizer: Roman Grigoriev
Georgia Institute of Technology, USA

Organizer: Vadim N. Biktashev
University of Exeter, United Kingdom

1:30-1:55 Interaction of Electric Field Stimuli with Scroll Waves in Three Dimensions

Niels Otani, Rochester Institute of Technology, USA; Valentin Krinski, CNRS, France

2:00-2:25 Unusually Simple Way to Create Spiral Wave in An Excitable Medium

Vladimir Zykov, Alexei Krekhov, and Eberhard Bodenschatz, Max-Planck-Institute for Dynamics and Self-Organization, Germany

2:30-2:55 Describing Scroll Wave Ring Interactions Via Interacting Potentials

Flavio M. Fenton, Georgia Institute of Technology, USA; *Jairo Rodriguez* and Daniel Olmos, Universidad de Sonora, Mexico

3:00-3:25 On the Generation of Spiral and Scroll Waves by Periodic Stimulation of Excitable Media in the Presence of Obstacles of Minimum Size

Daniel Olmos and Humberto Ocejo, Universidad de Sonora, Mexico

Wednesday, May 20

MS94

First Passage Times in Discrete and Continuous Systems - Part II of II

1:30 PM-3:30 PM

Room:Magpie A

For Part 1 see MS81

Numerous problems in nature are formulated in terms of Mean First Passage Time (MFPT) of Brownian particles in the presence of traps. For example, cells are regulated by chemical reactions involving signaling molecules that have to find their targets in a complex and crowded environment. The study of MFPT touches upon many topics and utilizes diverse tools including PDEs, stochastic differential equations, complex variables, generating functions and many others. This mini-session will bring together experts in this active field of research. Directions that will be considered include: search-and-rescue, mobile traps, narrow escape problems on bounded domains, connections to spike solutions of PDEs, and applications in biology and physics.

Organizer: Alan E. Lindsay
University of Notre Dame, USA

Organizer: Justin C. Tzou
Dalhousie University, Canada

1:30-1:55 Uniform Asymptotic Approximation of Diffusion to a Small Target

Jay Newby, The Ohio State University, USA

2:00-2:25 Narrow Escape to Traps with Absorbing and Reflecting Portions

Alan E. Lindsay, University of Notre Dame, USA

2:30-2:55 Sampling First-Passage Events When Drift Is Included in the First-Passage Kinetic Monte Carlo Method

Ava Mauro, University of Notre Dame, USA; Samuel A. Isaacson, Boston University, USA

3:00-3:25 Drunken Robber, Tipsy Cop: First Passage Times, Mobile Traps, and Hopf Bifurcations

Justin C. Tzou, *Shuangquan Xie*, and Theodore Kolokolnikov, Dalhousie University, Canada

Wednesday, May 20

MS95

Control of Multiscale Dynamics - Part II of II

1:30 PM-3:30 PM

Room:Magpie B

For Part 1 see MS82

The control of dynamical systems has been extensively studied in the past century, which led to significant applications such as space mission, aerocraft design, or nanoelectromechanical systems. Multiscale simulation and modeling, on the other hand, has become an active field in recent years, due to the multiscale nature of complex systems ubiquitous in practical applications. We consider it an emerging direction to go further and control multiscale systems, which was not possible without contemporary multiscale methods and computational architectures. The proposed minisymposium gathers researchers working on frontiers of related fields, with goals of shaping this new direction and contributing to important applications.

Organizer: Molei Tao
Georgia Institute of Technology, USA

1:30-1:55 Control of a Model of DNA Opening Dynamics via Resonance with a Terahertz Field

Wang-Sang Koon, California Institute of Technology, USA

2:00-2:25 A Dynamical Switching of Reactive and Nonreactive Modes at High Energies

Tamiki Komatsuzaki, Hokkaido University, Japan; Mikito Toda, Nara Women's University, Japan; Hiroshi Teramoto, Hokkaido University, Japan

2:30-2:55 Mode-Specific Effects in Structural Transitions of Atomic Clusters with Multiple Channels

Tomohiro Yanao, Waseda University, Japan

3:00-3:25 Obtaining Coarse-Grained Models from Multiscale Data

Sebastian Krumscheid, École Polytechnique Fédérale de Lausanne, Switzerland; Greg Pavliotis and Serafim Kalliadasis, Imperial College London, United Kingdom

Wednesday, May 20

MS96

Wave Propagation in Highly Nonlinear Dispersive Media - Part II of II

1:30 PM-3:30 PM

Room:Wasatch A

For Part 1 see MS83

Wave propagation in highly nonlinear dispersive media has recently attracted considerable attention of the interdisciplinary community that includes applied mathematicians, physicists and engineers. In particular, dynamics of granular crystals has been a subject of intensive theoretical and experimental research because of their unique, adaptive dynamical properties. Strongly nonlinear dispersive media may exhibit quite intriguing phenomena such as broadband absorption, high-rate wave attenuation and strong energy localization, rendering them highly attractive for multiple engineering applications. In this minisymposium, leading experts dealing with this class of dynamical systems will come together for a creative exchange of ideas involving fundamental and applied research.

Organizer: Anna Vainchtein
University of Pittsburgh, USA

Organizer: Yuli Starosvetsky
Technion - Israel Institute of Technology, Israel

1:30-1:55 Nonlinear Dynamics of Non-Stretched Membrane

Leonid Manevich, Russian Academy of Sciences, Russia

2:00-2:25 Discrete Breathers in Vibro-Impact Lattice Models

Itay Grinberg and Oleg Gendelman, Technion Israel Institute of Technology, Israel

2:30-2:55 Mixed Solitary – Shear Waves in a Granular Network

Yijing Zhang, University of Illinois at Urbana-Champaign, USA; Md. Arif Hasan, University of Illinois, USA; Yuli Starosvetsky, Technion - Israel Institute of Technology, Israel; D. Michael McFarland and Alexander Vakakis, University of Illinois, USA

3:00-3:25 Stable Two-Dimensional Solitons in Free Space: Gross-Pitaevskii Equations with the Spin-Orbit Coupling

Boris Malomed, Tel Aviv University, Israel

Wednesday, May 20

MS98

Advances in Viral Infection Modeling - Part II of II

1:30 PM-3:30 PM

Room:Maybird

For Part 1 see MS85

Viral infections, be they acute, like influenza or ebola, or chronic, like HIV, pose a continuing threat to daily life. In recent years mathematical modeling has become an important tool in investigating these infections, and novel methods are rapidly emerging. The primary goal of this minisymposium is to provide a platform for discussion of mathematical advances in viral infection modeling and resulting insights into viral infections, at both the within-host and between-hosts (epidemiological) scales.

Organizer: Jessica M. Conway
Pennsylvania State University, USA

Organizer: Naveen K. Vaidya
University of Missouri, Kansas City, USA

1:30-1:55 Modeling HCV Infection: Viral Dynamics and Genotypic Diversity

Ruy M. Ribeiro, Los Alamos National Laboratory, USA

2:00-2:25 HIV Viral Rebound Times Following Suspension of Art: Stochastic Model Predictions

Jessica M. Conway, Pennsylvania State University, USA

2:30-2:55 Modeling HIV Infection Dynamics under Conditions of Drugs of Abuse

Naveen K. Vaidya, University of Missouri, Kansas City, USA

3:00-3:25 Modeling Equine Infectious Anemia Virus Infection: Virus Dynamics, Immune Control, and Escape

Elissa Schwartz, Washington State University, USA

Wednesday, May 20

MS99

Front Propagation in Advection-Reaction-Diffusion Systems - Part II of II

1:30 PM-3:30 PM

Room:Superior A

For Part 1 see MS86

Autocatalytic reactions in a spatially-extended system are characterized by the propagation of reaction fronts separating the species. The front dynamics is generally well-understood for reaction-diffusion systems in the absence of substrate flow. The effects of fluid motion on fronts in the general advection-reaction-diffusion (ARD) case have only recently received significant attention, despite the wide applicability of ARD, including microfluidic chemical reactors, plasmas, ecosystem dynamics in the oceans (e.g., plankton blooms), cellular- and embryonic-scale biological processes. This minisymposium brings together groups studying ARD systems from a variety of perspectives, including experiments, dynamical systems theory, numerical PDEs, and analytics.

Organizer: Kevin A. Mitchell
University of California, Merced, USA

Organizer: Thomas H. Solomon
Bucknell University, USA

Organizer: John R. Mahoney
University of California, Merced, USA

1:30-1:55 The Domain Dependence of Chemotaxis in a Two-Dimensional Turbulent Flow

Kimberley Jones and Wenbo Tang, Arizona State University, USA

2:00-2:25 Flow and Grow: Experimental Studies of Time-Dependent Reaction-Diffusion-Advection Systems

Douglas H. Kelley, University of Rochester, USA

2:30-2:55 Lagrangian Coherent Structures for Reaction Fronts in Unsteady Flows

Kevin A. Mitchell and John R. Mahoney, University of California, Merced, USA

3:00-3:25 Transport in Chaotic Fluid Convection

Mark Paul, Virginia Tech, USA

Wednesday, May 20

MS100

Nonsmooth Dynamical Systems: Theory and Applications - Part II of II

1:30 PM-3:30 PM

Room:Superior B

For Part 1 see MS87

Many physical systems involve abrupt events, such as switches, impacts or thresholds, and are well-modelled by equations that are nonsmooth. This minisymposium will discuss novel applications of nonsmooth systems in ecology, optics and neuroscience, as well as describe new developments in the theory of nonsmooth systems. Overall the talks will highlight the various nuances of nonsmooth systems and show how these relate to the dynamical behaviour of the physical systems being modelled.

Organizer: David J. Simpson
Massey University, New Zealand

1:30-1:55 Lost in Transition: Nonlinearities in the Dynamics of Switching

Mike R. Jeffrey, University of Bristol, United Kingdom

2:00-2:25 Some Nonsmooth Problems Inspired by Conceptual Climate Models

Anna M. Barry, University of British Columbia, Canada

2:30-2:55 Grazing Bifurcations in Engineering and Medical Systems

Marian Wiercigroch, University of Aberdeen, United Kingdom

3:00-3:25 Continuation of Chatter in a Mechanical Valve

Harry Dankowicz and Erika Fotsch, University of Illinois at Urbana-Champaign, USA; Alan R. Champneys, University of Bristol, United Kingdom

Wednesday, May 20

MS101

Models from Data

1:30 PM-3:30 PM

Room:White Pine

Data modeling uses a model to represent a possibly large data set with a much smaller set of rules. The type of model depends on the goal of the modeling; data assimilation techniques can be used to create predictive models. If one wants to discover the structure of the data set, manifold learning techniques can reveal that a data set that appears high dimensional actually exists on a low dimensional manifold. Both types of modeling seek simple descriptions of complicated data sets.

Organizer: Thomas L. Carroll
Naval Research Laboratory, USA

1:30-1:55 Nonlinear Dynamics of Variational Data Assimilation

Henry D. Abarbanel, Kadakia Nirag, Jingxin Ye, Uriel I. Morone, and Daniel Rey, University of California, San Diego, USA

2:00-2:25 Precision Variational Approximations in Statistical Data Assimilation

Jingxin Ye, University of California, San Diego, USA

2:30-2:55 Manifold Learning Approach for Modelling Collective Chaos in High-Dimensional Dynamical Systems

Hiromichi Suetani, Kagoshima University, Japan

3:00-3:25 Attractor Comparisons Based on Density

Thomas L. Carroll, Naval Research Laboratory, USA

Wednesday, May 20

MS102

Complex Network Theory Based Approaches in the Analyses of Complex Systems and Data - Part II of II

1:30 PM-3:00 PM

Room:Primrose A

For Part 1 see MS89

Analysis of network data obtained from a complex system is often a challenging task. In this minisymposium we will be discussing few novel approaches for obtaining insights into the structural and functional properties of empirical networks and networks inferred from data. One of our focus areas will be to employ simulation of variety of dynamical processes on networks to study properties of empirical networks. We will also discuss methodologies to overcome problems in the analysis of empirical networks due to spurious or missing links. Dynamical system based approaches for transforming data into a network representing will also be presented.

Organizer: Nishant Malik
University of North Carolina at Chapel Hill, USA

1:30-1:55 Shadow Networks: Discovering Hidden Nodes with Models of Information Flow

James Bagrow, University of Vermont, USA

2:00-2:25 A Network Measure for the Analysis and Visualization of Large-Scale Graphs

Roldan Pozo, National Institute of Standards and Technology, USA

2:30-2:55 Revealing Collectivity in Evolving Networks: A Random Matrix Theory Approach

Saray Shai, University of North Carolina at Chapel Hill, USA

Wednesday, May 20

MS103

Transfer Operator Methods: Geometry, Continuous Time, Infinite Dimensions, Fast Computation

1:30 PM-3:30 PM

Room:Primrose B

Transfer operators are global descriptors of ensemble evolution under nonlinear dynamics and efficient methods of computing coherent structures and attractors. The speakers will describe advances in four areas. First, a new fundamental geometric characterisation of finite-time coherent sets and its associated transfer operator. Second, new spectral theory and numerics for periodically-driven flows and their time-asymptotic coherent sets. Third, a transfer operator approach to computing attractors for infinite-dimensional delay differential equations. Fourth, numerical methods for computing coherent sets for time-dependent advection-diffusion equations.

Organizer: Gary Froyland
University of New South Wales, Australia

Organizer: Kathrin Padberg-Gehle
Dresden University of Technology, Germany

1:30-1:55 The Geometry of Lagrangian Coherent Structures

Gary Froyland, University of New South Wales, Australia

2:00-2:25 Coherent Families: Spectral Theory for Transfer Operators in Continuous Time

Peter Koltai, Free University of Berlin, Germany; Gary Froyland, University of New South Wales, Australia

2:30-2:55 On the Computation of Attractors for Delay Differential Equations

Michael Dellnitz, University of Paderborn, Germany

3:00-3:25 Computing Coherent Sets in Turbulent Systems

Andreas Denner, Technische Universitaet Muenchen, Germany; Oliver Junge, University of Paderborn, Germany

Wednesday, May 20

MS119

From Singular Perturbation Theory to some Slow-Fast Systems: A Taste

1:30 PM-3:30 PM

Room:Wasatch B

Geometric Singular Perturbation Theory and the rôle of an small parameter in Fast-Slow systems permit to decompose the dynamics and to analyse global changes and bifurcations when such parameter decreases. Besides, Singular Perturbation Theory is closely related to problems concerning persistence of homo/heteroclinic connections, beyond-all-orders algebraic expansions and Stokes phenomenon. The aim of this minisymposium is to offer a very general (but partial) overview of some of these problems under both a theoretical and numerical viewpoints.

Organizer: J. Tomas Lazaro
Universitat Politecnica de Catalunya, Spain

Organizer: Sergio Serrano
University of Zaragoza, Spain

1:30-1:55 Stokes Phenomenon in a Singularly Perturbed Differential Equation

Vassili Gelfreich, University of Warwick, United Kingdom

2:00-2:25 Homoclinic Orbits With Many Loops Near a 0^2 ïΩ Resonant Fixed Point Of Hamiltonian Systems

Tiphaine Jézéquel, University of Tours, France; Patrick Bernard, CEREMADE Universite Paris 9 Dauphine, France; *Éric Lombardi*, Universite Paul Sabatier, France

2:30-2:55 Canard Orbits and Mixed-Mode Oscillations in a Chemical Reaction Model

Bernd Krauskopf, Jose Mujica, and Hinke M. Osinga, University of Auckland, New Zealand

3:00-3:25 Symbolic Dynamical Unfolding of Spike-Adding Bifurcations in Chaotic Neuron Models

Roberto Barrio, University of Zaragoza, Spain; Marc Lefranc, PHLAM - Universite de Lille, France; M. Angeles Martinez and Sergio Serrano, University of Zaragoza, Spain

Coffee Break

3:30 PM-4:00 PM

Room:Golden Cliff

Wednesday, May 20

MT2

Stochastic Dynamics of Rare Events

4:00 PM-6:00 PM

Room:Ballroom III

Chair: Eric Forgoston, Montclair State University, USA

Noise plays a fundamental role in a wide variety of physical and biological dynamical systems. The noise may be internal or external - internal noise is inherent to the system itself and arises due to the random interactions of a finite number of agents in the system, while external noise arises from a source outside of the system. In recent years, researchers have identified situations where even weak noise can induce a large fluctuation that leads to population extinction, switching between metastable states in ecological systems, or the escape of a particle from a potential well. The purpose of this minitutorial is to expose the audience to the theory underlying the dynamics of rare events for stochastic ODEs and PDEs along with a wide variety of applications.

Noise-Induced Rare Events: Switching, Escape, and Extinction in Stochastic ODEs

Eric Forgoston, Montclair State University, USA

Noise-Induced Rare Events: Failures and Exits in Stochastic Wave Equations

Richard O. Moore, New Jersey Institute of Technology, USA

Noise-Induced Rare Events: Applications in Physical and Biological Sciences

Michael Khasin, NASA Ames Research Center, USA

Wednesday, May 20

MS104

Featured Minisymposium: Non-Autonomous Instabilities

4:00 PM-6:00 PM

Room:Ballroom I

In many applications from the natural sciences and engineering aperiodic external forcing often leads to interesting nonlinear phenomena that can be characterised as non-autonomous instabilities. Such instabilities are mathematically challenging and often puzzle scientists because they cannot, owing to their transient or finite-time nature, be explained using traditional bifurcation theory. This minisymposium highlights recent techniques to analyse stability of non-autonomous ODEs and PDEs, with applications to rate-induced tipping points, failure boundaries in earthquake engineering and finite-time transport in (ocean) surface flows.

Organizer: Sebastian M. Wieczorek
University College Cork, Ireland

4:00-4:25 Rate-Induced Bifurcations in Slow-Fast Systems
Sebastian M. Wieczorek, University College Cork, Ireland

4:30-4:55 Interactions Between Noise and Rate-Induced Tipping
Paul Ritchie, University of Exeter, United Kingdom

5:00-5:25 A Direct Method for Computing Failure Boundaries of Non-autonomous Systems
Hinke M. Osinga, University of Auckland, New Zealand

5:30-5:55 Finite-Time Lagrangian Transport Through Surfaces in Volume-Preserving Flows
Daniel Karrasch, ETH Zürich, Switzerland

Wednesday, May 20

MS105

Featured Minisymposium: Random Walks, First Passage Time and Applications

4:00 PM-6:00 PM

Room:Ballroom II

Numerous problems -- from the molecular to macroscopic scales -- involve strategies based on random (possibly biased) walks. Examples range from fast-folding DNA strands, to predator-prey interactions and search and rescue operations. In this featured symposium, we present novel results in the field that also show the diversity and beauty of the subject. The proposed speakers are world-renowned experts that will present new applications to problems in cellular biology, chemistry, statistical mechanics, neuroscience and even sports. The topics of this session unify various approaches used, offering unique perspectives to reach and inform a wide target audience.

Organizer: Theodore Kolokolnikov
Dalhousie University, Canada

Organizer: Sidney Redner
Santa Fe Institute, USA

4:00-4:25 First Passage Time Problems for Stochastic Hybrid Systems
Paul C. Bressloff, University of Utah, USA and University of Oxford, United Kingdom

4:30-4:55 Exploration and Trapping of Mortal Random Walkers
Katja Lindenberg, University of California, San Diego, USA; Santos B. Yuste and Enrique Abad, Universidad de Extremadura, Spain

5:00-5:25 Trajectory-to-Trajectory Fluctuations in the First-Passage Phenomena in Bounded Domains
Gleb Oshanin, Laboratoire de Physique Théorique de la Matière Condensée, France

5:30-5:55 Application of First-Passage Ideas to the Statistics of Lead Changes in Basketball
Sidney Redner, Santa Fe Institute, USA; Aaron Clauset, University of Colorado Boulder, USA; Marina Kogan, University of Colorado, USA

Wednesday, May 20

MS106

Featured Minisymposium: Time-Delayed Feedback

4:00 PM-6:00 PM

Room:Wasatch B

Time-delayed feedback is a simple and powerful method for influencing and controlling complex nonlinear systems. In its simplest form, the method has been successfully used to control unstable periodic orbits in dynamical models arising for instance in engineering, physics or biology. More recently, the scope of time-delayed feedback has been expanded to systems with multiple delay and the connection with fixed point problems has been clarified. In this minisymposium we will cover these new developments and discuss applications of time delay to climate systems and cluster synchronisation

Organizer: Andreas Amann
University College Cork, Ireland

4:00-4:25 Pattern Formation in Systems with Multiple Delayed Feedbacks
Serhiy Yanchuk, Humboldt University at Berlin, Germany

4:30-4:55 Connection Between Extended Time-Delayed Feedback and Nonlinear Fixed-Point Problems
Jan Sieber, University of Exeter, United Kingdom

5:00-5:25 Interplay of Adaptive Topology and Time Delay in the Control of Cluster Synchronization
Judith Lehnert, Technische Universität Berlin, Germany; Alexander Fradkov, St. Petersburg State University, Russia; Eckehard Schöll and Philipp Hövel, Technische Universität Berlin, Germany; Anton Selivanov, St. Petersburg State University, Russia

5:30-5:55 Bifurcation Analysis of a Model for the El Nño Southern Oscillation
Andrew Keane, Bernd Krauskopf, and Claire Postlethwaite, University of Auckland, New Zealand

Wednesday, May 20

MS107

Featured Minisymposium: Emerging Strategies for Stability Analysis of Electrical Power Grids

4:00 PM-6:00 PM

Room:Maybird

The so-called swing equations which describe the course grained dynamics on an electrical power grid are highly non-linear with a solution space that grows with the size of the grid. Due to their rich dynamics, the equations have been the subject of intense research using a wide range of techniques. This minisymposium focuses on the global structure of these equations and develops new approaches to study the system stability by using a combination of tools such as power flow approximations, bifurcation theory, Lyapunov functions and stochastic methods. The speakers will discuss their latest results in this area and present examples of relevance in applications.

Organizer: Lewis G. Roberts
University of Bristol, United Kingdom

Organizer: Florian Dorfler
ETH Zürich, Switzerland

4:00-4:25 A Parametric Investigation of Rotor Angle Stability Using Direct Methods

Lewis G. Roberts, Alan R. Champneys, and Mario Di Bernardo, University of Bristol, United Kingdom; Keith Bell, University of Strathclyde, United Kingdom

4:30-4:55 Voltage Stability in Power Networks and Microgrids

Florian Dorfler, ETH Zürich, Switzerland; John Simpson-Porco, University of California, USA; Francesco Bullo, University of California, Santa Barbara, USA

5:00-5:25 Finding Useful Statistical Indicators of Instability in Stochastically Forced Power Systems

Goodarz Ghanavati, *Paul Hines*, and Taras Lakoba, University of Vermont, USA

5:30-5:55 Synchronization Stability of Lossy and Uncertain Power Grids

Konstantin Turitsyn and Thanh Long Vu, Massachusetts Institute of Technology, USA

Wednesday, May 20

MS108

Featured Minisymposium: Invariant Manifolds Unravelling Complicated Dynamics

4:00 PM-6:00 PM

Room:Primrose A

Global invariant manifolds of maps and vector fields undergo critical re-arrangements under parameter variation. These topological and geometric transitions may result in drastic changes of the global dynamics. Typically, major changes to invariant manifolds may trigger the onset of chaos, transformation or creation of basins of attraction, the formation of homo- and heteroclinic orbits and, ultimately, the reorganization of the overall structure of the phase space. The aim of this minisymposium is to present recent advances and discuss new challenges in the way invariant manifolds can be used as a tool to understand complicated global phenomena.

Organizer: Stefanie Hittmeyer
University of Auckland, New Zealand

Organizer: Pablo Aguirre
Universidad Técnica Federico Santa María, Chile

4:00-4:25 Bifurcations of Generalised Julia Sets Near the Complex Quadratic Family

Stefanie Hittmeyer, Bernd Krauskopf, and Hinke M. Osinga, University of Auckland, New Zealand

4:30-4:55 Parameterization Method for Local Stable/unstable Manifolds of Periodic Orbits

Jason Mireles James, Rutgers University, USA

5:00-5:25 A Global Bifurcation of Mixed-mode Oscillations

Ian M. Lizarraga and John Guckenheimer, Cornell University, USA

5:30-5:55 Practical Stability Versus Diffusion in the Spatial Restricted Three-body Problem

Maisa O. Terra, Technological Institute of Aeronautics, Brazil; Carles Simó, University of Barcelona, Spain; Priscilla de Sousa-Silva, Technological Institute of Aeronautics, Brazil

Wednesday, May 20

MS109

Featured Minisymposium: Medical Applications

4:00 PM-6:00 PM

Room:Primrose B

In recent years, there has been growing interest in employing ideas from dynamical systems and control theory for medical applications. This minisymposium will emphasize recent theoretical and experimental advances in the way such approaches may be used to both understand and combat the underlying mechanisms of dysfunction that can occur for specific diseases. We include a broad sampling of speakers representing applications from the fields of cardiology, neuroscience, and diabetes research.

Organizer: Dan D. Wilson
University of California, Santa Barbara, USA

Organizer: Jeff Moehlis
University of California, Santa Barbara, USA

4:00-4:25 Termination of Cardiac Alternans Using Isostable Response Curves

Dan D. Wilson and Jeff Moehlis, University of California, Santa Barbara, USA

4:30-4:55 Unification of Neuronal Spikes, Seizures, and Spreading Depression

Steven J. Schiff, Pennsylvania State University, USA; Yina Wei, University of California, Riverside, USA; Ghanim Ullah, University of South Florida, USA

5:00-5:25 Therapeutic Mechanisms of High Frequency DBS in Parkinson's Disease: Neural Restoration Through Loop-Based Reinforcement

Sridevi Sarma, Johns Hopkins University, USA; Sabato Santaniello, University of Colorado Boulder, USA

5:30-5:55 Perspectives on Theories of Diabetogenesis and Glucose Management

Pranay Goel, Indian Institute for Science Education and Research, Pune, India; Saroj Ghaskadbi, Savitribai Phule Pune University, India

Dinner Break

6:00 PM-8:30 PM

Attendees on their own

Wednesday, May 20

PP2

Poster Session and Dessert Reception

8:30 PM-10:30 PM

Room:Ballroom

Intermittent Synchronization/ desynchronization in Population Dynamics

Sungwoo Ahn, Arizona State University, USA; Leonid Rubchinsky, Indiana University - Purdue University Indianapolis, USA

Parabolic Bursting in Inhibitory Neural Circuits

Deniz Alacam and Andrey Shilnikov, Georgia State University, USA

An Accurate Computation of the Tangent Map for Computation of Lagrangian Coherent Structures

Siavash Ameli and Shawn Shadden, University of California, Berkeley, USA

Nonlinear Dynamics in Coupled Semiconductor Laser Network Implementations

Apostolos Argyris, Michail Bourmpos, Alexandros Fragkos, and Dimitris Syvridis, National & Kapodistrian University of Athens, Greece

Symplectic Maps with Reversed Current in a Tokamaks

Bruno Bartoloni and Ibere L. Caldas, University of Sao Paulo, Brazil

Analysis of Spatiotemporal Dynamical Systems from Multi-Attribute Satellite Images

Ranil Basnayake and Erik Bollt, Clarkson University, USA; Nicholas Tufillaro, Oregon State University, USA; Jie Sun, Clarkson University, USA

Phase Response Analysis of the Circadian Clock in Neurospora Crassa

Jacob Bellman, University of Cincinnati, USA

Time Series Based Prediction of Extreme Events in High-Dimensional Excitable Systems

Stephan Bialonski, Max Planck Institute for Dynamics of Complex Systems, Germany; Gerrit Ansmann, University of Bonn, Germany; Holger Kantz, Max Planck Institute for Physics of Complex Systems, Germany

continued in next column

Slow-fast Analysis of Earthquake Faulting

Elena Bossolini, Kristian Uldall Kristiansen, and Morten Brøns, Technical University of Denmark, Denmark

Quasicycles in the Stochastic Hybrid Morris-Lecar Neural Model

Heather A. Brooks, University of Utah, USA; Paul C. Bressloff, University of Utah, USA and University of Oxford, United Kingdom

Computation of Normally Hyperbolic Invariant Manifolds

Marta Canadell, Georgia Institute of Technology, USA; Alex Haro, Universitat de Barcelona, Spain

A Novel Speech-Based Diagnostic Test for Parkinson's Disease Integrating Machine Learning with Web and Mobile Application Development for Cloud Deployment

Pooja Chandrashekar, Thomas Jefferson High School of Science and Techonology, USA

An Agent-Based Model for mRNA Localization in Frog Oocytes

Veronica M. Ciocanel and Bjorn Sandstede, Brown University, USA

Effects of Stochastic Gap-Junctional Coupling in Cardiac Cells and Tissue

William Consagra, Rochester Institute of Technology, USA

Maximizing Plant Fitness Under Herbivore Attack

Karen M. Cumings, Peter R. Kramer, and Bradford C. Lister, Rensselaer Polytechnic Institute, USA

The Derivation of Mass Action Laws: Issues and Questions

Jonathan Dawes, University of Bath, United Kingdom; Max O. Souza, Universidade Federal Fluminense, Brazil

Heterogeneity and Oscillations in Small Predator-Prey Swarms

Jeff Dunworth and Bard Ermentrout, University of Pittsburgh, USA

Bacterial Disinfection with the Presence of Persisters

Sepideh Ebadi, Florida State University, USA

Chaotic Mixing in a Curved Channel with Slip Surfaces

Piyush Garg, Indian Institute of Technology Roorkee, India; Jason R. Picardo and Subramaniam Pushpavanam, Indian Institute of Technology Madras, India

continued in next column

Feasibility of Binding Heteroclinic Networks

Xue Gong, Ohio University, USA; Valentin Afraimovich, Universidad Autonoma de San Luis Potosi, Mexico

Dynamic Square Patterns in 2D Neural Fields

Kevin R. Green and Lennaert van Veen, University of Ontario Institute of Technology, Canada

Controllability of Brain Networks

Shi Gu, University of Pennsylvania, USA; Fabio Pasqualetti, University of California, Riverside, USA; Matthew Ceislak and Scott Grafton, University of California, Santa Barbara, USA; Danielle S. Bassett, University of Pennsylvania, USA

Compressive Sensing with Exactly Solvable Chaos

Sidni Hale, Anthony DiPofi, and Bradley Kimbrell, Radix Phi, USA

Identifying the Role of Store-Operated Calcium Channels in Astrocytes Via An Open-Cell Model

Gregory A. Handy, Alla Borisyuk, Marsa Taheri, and John White, University of Utah, USA

Behavioral Dynamics and STD Transmission

Michael A. Hayashi and Marisa Eisenberg, University of Michigan, USA

Master Stability Functions for the Fixed Point Solution of Synchronized Identical Systems with Linear Delay-Coupling and a Single Constant Delay

Stanley R. Huddy and Jie Sun, Clarkson University, USA

Windows of Opportunity: Synchronization in On-Off Stochastic Networks

Russell Jeter and Igor Belykh, Georgia State University, USA

Two-Theta Neuron: Phase Models for Bursting Networks

Aaron Kelley, Georgia State University, USA

Canard-Mediated Dynamics in a Phantom Burster

Elif Köksal Ersöz, Mathieu Desroches, Maciej Krupa, and Frédérique Cleément, INRIA Paris-Rocquencourt, France

A Mathematical Model for Adaptive Crawling Locomotion

Shigeru Kuroda and Toshiyuki Nakagaki, Hokkaido University, Japan

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Wednesday, May 20

PP2

Poster Session and Dessert Reception

8:30 PM-10:30 PM

Room:Ballroom

cont.

Effective Dispersion Relation of the Nonlinear Schrödinger Equation

Katelyn J. Leisman and Gregor Kovačič, Rensselaer Polytechnic Institute, USA; David Cai, Courant Institute of Mathematical Sciences, New York University, USA

Mathematical Model of Bidirectional Vesicle Transport and Sporadic Capture in Axons

Ethan Levien, University of Utah, USA; Paul C. Bressloff, University of Utah, USA and University of Oxford, United Kingdom

Modelocking in Chaotic Advection-Reaction-Diffusion Systems

Rory A. Locke, John R. Mahoney, and Kevin A. Mitchell, University of California, Merced, USA

Effect of Multi-Species Mass Emergence on Biodiversity

James E. McClure and Nicole Abaid, Virginia Tech, USA

A B Cell Receptor Signaling Model and Dynamic Origins of Cell Response

Reginald Mcgee, Purdue University, USA

Stability of Morphodynamic Equilibria in Tidal Basins

Corine J. Meerman and Vivi Rottschäfer, Leiden University, Netherlands; Henk Schuttelaars, Delft University of Technology, Netherlands

Frequency-Dependent Left-Right Coordination in Locomotor Pattern Generation

Yaroslav Molkov, Indiana University - Purdue University Indianapolis, USA; Bartholomew Bacak, Drexel University College of Medicine, USA; Ilya A. Rybak, Drexel University, USA

continued in next column

Capacity for Learning the Shape of Arena in the Single-Celled Swimmer, Viewed from Slow Dynamics of Membrane Potential

Toshiyuki Nakagaki and Itsuki Kunita, Hokkaido University, Japan; Tatsuya Yamaguchi, Kyushu University, Japan; Masakazu Akiyama, Hokkaido University, Japan; Atsushi Tero, Kyushu University, Japan; Shigeru Kuroda and Kaito Ooki, Hokkaido University, Japan

Co-Dimension Two Bifurcations in Piecewise-Smooth Continuous Dynamical Systems

Wilten Nicola and Sue Ann Campbell, University of Waterloo, Canada

Analysis of Malaria Transmission Dynamics with Saturated Incidence

Samson Olaniyi, Ladoke Akintola University of Technology, Nigeria

Temporally Periodic Neural Responses from Spatially Periodic Stimuli

Jason E. Pina and Bard Ermentrout, University of Pittsburgh, USA

Using a Stochastic Field Theory to Understand Collective Behavior of Swimming Microorganisms

Yuzhou Qian, Peter R. Kramer, and Patrick Underhill, Rensselaer Polytechnic Institute, USA

Consensus and Synchronization over Biologically-Inspired Networks: From Collaboration to Antagonism

Subhradeep Roy and Nicole Abaid, Virginia Tech, USA

Oscillatory Shear Flow Influence on the Two Point Vortex Dynamics

Evgeny Ryzhov and Konstantin Koshel, Pacific Oceanological Institute of the Russian Academy of Sciences, Russia

Wild Dynamics in Nonlinear Integrate-and-Fire Neurons: Mixed-Mode Bursting, Spike Adding and Chaos

Justyna H. Signerska, INRIA, France; Jonathan D. Touboul, Collège de France, France; Alexandre Vidal, University of Evry-Val-d'Essonne, France

Return Times and Correlation Decay in Linked Twist Maps

Rob Sturman, University of Leeds, United Kingdom

continued in next column

Osteocyte Network Formation

Jake P. Taylor-King, Mason A. Porter, and Jon Chapman, University of Oxford, United Kingdom; David Basanta, H. Lee Moffitt Cancer Center & Research Institute, USA

On a FitzHugh-Nagumo Kinetic Model for Neural Networks

Cristobal Quininao, Laboratoire Jacques-Louis Lions, France; *Jonathan D. Touboul*, Collège de France, France; Stéphane Mischler, Universite Paris 9 Dauphine, France

Examining Partial Cascades in Clustered Networks with High Intervertex Path Lengths

Yosef M. Treitman and Peter R. Kramer, Rensselaer Polytechnic Institute, USA

Almost Complete Separation of a Fluid Component from a Mixture Using the Burgers Networks of Micro-separators

Shinya Watanabe, Ibaraki University, Japan; Sohei Matsumoto, National Institute of Advanced Industrial Science and Technology, Japan; Tomohiro Higurashi, Yuya Yoshikawa, and Naoki Ono, Shibaura Institute of Technology, Japan

New Data Anysis Approach for Complex Signals with Low Signal to Noise Ratio's

Jeremy Wojcik, Georgia State University, USA

Data Assimilation for Traffic State and Parameter Estimation

Chao Xia, Bjorn Sandstede, and Paul Carter, Brown University, USA; Laura Slivinski, Woods Hole Oceanographic Institute, USA

Stochastic Active-Transport Model of Cell Polarization

Bin Xu, University of Utah, USA; Paul C. Bressloff, University of Utah, USA and University of Oxford, United Kingdom

Statistical Properties of Finite Systems of Point-Particles Interacting Through Binary Collisions

Alexander L. Young, Joceline Lega, and Sunder Sethuraman, University of Arizona, USA

continued on next page

Heteroclinic Separators of Magnetic Fields in Electrically Conducting Fluids

Evgeny Zhuzhoma, National Research University Higher School of Economics, Russia; Vyatcheslav Grines and Timur Medvedev, Lobachevsky State University of Nizhny Novgorod, Russia; Olga Pochinka, National Research University Higher School of Economics, Russia

Equivalent Probability Density Moments Determine Equivalent Epidemics in An Sirs Model with Temporary Immunity

Thomas W. Carr, Southern Methodist University, USA

Waveaction Spectra for Fully Nonlinear MMT Model

Michael Schwarz, Gregor Kovacic, and Peter R. Kramer, Rensselaer Polytechnic Institute, USA; David Cai, Shanghai Jiao Tong University, China and Courant Institute of Mathematical Sciences, New York University, USA

Rigorous Numerics for Analytic Solutions of Differential Equations: The Radii Polynomial Approach

Allan R. Hungria, University of Delaware, USA; Jean-Philippe Lessard, Université Laval, Canada; Jason Mireles-James, Florida Atlantic University, USA

Thursday, May 21

Registration

8:00 AM-4:45 PM

Room:Ballroom Foyer

MS110

Effective Multiscale Computational Modeling of Spatio-temporal Systems

8:30 AM-10:30 AM

Room:Ballroom I

Across science and engineering many systems are only realistically described by models on multiple spatial and temporal scales. Such multiscale systems are notoriously complex and computationally demanding. In developing the desired 'coarse-grained' or macroscale model, major concerns are the efficiency of the the macroscale modelling and its accuracy. We discuss recent developments in the computational modelling of the emergent dynamics of multiscale systems.

Organizer: Anthony J. Roberts
University of Adelaide, Australia

8:30-8:55 Better Buffers for Patches in Macroscale Simulation of Systems with Microscale Randomness

Anthony J. Roberts, University of Adelaide, Australia

9:00-9:25 Resilient Algorithms for Reconstructing and Simulating Gappy Flow Fields in CFD

Seungjoon Lee, Brown University, USA; Ioannis Kevrekedis, Princeton University, USA; George E. Karniadakis, Brown University, USA

9:30-9:55 Triggers of Rogue Waves in Deep Water Envelope Equations

Will Cousins and Themistoklis Sapsis, Massachusetts Institute of Technology, USA

10:00-10:25 Boundary Conditions and the Linking of Computational Domains in Patch Dynamics Schemes

I. G. Kevrekidis, Princeton University, USA

Thursday, May 21

MS111

Recent Insights into Controling Flow Structures - Part I of II

8:30 AM-10:30 AM

Room:Ballroom II

For Part 2 see MS124

Interior flow entities such as fluid interfaces, coherent structures and invariant manifolds have a profound influence on transport in unsteady flows. The ability to control them is attracting much recent interest, fueled in part by emerging biotechnological applications at the microfluidic level. This minisymposium will cover a range of state-of-the-art approaches to controling flow structures which are inspired by dynamical systems methods.

Organizer: Sanjeeva Balasuriya
University of Adelaide, Australia

Organizer: Marko Budisic
University of Wisconsin, Madison, USA

Organizer: Jean-Luc Thiffeault
University of Wisconsin, Madison, USA

8:30-8:55 Control of Thin-Layer Flows with Patterned Surfaces

Jean-Luc Thiffeault, University of Wisconsin, Madison, USA; Jay Johnson, University of Texas at Austin, USA

9:00-9:25 Mesohyperbolicity, Mix-Norm and the Hunt for Mh370

Sophie Loire and Hassan Arbabi, University of California, Santa Barbara, USA; Stefan Ivic, Rijeka University, Croatia; Patrick Clary, University of California, Santa Barbara, USA; Bojan Crnkovic and Nelida Crnjaric-Zic, Rijeka University, Croatia; Igor Mezic, University of California, Santa Barbara, USA

continued on next page

Thursday, May 21

MS111

Recent Insights into Controling Flow Structures - Part I of II

8:30 AM-10:30 AM

Room:Ballroom II

cont.

9:30-9:55 Closed-Loop Control of Complex and Turbulent Flows Using Machine Learning Control: a Reverse Engineering Approach

Thomas Duriez, Buenos Aires University, Argentina; Vladimir Parezanovic, Kai Von Krbek, Jean-Paul Bonnet, Laurent Cordier, and Bernd R. Noack, CNRS, France; Marc Segond and Markus W Abel, Ambrosys GmbH, Germany; Nicolas Gautier and Jean-Luc Aider, CNRS, France; Cedric Raibaudo, Christophe Cuvier, and Michel Stanislas, École Centrale de Lille, France; Antoine Debien, Nicolas Mazellier, and Azeddine Kourta, Universite d'Orleans, France; Steven Brunton, University of Washington, USA

10:00-10:25 Controlling Hyperbolic Trajectories and Invariant Manifolds in Flows

Sanjeeva Balasuriya, University of Adelaide, Australia; Kathrin Padberg-Gehle, Dresden University of Technology, Germany

Thursday, May 21

MS112

Dynamical Systems Aspects of Legged Locomotion

8:30 AM-10:30 AM

Room:Ballroom III

The purpose of this minisymposium is to review the state of the art in biomechanical and neural modelling of legged locomotion. Topics covered will include interaction between central pattern generators and muscles, experimental observation of human subjects on steady and moving ground, cross-species comparison, stability, basins of attraction, gait transition, feedback control and reduced-order models.

Organizer: Shinya Aoi
Kyoto University, Japan

Organizer: Alan R. Champneys
University of Bristol, United Kingdom

8:30-8:55 What Can Coupled, Nonlinear Oscillators Say About Noisy, Perturbed Cockroaches

Philip Holmes, Princeton University, USA

9:00-9:25 Formation Mechanism for Basin of Attraction of Bipedal Working Models

Obayashi Ippei, Kyoto University, Japan

9:30-9:55 Experimental Observation of Rhythm Control of Human Gait Using Moving Floor

Tetsuro Funato, University of Electro-Communications, Japan; Shinya Aoi, Nozomi Tomita, and Tsuchiya Kazuo, Kyoto University, Japan

10:00-10:25 Lateral Balance of Human Walking and Human Structure Interaction

John Macdonald, Jeremy Burn, Matteusz Bocian, and Alan R. Champneys, University of Bristol, United Kingdom

Thursday, May 21

MS113

Statistical Physics and Nonlinear Dynamics for the Earth's Cryosphere

8:30 AM-10:30 AM

Room:Magpie A

Important elements of the Earth's Cryosphere such as sea ice, permafrost and snow were formed under temperature change resulting in nonlinear phase transitions. These critical phenomena in the Earth's Cryosphere remain of continuing interest as the climate system warms, and are crucial for the stability of the climate system. The melting processes in the Earth's Cryosphere can be investigated through classical statistical physics models as well the nonlinear behaviour of the climate system caused by phase transitions can be described with help of standard nonlinear dynamics tools.

Organizer: Ivan Sudakov
University of Utah, USA

8:30-8:55 Statistical Physics Models for Critical Phenomena in Permafrost Lakes

Ivan Sudakov, University of Utah, USA

9:00-9:25 The Evolution of Complexity in Arctic Melt Ponds: a Statistical Physics Perspective

Yiping Ma, University of Colorado Boulder, USA

9:30-9:55 How Climate Model Complexity Impacts the Stability of the Sea Ice Cover

Till Wagner, University of California, San Diego, USA; Ian Eisenman, Scripps Institution of Oceanography, USA

10:00-10:25 Growth and Fluctuations of Suncups on Alpine Snowpacks: Comparison of Field Observations with a Nonlinear Pde Model

Tom Tiedje, University of Victoria, Canada; Kevin A. Mitchell, Simon Fraser University, Canada

Thursday, May 21

MS114

Mathematical Modeling of Basal Ganglia

8:30 AM-10:30 AM

Room:Magpie B

Basal ganglia is a set of subcortical brain structures involved in many different functions, including reinforcement learning and control of cognitive and motor programs. The impairment of the basal ganglia may lead to different disorders including Parkinson's disease. The objective of this minisymposium is to present together moderns developments in the basal ganglia modeling in application to different aspects of basal ganglia function and dysfunction, such as dynamic patterns of activity in the basal ganglia, deep brain stimulation of the basal ganglia, and interaction of basal ganglia with brain's cortex.

Organizer: Yixin Guo
Drexel University, USA

Organizer: Leonid Rubchinsky
Indiana University - Purdue University Indianapolis, USA

8:30-8:55 Cortical Impact on the Dynamics of Subthalamo-pallidal Networks

Leonid Rubchinsky and Sungwoo Ahn, Indiana University - Purdue University Indianapolis, USA; Elizabeth Zauber, Indiana University, USA; Robert Worth, Indiana University, USA

9:00-9:25 Oscillations and Action Selection in a Multi-Channel Model of the Basal Ganglia

Roman M. Borisyuk and *Robert Merrison-Hort*, Plymouth University, United Kingdom

9:30-9:55 Possible Mechanisms for Generation of Beta Oscillations in Parkinson's Disease

Alexander Pavlides, University of Oxford, United Kingdom; John Hogan, Bristol Centre for Applied Nonlinear Mathematics and University of Bristol, United Kingdom; *Rafal Bogacz,* University of Oxford, United Kingdom

10:00-10:25 Identifying and Tracking Transitions in Neural Spiking Dynamics in the Subthalamic Nucleus of Parkinson's Patients

Uri Eden, Boston University, USA

Thursday, May 21

MS115

Inverse Problems in Network Dynamics - Part I of II

8:30 AM-10:30 AM

Room:Wasatch A

For Part 2 see MS127

Network Dynamics constitutes a rapidly expanding field with applications in natural and social science, medicine, engineering, and beyond. Commonly, mathematical scientists study how a specific network model behaves collectively as a function of parameters or inputs. Here, taking a complementary view, we ask what recorded time series from a network's units and respective correlation and information measures tell us about the units' local dynamics and their real physical interactions. Such inverse network dynamics are much less explored and even less understood. The minisymposium features recent trends, from foundations and applications in time series analysis to models in physics and biology.

Organizer: Michael Rosenblum
University of Potsdam, Germany

Organizer: Marc Timme
Max-Planck-Institute for Dynamics and Self-Organization, Germany

8:30-8:55 Data-Driven Network Inference: Achievements, Problems, Possible Research Directions

Klaus Lehnertz, University of Bonn, Germany

9:00-9:25 Data Based Modelling: Inferring the Direct Directed Network Structure from Data

Björn Schelter, University of Aberdeen, United Kingdom; Marco Thiel, King's College, University of Aberdeen, United Kingdom

9:30-9:55 Topology Predicts Dynamics; Dynamics Constrain Topology

Srinivas Gorur-Shandilya, Yale University, USA

10:00-10:25 Network Structure from Responses of Time-invariants

Mor Nitzan, Hebrew University of Jerusalem, Israel; Jose Casadiego and Marc Timme, Max-Planck-Institute for Dynamics and Self-Organization, Germany

Thursday, May 21

MS117

Complex Collective Dynamics of Oscillator Networks - Part I of II

8:30 AM-10:30 AM

Room:Maybird

For Part 2 see MS129

Considerable progress has recently been made in understanding the collective dynamics of large oscillator networks. New analytical tools have been created and extended in their applicability, and novel effects have been demonstrated not only theoretically and numerically, but also experimentally. Results in this field have broad application to both physical and biological systems. Part one of this symposium will report recent general mean field results involving chimera states, assortative networks, and generalizations of the classic Kuramoto model. Part two will focus on networks of neuronal oscillators, their relationship to field models, and the dynamical consequences of connectivity.

Organizer: Paul So
George Mason University, USA

Organizer: Arkady Pikovsky
University of Potsdam, Germany

Organizer: Ernest Barreto
George Mason University, USA

8:30-8:55 Chimera States in Globally Coupled Oscillators

Arkady Pikovsky, Michael Rosenblum, and Azamat Yeldesbay, University of Potsdam, Germany

9:00-9:25 On the Mechanical Origin of Chimera States

Erik A. Martens, University of Copenhagen, Denmark

9:30-9:55 The Kuramoto Model of Coupled Oscillators with a Bi-Harmonic Coupling Function

Maxim Komarov, Potsdam University, Germany

10:00-10:25 Mean Field Theory of Assortative Networks of Phase Oscillators

Juan G. Restrepo, University of Colorado Boulder, USA; Edward Ott, University of Maryland, USA

Thursday, May 21

MS118

Recent Advances on Multiple Timescale Dynamics - Part I of II

8:30 AM-10:30 AM

Room:Superior A

For Part 2 see MS130

Multiple timescales are ubiquitous in models of real-world phenomena such as neuron firing, laser dynamics, and climatic rhythms. Differential equations involving variables evolving on distinct timescales yield rich and notoriously hard mathematical questions. This two-part minisymposium presents recent results on singularly perturbed ODEs, which is the most amenable paradigm for analysis of multiple timescale phenomena. We will give a panorama of this topic, from theoretical work on planar canard problems, in both smooth and non-smooth vector fields (Part I), to more application-driven studies of complex oscillations with at least three variables and two or more timescales (Part II).

Organizer: Mathieu Desroches
INRIA Paris-Rocquencourt, France

Organizer: Vivien Kirk
University of Auckland, New Zealand

Organizer: Jonathan E. Rubin
University of Pittsburgh, USA

8:30-8:55 Theoretical Analysis of Homoclinic Canards

Jean-Pierre Francoise, Universite Pierre et Marie Curie (Paris 6), France

9:00-9:25 Singular Bogdanov-Takens Bifurcations in the Plane

Peter De Maesschalck, Hasselt University, Belgium

9:30-9:55 Canard Orbits in Planar Slow-Fast Piecewise-Linear Systems

Soledad Fernandez-Garcia, Mathieu Desroches, and Martin Krupa, INRIA Paris-Rocquencourt, France; Antonio E. Teruel, University of the Balearic Islands, Spain

10:00-10:25 Folded Nodes, Canards and Mixed Mode Oscilations in 3D Piecewise-Linear Systems

Antonio E. Teruel, University of the Balearic Islands, Spain; Mathieu Desroches, INRIA Paris-Rocquencourt, France; Enrique Ponce, Universidad de Sevilla, Spain; Rafel Prohens, University of the Balearic Islands, Spain; Antoni Guillamon, Polytechnic University of Catalonia, Spain; Emilio Freire, Universidad de Sevilla, Spain

Thursday, May 21

MS120

Stochastic Dynamics and Their Applications - Part I of II

8:30 AM-10:30 AM

Room:White Pine

For Part 2 see MS132

Stochastic dynamical concepts are crucial in modelling the dynamical behavior of dynamical systems under uncertainty. There are some theory results of the stochastic dynamics such as the stochastic attractors, invariant manifolds, invariant measures. However, the theory is restricted on some conditions. Applied science and engineering requires more stochastic dynamical techniques. The objective of this minisymposium is to bring the bridge between the new theory methods and approaches to stochastic dynamics in applications.

Organizer: Xiaopeng Chen
Peking University, China

Organizer: Jinqiao Duan
Illinois Institute of Technology, USA

8:30-8:55 Slow Manifolds and Interface Motion for Stochastic PDEs

Dirk Blömker, Universität Augsburg, Germany

9:00-9:25 Slow Manifolds for a Nonlocal Spde

Lu Bai, Huazhong University of Science & Technology, China

9:30-9:55 Self-similarity in Stochastic PDEs

Wei Wang, Nanjing University, China

10:00-10:25 On the Complete Dynamical Behavior for Three Dimensional Stochastic Competitive Lotka-VolterraSystems

Jifa Jiang, Shanghai Normal University, China

Thursday, May 21

MS121

Engineering Applications of Non-smooth Dynamics - Part I of II

8:30 AM-10:30 AM

Room:Primrose A

For Part 2 see MS133

Friction and impact are challenging research areas of engineering. These phenomena are commonly described by empirical models, such as the coefficient of restitution or various friction models, including the Coulomb-Amontons' law. Modelling contact mechanics from first principles is almost impossible, each model needs some parameter fitting. Even when a model is available, one might not be able to solve it due to various mathematical singularities, where there is no unique prediction. This minisymposium shows a number of applications where the 'rough' terrain of non-smooth dynamics must be carefully navigated. Attempts will be also made to resolve singularities and identify contact force models.

Organizer: Robert Szalai
University of Bristol, United Kingdom

8:30-8:55 Exploring Experimental Paths for Reliable Mathematical Models of Friction

Thibaut Putelat, University of Bristol, United Kingdom

9:00-9:25 Painlevé Paradox: Lessons That We Do Not Learn from Simple Examples

Peter L. Varkonyi, Budapest University of Technology and Economics, Hungary

9:30-9:55 Testing of a Spacecraft Structure with Non-Smooth Nonlinearities

Ludovic Renson, J.P. Noel, and G. Kerschen, University of Liege, Belgium

10:00-10:25 Nonlinear Dynamics and Bifurcations of Rotor-Stator Contact in Rotating Machines

Nicholas Vlajic, National Institute of Standards and Technology, USA; Alan R. Champneys, University of Bristol, United Kingdom; Michael Friswell and Kiran Vijayan, Swansea University of South Wales, United Kingdom

Thursday, May 21

MS122

Nonlinear Waves in Coupled Systems - Part I of II

8:30 AM-10:30 AM

Room:Primrose B

For Part 2 see MS134

Traveling waves are special solutions of partial differential equations posed on infinite domains that have spatially homogeneous equilibria. They appear in many applications and attract interest not only because they represent coherent structures, but also because information about traveling waves helps to understand complex dynamics of the physical system and therefore is of importance for the general understanding of the underlying phenomenon. In this special session, we bring together researchers who study various aspects of nonlinear waves in coupled systems of partial differential equations using analytical and numerical techniques, in particular addressing the existence, stability, and speed selection issues.

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

Organizer: Vahagn Manukian
Miami University, USA

8:30-8:55 Nonlinear Waves in a Lugiato-Lefever Model

Mariana Haragus, Université de Franche-Comté, France

9:00-9:25 The Entry-exit Function and Geometric Singular Perturbation Theory

Peter De Maesschalck, Hasselt University, Belgium; *Stephen Schecter*, North Carolina State University, USA

9:30-9:55 Oscillons Near Hopf Bifurcations of Planar Reaction Diffusion Equations

Kelly Mcquighan, Boston University, USA; Bjorn Sandstede, Brown University, USA

10:00-10:25 Stability of Traveling Waves in a Model for a Thin Liquid Film Flow

Vahagn Manukian, Miami University, USA

Coffee Break

10:30 AM-11:00 AM

Room:Golden Cliff

Thursday, May 21

Red Sock Award Announcements

11:00 AM-11:15 AM

Room:Ballroom

IP6

Brain Control - It's Not Just for Mad Scientists

11:15 AM-12:00 PM

Room:Ballroom

Chair: Anthony J. Roberts, University of Adelaide, Australia

The brain is an amazing organ - and dynamical system - which is responsible for a number of important functions including cognition, attention, emotion, perception, memory, and motor control. Some brain disorders are hypothesized to have a dynamical origin; in particular, it has been been hypothesized that some symptoms of Parkinson's disease are due to pathologically synchronized neural activity in the motor control region of the brain. We have developed a procedure for determining an optimal electrical deep brain stimulus which desynchronizes the activity of a group of neurons by maximizing the Lyapunov exponent associated with their phase dynamics, work that could lead to an improved "brain control" method for treating Parkinson's disease. The use of related control methods for treating other medical disorders, including cardiac arrhythmias, will also be discussed.

Jeff Moehlis
University of California, Santa Barbara, USA

Lunch Break

12:00 PM-1:30 PM

Attendees on their own

Thursday, May 21

MS6

Analysis, Modeling, and Forecasting in Biomedicine

1:30 PM-3:30 PM

Room:Magpie A

We will discuss how to use biomedical data to reconstruct and forecast state in different contexts. Specific topics include: (i) model-based forecasting of glucose in type 2 diabetics using sparsely collected data, (ii) model-based forecasting of sleep-wake cycles, (iii) prediction of recovery of consciousness in patients with severe brain injury using clinically collected data, and (iv), time series analysis and modeling using electronic health record data to discover and forecast drug side effects. The talks will focus integrating a diverse set of tools such as data assimilation, spectral time series analysis and Granger causality with real biomedical data.

Organizer: David J. Albers
Columbia University, USA

1:30-1:55 Time Series Modeling and Analysis Using Electronic Health Record Data

George Hripcsak, Columbia University, USA

2:00-2:25 Predicting Recovery of Consciousness in Patients with Brain Injury

Hans-Peter Frey, Columbia University, USA

2:30-2:55 Model-Based Glucose Forecasting for Type 2 Diabetics

David J. Albers, Columbia University, USA

3:00-3:25 Assimilating Sleep - Putting the Model to the Data

Bruce J. Gluckman, Pennsylvania State University, USA

Thursday, May 21

MS123

Spatio-temporal Patterns in Ecology

1:30 PM-3:30 PM

Room:Ballroom I

Many populations and ecosystems exhibit spatial structures, most often generated by interactions between the organisms themselves and their environment. This spatial self-organisation may appear as patterns in vegetation, in the form of flocks of birds or schools of fish. The underlying driving mechanisms and dynamics are for a large part not well-understood. Moreover, ecological questions about spatio-temporal dynamics often generate fundamental challenges to the mathematical theory. In this mini-symposium, various approaches are taken to study ecological and mathematical aspects of the formation of patterns in ecological systems.

Organizer: Vivi Rottschafer
Leiden University, Netherlands

Organizer: Arjen Doelman
Leiden University, Netherlands

1:30-1:55 Models of Patchy Invasion: A Mathematical Toy Or a New Paradigm?

Sergei Petrovskii, University of Leicester, United Kingdom

2:00-2:25 The Effect of Slow Spatial Processes in a Phytoplankton-Nutrient Model

Lotte Sewalt and Arjen Doelman, Leiden University, Netherlands; Antonios Zagaris, University of Twente, Netherlands

2:30-2:55 Stripe Pattern Selection by Advective RD Systems: Resilience of Banded Vegetation on Slopes

Eric Siero and Arjen Doelman, Leiden University, Netherlands; Jens Rademacher, University of Bremen, Germany

3:00-3:25 Pattern-formation in Semiarid Vegetation: Using Bifurcation Theory for Model Comparison

Sarah Iams, Northwestern University, USA

Thursday, May 21

MS124

Recent Insights into Controling Flow Structures - Part II of II

1:30 PM-3:30 PM

Room:Ballroom II

For Part 1 see MS111

Interior flow entities such as fluid interfaces, coherent structures and invariant manifolds have a profound influence on transport in unsteady flows. The ability to control them is attracting much recent interest, fueled in part by emerging biotechnological applications at the microfluidic level. This minisymposium will cover a range of state-of-the-art approaches to controling flow structures which are inspired by dynamical systems methods.

Organizer: Sanjeeva Balasuriya
University of Adelaide, Australia

Organizer: Marko Budisic
University of Wisconsin, Madison, USA

Organizer: Jean-Luc Thiffeault
University of Wisconsin, Madison, USA

1:30-1:55 Multi-Objective Optimal Control of Transport and Mixing in Fluids

Kathrin Padberg-Gehle, Dresden University of Technology, Germany; Sina Ober-Blöbaum, University of Paderborn, Germany

2:00-2:25 Input-Ouptut Analysis in Channel Flows and Implications for Flow Control

Bassam A. Bamieh, University of California, Santa Barbara, USA

2:30-2:55 Correlating Dynamical Structures with Forcing in 2D Flow

Nicholas T. Ouellette, Yale University, USA

3:00-3:25 Nematic Liquid Crystal Flow in a Microfluid: Topological Transitions

Linda Cummings, New Jersey Institute of Technology, USA; Thomas Anderson, California Institute of Technology, USA; Lou Kondic, New Jersey Institute of Technology, USA

Thursday, May 21

MS125

CANCELLED - Data Driven Methods for Dynamical Systems

1:30 PM-3:30 PM

Room:Ballroom III

CANCELLED

In many applications driven by large-scale high-dimensional datasets, there is evidence of a coarse low-dimensional structure nonlinearly embedded in the ambient space. Modern nonlinear methods leverage these coarse geometric structures by constructing discrete approximations to operators, such at the Laplacian, which encode geometric information. Applying these methods to data generated by a dynamical system requires that they respect the time ordering, which is the fundamental structure of dynamics. In this special session we discuss recent developments and explore future ideas for finding coarse geometric structure in large-scale dynamical datasets with a time-ordering, including applications to improve prediction, and uncertainty quantification.

Organizer: Dimitrios Giannakis
Courant Institute of Mathematical Sciences, New York University, USA

Organizer: Tyrus Berry
Pennsylvania State University, USA

Thursday, May 21

MS126

Voltage and Calcium Dynamics in Single Cells and Multicellular Systems

1:30 PM-3:30 PM

Room:Magpie B

Cardiac cell contraction originates with a change in membrane potential that leads to a large release of calcium from intracellular stores and produce contraction. During normal function calcium follows voltage and contraction is uniform. However in disease or extremely fast pacing calcium and voltage coupling can change as well as their respective magnitudes, they can lead to period doubling bifurcations that in turn can produce complex spatiotemporal patterns and initiate arrhythmias. In this minisymposium we will present experimental results and theoretical mechanisms that describe some of the dynamics between calcium and voltage that can lead to cardiac arrhythmias.

Organizer: Flavio Fenton
Georgia Institute of Technology, USA

Organizer: Yanyan Yi
Georgia Institute of Technology, USA

1:30-1:55 Synchronization of Calcium Sparks and Waves

Daisuke Sato, University of California, Davis, USA

2:00-2:25 Nucleation and Dynamics of Spontaneous Ca Waves in Cardiac Cells

Yohannes Shiferaw, California State University, Northridge, USA

2:30-2:55 Effects of Implementing Contraction to Calcium-Voltage Models

Yanyan Ji, Georgia Insitute of Technology, USA and Jagiellonian University, Poland; Flavio M. Fenton, Georgia Institute of Technology, USA; Richard Gray, U.S. Food and Drug Administration, USA

3:00-3:25 Complex Dynamic Patterns of Voltage and Calcium in Mammalian Hearts

Ilija Uzelac and Flavio M. Fenton, Georgia Institute of Technology, USA

Thursday, May 21

MS127

Inverse Problems in Network Dynamics - Part II of II

1:30 PM-3:30 PM

Room:Wasatch A

For Part 1 see MS115

Network Dynamics constitutes a rapidly expanding field with applications in natural and social science, medicine, engineering, and beyond. Commonly, mathematical scientists study how a specific network model behaves collectively as a function of parameters or inputs. Here, taking a complementary view, we ask what recorded time series from a network's units and respective correlation and information measures tell us about the units' local dynamics and their real physical interactions. Such inverse network dynamics are much less explored and even less understood. The minisymposium features recent trends, from foundations and applications in time series analysis to models in physics and biology.

Organizer: Michael Rosenblum
University of Potsdam, Germany

Organizer: Marc Timme
Max-Planck-Institute for Dynamics and Self-Organization, Germany

1:30-1:55 Reconstructing Network Connectivity by Triplet Analysis

Michael Rosenblum, University of Potsdam, Germany

2:00-2:25 Dynamic Information Routing in Complex Networks

Christoph Kirst, Rockefeller University, USA

2:30-2:55 Unraveling Network Topology from Derivative-Variable Correlations

Zoran Levnajic, Laboratory of Data Technologies, Slovenia

3:00-3:25 From Neural Dynamics to Network Properties and Cognitive Function

Daniel Maruyama, Nicollette Ognjanovski, Sara Aton, and *Michal Zochowski*, University of Michigan, USA

Thursday, May 21

MS128

Advances in Computer Assisted Proof for Infinite Dimensional Dynamical Systems

1:30 PM-3:30 PM

Room:Wasatch B

When analyzing global dynamics of infinite dimensional dynamical systems numerical simulation and analytical methods are indispensable tools. Starting with the seminal work of Lanford and Eckmann, rigorous numerics aims at bridging the apparent gap between what can be computed and what can proved rigorously. Mathematically rigorous information on global dynamical features is obtained by starting from finite dimensional approximations of a dynamical scaffold (fixed points, traveling waves, periodic and connecting orbits). This minisymposium explores recent advances in rigorous numerics for topics such as pattern detection in higher order equations, global dynamics of parabolic PDEs and infinite dimensional maps.

Organizer: Christian P. Reinhardt
VU University, Amsterdam, Netherlands

Organizer: Jason Mireles-James
Florida Atlantic University, USA

1:30-1:55 The Parametrization Method in Infinite Dimensions

Christian P. Reinhardt, VU University, Amsterdam, Netherlands; Jason Mireles-James, Florida Atlantic University, USA

2:00-2:25 Rigorous Numerics for Some Pattern Formation Problems

Jan Bouwe Van Den Berg, VU University, Amsterdam, Netherlands

2:30-2:55 Rigorous Numerics for Symbolic Dynamics and Topological Entropy Bounds

Sarah Day, College of William & Mary, USA; Rafael Frongillo, University of California, Berkeley, USA

3:00-3:25 Orbital Stability Investigations for Travelling Waves in a Nonlinearly Supported Beam

Michael Plum, Karlsruhe University, Germany

Thursday, May 21

MS129

Complex Collective Dynamics of Oscillator Networks - Part II of II

1:30 PM-3:00 PM

Room:Maybird

For Part 1 see MS117

Considerable progress has recently been made in understanding the collective dynamics of large oscillator networks. New analytical tools have been created and extended in their applicability, and novel effects have been demonstrated not only theoretically and numerically, but also experimentally. Results in this field have broad application to both physical and biological systems. Part one of this symposium will report recent general mean field results involving chimera states, assortative networks, and generalizations of the classic Kuramoto model. Part two will focus on networks of neuronal oscillators, their relationship to field models, and the dynamical consequences of connectivity.

Organizer: Paul So

George Mason University, USA

Organizer: Arkady Pikovsky

University of Potsdam, Germany

Organizer: Ernest Barreto

George Mason University, USA

1:30-1:55 Neural Field Models Which Include Gap Junctions

Carlo R. Laing, Massey University, New Zealand

2:00-2:25 From Ensembles of Pulse-Coupled Oscillators to Firing-Rate Models

Diego Pazó, Instituto de Física de Cantabria (IFCA), Spain; Ernest Montbrio, Universitat Pompeu Fabra, Spain; Alex Roxin, Centre de Recerca Matemàtica, Spain

2:30-2:55 Suppressing Complex Collective Behavior in a Network of Theta Neurons by Synaptic Diversity

Lucas Lin, Thomas Jefferson High School of Science and Techonology, USA; Ernest Barreto and *Paul So*, George Mason University, USA

Thursday, May 21

MS130

Recent Advances on Multiple Timescale Dynamics - Part II of II

1:30 PM-3:30 PM

Room:Superior A

For Part 1 see MS118

Multiple timescales are ubiquitous in models of real-world phenomena such as neuron firing, laser dynamics, and climatic rhythms. Differential equations involving variables evolving on distinct timescales yield rich and notoriously hard mathematical questions. This two-part minisymposium presents recent results on singularly perturbed ODEs, which is the most amenable paradigm for analysis of multiple timescale phenomena. We will give a panorama of this topic, from theoretical work on planar canard problems, in both smooth and non-smooth vector fields (Part I), to more application-driven studies of complex oscillations with at least three variables and two or more timescales (Part II).

Organizer: Mathieu Desroches

INRIA Paris-Rocquencourt, France

Organizer: Vivien Kirk

University of Auckland, New Zealand

Organizer: Jonathan E. Rubin

University of Pittsburgh, USA

1:30-1:55 Three Timescale Phenomena in Coupled Morris-Lecar Equations

Pingyu Nan, University of Auckland, New Zealand; Yangyang Wang, University of Pittsburgh, USA; *Vivien Kirk*, University of Auckland, New Zealand; Jonathan E. Rubin, University of Pittsburgh, USA

2:00-2:25 An Organizing Center for Spatiotemporal Bursting

Alessio Franci, University of Cambridge, United Kingdom; Guillaume Drion, Brandeis University, USA; Rodolphe Sepulchre, University of Cambridge, United Kingdom

continued in next column

2:30-2:55 Mixed-Mode Bursting Oscillations (MMBOs): Slow Passage Through a Spike-adding Canard Explosion

Mathieu Desroches, INRIA Paris-Rocquencourt, France; Tasso J. Kaper, Boston University, USA; Martin Krupa, INRIA Paris-Rocquencourt, France

3:00-3:25 Averaging, Folded Singularities and Torus Canards in a Coupled Neuron Model

Kerry-Lyn Roberts, University of Sydney, Australia; *Jonathan E. Rubin*, University of Pittsburgh, USA; Martin Wechselberger, University of Sydney, Australia

Thursday, May 21

MS131

Uncertainty Propogation in High Dimensional Systems

1:30 PM-3:30 PM

Room:Superior B

Uncertainty can be found everywhere in real control systems, from the sensor readings to the dynamics themselves. Given incomplete knowledge one must have a means of estimating the likelihood of a given event, such as the toppling over of a robotic walker. In terms of computation, this is a substantially greater challenge than deterministic prediction. Computing likelihood boils down to computing the advection of a probability density. This is typically an infinite dimensional inverse problem. In this series of talks we present a range of approaches for attacking this problem numerically.

Organizer: Henry O. Jacobs
Imperial College London, United Kingdom

Organizer: Ram Vasudevan
University of Michigan, USA

1:30-1:55 Optimal Control Design and Value Function Estimation for Nonlinear Dynamical Systems

Milan Korda, École Polytechnique Fédérale de Lausanne, Switzerland

2:00-2:25 Transfer Operator Methods for Stability Analysis and Control

Umesh Vaidya, Iowa State University, USA

2:30-2:55 Unitary Representations of Diffeomorphisms: Halfway Between Koopmanism and Transfer Operator Theory

Henry O. Jacobs, Imperial College London, United Kingdom

3:00-3:25 Numerical Advection of Probability Densities for High Dimensional Systems

Ram Vasudevan, University of Michigan, USA

Thursday, May 21

MS132

Stochastic Dynamics and Their Applications - Part II of II

1:30 PM-3:00 PM

Room:White Pine

For Part 1 see MS120

Stochastic dynamical concepts are crucial in modelling the dynamical behavior of dynamical systems under uncertainty. There are some theory results of the stochastic dynamics such as the stochastic attractors, invariant manifolds, invariant measures. However, the theory is restricted on some conditions. Applied science and engineering requires more stochastic dynamical techniques. The objective of this minisymposium is to bring the bridge between the new theory methods and approaches to stochastic dynamics in applications.

Organizer: Xiaopeng Chen
Peking University, China

Organizer: Jinqiao Duan
Illinois Institute of Technology, USA

1:30-1:55 How to Quantify Non-Gaussian Stochastic Dynamics?

Jinqiao Duan, Illinois Institute of Technology, USA

2:00-2:25 Random Dynamical Systems for Non-Densely Defined Evolution Equations

Alexandra Neamtu, Friedrich Schiller Universität Jena, Germany

2:30-2:55 Stochastic Center Manifolds Without Gap Conditions

Xiaopeng Chen, Peking University, China

Thursday, May 21

MS133

Engineering Applications of Non-smooth Dynamics - Part II of II

1:30 PM-3:30 PM

Room:Primrose A

For Part 1 see MS121

Friction and impact are challenging research areas of engineering. These phenomena are commonly described by empirical models, such as the coefficient of restitution or various friction models, including the Coulomb-Amontons' law. Modelling contact mechanics from first principles is almost impossible, each model needs some parameter fitting. Even when a model is available, one might not be able to solve it due to various mathematical singularities, where there is no unique prediction. This minisymposium shows a number of applications where the 'rough' terrain of non-smooth dynamics must be carefully navigated. Attempts will be also made to resolve singularities and identify contact force models.

Organizer: Robert Szalai
University of Bristol, United Kingdom

1:30-1:55 Contact and Friction Within Geometrically Exact Shell Theory - Modeling Microslip and Dissipation in Structural Systems

D Dane Quinn, University of Akron, USA

2:00-2:25 A New Semi-Analytical Algorithm for Two-Dimensional Coulomb Frictional System

Xiaosun Wang, Wuhan University, China; Jim Barber, University of Michigan, USA

2:30-2:55 Lessons Learnt from the Two-Ball Bounce Problem

Yani Berdeni, University of Bristol, United Kingdom

3:00-3:25 Predicting Conditions for Self-sustained Vibration in Drillstrings

Tore Butlin, University of Cambridge, United Kingdom

Thursday, May 21

MS134

Nonlinear Waves in Coupled Systems - Part II of II

1:30 PM-3:30 PM

Room:Primrose B

For Part 1 see MS122

Traveling waves are special solutions of partial differential equations posed on infinite domains that have spatially homogeneous equilibria. They appear in many applications and attract interest not only because they represent coherent structures, but also because information about traveling waves helps to understand complex dynamics of the physical system and therefore is of importance for the general understanding of the underlying phenomenon. In this special session, we bring together researchers who study various aspects of nonlinear waves in coupled systems of partial differential equations using analytical and numerical techniques, in particular addressing the existence, stability, and speed selection issues.

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

Organizer: Vahagn Manukian
Miami University, USA

1:30-1:55 An Overview of Evans Function Computation
Jeffrey Humpherys, Brigham Young University, USA

2:00-2:25 Invasion Fronts in Systems of Reaction Diffusion Equations
Matt Holzer, George Mason University, USA

2:30-2:55 Orbital Stability of Waves Traveling Along Vortex Filaments
Stéphane Lafortune, College of Charleston, USA

3:00-3:25 Stability of Combustion Fronts in Hydraulically Resistant Porous Media
Anna Ghazaryan, Miami University, USA

Coffee Break

3:30 PM-4:00 PM

Room:Golden Cliff

Thursday, May 21

Closing Remarks

4:00 PM-4:15 PM

Room:Ballroom

IP7

The Robotic Scientist: Distilling Natural Laws from Raw Data, from Robotics to Biology and Physics

4:15 PM-5:00 PM

Room:Ballroom

Chair: Timothy Sauer, George Mason University, USA

Can machines discover scientific laws automatically? Despite the prevalence of computing power, the process of finding natural laws and their corresponding equations has resisted automation. This talk will outline a series of recent research projects, starting with self-reflecting robotic systems, and ending with machines that can formulate hypotheses, design experiments, and interpret the results, to discover new scientific laws. We will see examples from psychology to cosmology, from classical physics to modern physics, from big science to small science.

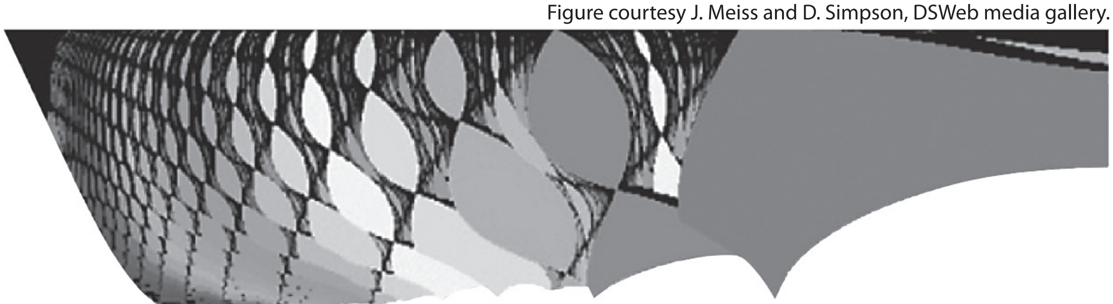
Hod Lipson
Cornell University, USA

Notes

DS15 Abstracts

2015 SIAM Conference on Applications of Dynamical Systems

Figure courtesy J. Meiss and D. Simpson, DSWeb media gallery.



May 17-21, 2015
Snowbird Ski and Summer Resort
Snowbird, Utah, USA

Abstracts are printed as submitted by the authors.

IP1
Advances on the Control of Nonlinear Network Dynamics

An increasing number of complex systems are now modeled as networks of coupled dynamical entities. Nonlinearity and high-dimensionality are hallmarks of the dynamics of such networks but have generally been regarded as obstacles to control. In this talk, I will discuss recent advances on mathematical and computational approaches to control high-dimensional nonlinear network dynamics under general constraints on the admissible interventions. I will present applications to the stabilization of power grids, identification of new therapeutic targets, mitigation of extinctions in food webs, and control of systemic failures in socio-economic systems. These examples will illustrate the potential and limitations of existing methods to address a broad class of problems, ranging from cascade control and transient stability to network reprogramming in general.

Adilson E. Motter
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IP2
Mathematics of Crime

There is an extensive applied mathematics literature developed for problems in the biological and physical sciences. Our understanding of social science problems from a mathematical standpoint is less developed, but also presents some very interesting problems, especially for young researchers. This lecture uses crime as a case study for using applied mathematical techniques in a social science application and covers a variety of mathematical methods that are applicable to such problems. We will review recent work on agent based models, methods in linear and nonlinear partial differential equations, variational methods for inverse problems and statistical point process models. From an application standpoint we will look at problems in residential burglaries and gang crimes. Examples will consider both "bottom up' and "top down' approaches to understanding the mathematics of crime, and how the two approaches could converge to a unifying theory.

Andrea L. Bertozzi
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IP3
Filtering Partially Observed Chaotic Deterministic Dynamical Systems

This talk is concerned with determining the state of a chaotic dynamical system, for which the initial condition is only known probabilisticlly, given partial and noisy observations. In particular it is of interest to study this problem in the limit of a large number of such observations, over a long time interval. A key question is to determine which observations are sufficient in order to accurately recover the signal, and thereby overcome the lack of predictability caused by sensitive dependence on initial conditions. A canonical application is the development of probabilistic weather forecasts. In order to study this problem concretely, we will focus on a wide class of dissipative differential equations with quadratic energy-conserving nonlinearity, including the Navier-Stokes equation on a two dimensional torus. The work presented is contained in the paper D. Sanz-Alonso and A.M.Stuart, "Long-time asymptotics of the filtering distribution for partially observed chaotic deterministic dynamical systems" (http://arxiv.org/abs/1411.6510); see also the paper K.J.H. Law, A. Shukla and A.M. Stuart, "Analysis of the 3DVAR filter for the partially observed Lorenz '63 model,"' Discrete and Continuous Dynamical Systems A, 34(2014), and the book K.J.H. Law, A.M.Stuart and K. Zygalalkis, "Data Assimilation: A Mathematical Introduction" (in preparation, 2015) for further background references.

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IP4
Fields of Dreams: Modeling and Analysis of Large Scale Activity in the Brain

With the advent of optogenetics and the ability to record large numbers of neurons with high temporal resolution, there is now a great deal of interest in both the temporal and spatial activity of neurons in the brain. In this talk, I will discuss a number of old and new developments in the study of these nonlinear integro-differential equations and how they apply to some new biological findings. Topics that I will discuss include the role of noise on spatio-temporal activity, the interaction between extrinsic and intrinsic activity, interactions between multiple spatial networks, and finally some recent applications of Filippov theory to discontinuous neural field models.

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IP5
Cooperation, Cheating, and Collapse in Biological Populations

Natural populations can suffer catastrophic collapse in response to small changes in environmental conditions as a result of a bifurcation in the dynamics of the system. We have used laboratory microbial ecosystems to directly measure theoretically proposed early warning signals of impending population collapse based on critical slowing down. Our experimental yeast populations cooperatively break down sugar, meaning that below a critical size the population cannot sustain itself. The cooperative nature of yeast growth on sucrose makes the population susceptible to "cheater" cells, which do not contribute to the public good and reduce the resilience of the population.

Jeff Gore
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IP6
Brain Control - It's Not Just for Mad Scientists

The brain is an amazing organ - and dynamical system - which is responsible for a number of important functions including cognition, attention, emotion, perception, memory, and motor control. Some brain disorders are hypothesized to have a dynamical origin; in particular, it has been been hypothesized that some symptoms of Parkinson's disease are due to pathologically synchronized neural activity in the motor control region of the brain. We have developed a procedure for determining an optimal electrical deep brain stimulus which desynchronizes the activity of a group of neurons by maximizing the Lyapunov exponent associated with their phase dynamics, work that could lead to an improved "brain control" method for treating Parkinson's disease. The use of related control methods for treating other medical disorders, including cardiac arrhythmias, will also be discussed.

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IP7

The Robotic Scientist: Distilling Natural Laws from Raw Data, from Robotics to Biology and Physics

Can machines discover scientific laws automatically? Despite the prevalence of computing power, the process of finding natural laws and their corresponding equations has resisted automation. This talk will outline a series of recent research projects, starting with self-reflecting robotic systems, and ending with machines that can formulate hypotheses, design experiments, and interpret the results, to discover new scientific laws. We will see examples from psychology to cosmology, from classical physics to modern physics, from big science to small science.

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SP1

Juergen Moser Lecture - Dynamics and Data

This lecture highlights interdisciplinary interactions of dynamical systems theory. Experimental data and computer simulation have inspired mathematical discoveries, while resulting theory has made successful predictions and created new scientific perspectives. Nonlinear dynamics has unified diverse fields of science and revealed deep mathematical phenomena. Examples involving

- One dimensional maps
- Numerical bifurcation analysis
- Multiple time scales
- Bursting and MMOs in neuroscience and chemistry
- Locomotion

are described, along with emerging areas having public impact.

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CP1

Morse-Floer Homology for Travelling Waves in Reaction-Diffusion Equations

This talk is about heteroclinic solutions u of

$$\partial_t^2 u - c\partial_t u + \Delta_x u + f(u) = 0.$$

For suitable (nonlocal) perturbations of this equation solutions can be assigned an index, and solutions with a fixed index form a finite dimensional manifold. Furthermore, for a large class of nonlinearities f we can count index 1 solutions. This allows us to define Morse-Floer homology groups, which are invariant with respect to continuation of f.

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CP1

Reaction-Diffusion Equations with Spatially Distributed Hysteresis in Higher Spatial Dimensions

Many chemical and biological processes are modelled by reaction-diffusion equations with a nonlinearity involving hysteresis. In such problems each spatial point can be in one of two configurations and the configuration changes in time via a hysteresis law. Points in different configurations segregate the domain into several subdomains and switching implies that these subdomains are separated by free boundaries. We will discuss how the hysteresis gives rise to a novel type of free boundary evolution.

Mark J. Curran
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CP1

Existence of Periodic Solutions of the FitzHugh-Nagumo Equations for An Explicit Range of the Small Parameter

We consider the FitzHugh-Nagumo system describing nerve impulse propagation in an axon. With aid of computer-assisted rigorous computations we are able to show the existence of the periodic pulse for an explicit range of singular perturbation parameter $\epsilon \in (0, \epsilon_0]$. Our right bound ϵ_0 is large enough to be reached by validated continuation methods designed for ODEs without time scale separation.

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CP1

Spatio-Temporal Dynamics of Heterogeneous Excitable Media

The propagation of electrical waves in biological tissue or concentration waves in chemical reactions are examples for complex dynamics in excitable media. Already simple homogeneous reaction-diffusion systems reveal a rich diversity of dynamical patterns, including spiral waves and spatio-temporal chaos. Here we consider excitable media including heterogeneities and study their (transient) dynamics in numerical simulations employing (covariant) Lypaunov Vectors, (linear) mode decompositions, and diffusion-mapped delay coordinates.

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Ulrich Parlitz, Stefan Luther

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CP1

Low Dimensional Models of Diffusion and Reaction in Stratified Micro Flows

We develop a low dimensional model of simultaneous interphase mass transfer and reaction in two-phase stratified flows through microchannels. Here, diffusion quickly equilibrates the distribution of species in the lateral direction. This singularly perturbed dynamical system has a *slow invariant manifold*, which is parameterized by a suitably weighted laterally averaged concentration. The *Lyapunov-Schmidt reduction* of bifurcation theory is used to compute this manifold and derive reduced order models for arbitrary reaction kinetics.

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CP1

Defect Solutions in Reaction-Diffusion Equations

In this talk, I will discuss the effect a heterogeneity can have on the pattern formation process for two different types of reaction-diffusion equations. These heterogeneities for example arise in models where a particular species is only produced in a particular part of the domain of interest. I will mainly focus on the pinning of solutions near and away from the heterogeneity.

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CP2

Generalized Behavior of the Two-phase System in (1+1) D

The two-phase model is well known for its applications in gel-dynamics. A network made of an extracellular polymeric substance (EPS) is immersed in a fluid solvent. The network provides a layer of protection for bacterial growth. We find a general reduction in the two-phase system for an arbitrary growth in (1+1) D to a system of a single variable. This system emits several solutions. The first two solutions show that in the presence of logistic growth in a frictionless environment, osmotic pressure has a negligible effect. The third solutions shows that the inviscid two-phase system emits shocks and rarefactions.

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CP2

Scaling and Robustness of Two Component Morphogen Patterning Systems

Embryonic development requires highly reproducible mechanisms of pattern formation so that cell fate is assigned at the right time and location. To identify the mechanisms of pattern regulation, we developed a Two Component System (TCS) model of morphogen (m) and modulator (M) that interact and spatially alter the biochemical properties of each other. We identified a number of network motifs that confer scaling and robustness of morphogen patterning including bilateral repression and others.

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CP2

Solitary Waves in the Excitable Discrete Burridge-Knopoff Model

The Burridge-Knopoff model describes the dynamics of an elastic chain of blocks pulled over a surface. This model accounts for nonlinear friction phenomena and displays excitability when the velocity-dependent friction force is non-monotone. We introduce a simplified piecewise linear friction law (reminiscent of the McKean nonlinearity in spiking neuron models) which allows us to analyze the existence of large amplitude solitary waves. Propagation failure is shown to occur for weakly coupled oscillators.

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CP2

Aspects and Applications of Generalized Synchronization

Different concepts of generalized synchronization of coupled (chaotic) dynamical systems and corresponding time series analysis methods are revisited and compared. Furthermore, we address the relation to snapshot attractors as well as potential applications of generalized synchronization for state estimation and data assimilation. For all topics representative examples will be given to illustrate the main statements.

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CP2

Discrete Synchronization of Massively Connected Systems Using Hierarchical Couplings

We study the synchronization of massively connected networks of which interactions come from successive hierarchical couplings. Motivations of this work come from the growing necessity of understanding properties of complex systems that often exhibit a hierarchical structure. Starting with a set of 2^n coupled maps, we obtain synchronization results for infinitely many, i.e for a Cantor set of maps. We also prove synchronization happens when the network is still massively connected but with an infinite number of broken links inside the hierarchical structure.

Camille Poignard
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CP2

Nonlinear Dynamics of Two-Colored Filaments

Propagation of light filaments is a highly nonlinear process that results from light-matter interactions. It is important area in nonlinear optics with much ongoing theoretical and experimental research efforts. While there has been much progress in both fronts, there remain many challenges to produce long-lived filaments. Modeling requires good understanding of light matter interactions with a particular objective of determining conditions that limits spatio-temporal instabilities thus producing quasi-stable dynamics. While typical studies concentrate on optical filaments at a single frequency, mostly in the infrared (IR) and the ultraviolet (UV) wavelengths, under suitable conditions nonlinear wave-mixing can lead to multicolored filaments. In this talk I will present new results that consider the co-existence of UV/IR filaments under a variety of spatial configurations

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CP3

Heterogeneities in Temporal Networks Emerging from Adaptive Social Interactions

Recent studies on social empirical data have revealed heterogeneities in human dynamics, which are signs of the distinctive mechanism underlying the dynamical behaviors of societies. It is known that human activity is bursty, and the social interactions have scale-free structures. To facilitate unified understanding of social dynamics and networks, we propose a model of adaptive temporal networks. Under suitable conditions, this model exhibits heterogeneous temporal and structural behaviors even from a completely homogenous initial condition.

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CP3

Analysis of Connected Vehicle Networks with Nontrivial Connectivity, a Modal Decomposition Approach

Connected vehicles that communicate via wireless vehicle-to-vehicle communication are gaining increasing attention due to their potential in improving traffic safety, mobility, and efficiency. As connected vehicle systems become more complex, the analysis of the arising networked dynamical systems becomes more challenging. We present a novel method to analyze the network modes by expansion around a network of simple connectivity, and demonstrate that unstable traffic flow can be stabilized using long-range interactions.

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CP3

Simulating the Dynamics of College Drinking

Heavy episodic or binge drinking is among the most difficult public health challenges on college campuses. Integrating peer influence models from public health and identity verification from social psychology as mechanisms that influence drinking behavior, we develop an agent-based simulation to examine the dynamics of drinking events, as students group together and interact. We also consider the conditions necessary for widely-used social norms interventions to be effective.

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CP3

Integrating Hydrological and Waterborne Disease Network Models

Mechanistic drivers of the seasonal patterns of cholera in Bangladesh remain poorly understood. A community network model for cholera dynamics is developed. A hydrological model for the Ganges-Brahmaputra-Meghna river basin is integrated into the disease network model to account for seasonality of surface water connectivity and contamination. We demonstrate that the integrated model can contribute to the understanding of disease dynamics and potentially to the development of disease forecasting tools.

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Joseph H. Tien
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Department of Mathematics
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CP3

Phase Response Properties of Collective Rhythms in Networks of Coupled Dynamical Systems

Phase response property of a network of diffusively coupled dynamical units undergoing collective oscillations is studied. Each unit can possess arbitrary local dynamics as long as the whole coupled system exhibits stable limit-cycle oscillations. The phase response property of the system can be decomposed into Laplacian eigenmodes of the coupling network, which reveals how each individual mode contributes to the total phase response. Phase synchronization of simple dynamical networks is analyzed as an example.

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Sho Yasui
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CP4

Prediction in Projection

Full and accurate reconstruction of dynamics from time-series data—e.g., via delay-coordinate embedding—is a real challenge in practice. For the purposes of forecasting, however, reconstructions that do not satisfy the dimension conditions of the embedding theorems can still be quite useful. Despite the lack of topological conjugacy, near-neighbor forecast methods working in these reduced-order spaces are as (or more) effective than in complete embeddings. We demonstrate this using both synthetic and experimental time series data.

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Elizabeth Bradley
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CP4

Sparse Sensing Based Detection of Dynamical Phenomena and Flow Transitions

Reduced order models for fluid dynamics are often sensitive to changes in flow topology and require some information about the dynamical regime of operation. Using sparse sensing and reconstruction techniques, we present a framework to detect dynamical phenomena such as bifurcations and changes in flow topology in a variety of thermo-fluid dynamical systems. This framework can be combined with adaptive reduced order models for improved observation and control. We present some numerical results for the case of Navier Stokes and Boussinesq equations.

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CP4

Bifold Visualization of Dynamic Networks

We consider binary datasets arising from bipartite data, where the data describes the relationships between two types of entities (such as a user "liking' a certain movie). Comparing the binary patterns between entities provides a dissimilarity measure which allows projecting that data in a Euclidean representation. We apply our algorithm to datasets of US senators and their voting records. By simultaneously representing intergroup and intragroup relationships, significant additional insight is provided by the visualization.

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CP4

An Algorithmic Approach to Computing Lattice Structures of Attractors

We describe the lifting of sublattices of attractors, which are computationally less accessible, to lattices of forward invariant sets and attracting neighborhoods, which are computationally accessible. We provide necessary and sufficient conditions for such a lift to exist along with algorithms to check whether such conditions are met or not and to construct the lift if met. We illustrate the algorithms with some examples.

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CP4

Expanded Mixed Finite Element Method for Generalized Forchheimer Flows

We study the expanded mixed finite element method applied to the Forchheimer fluid flow in porous media. The bounds for the solutions are established. Utilizing the spe-

cial properties of Forchheimer equation and boundedness of solutions we prove the optimal error estimates in L^2-norm for solution. The error bounds are established for the solution and divergence of the vector variable in Lebesgue norms and Sobolev norms. A numerical example using the lowest order Raviart-Thomas (RT_0) mixed element are provided agreement with our theoretical analysis.

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CP4

A Method for Identification of Spatially-Varying Parameters Despite Missing Data with Application to Remote SensingA Method for Identification of Spatially-Varying Parameters Despite Missing Data with Application to Remote Sensing

Remote sensing data allows for ecological inferences over large-scale oceanic regions. Proposed models require parameter tuning to match data observations, including synchronization and filtering methods. A major hindrance in applying synchronization methods to remote sensing data is the frequency with which clouds hide parts of a satellite image. A synchronization method is discussed to infer unknown model parameters and states, despite hidden data. We treat a PDE as a temporally-varying network to prove the method.

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CP5

A Mathematical Model for the Sexual Selection of Extravagant and Costly Mating Displays

The evolution of extravagant and costly ornaments on animals has intrigued biologists and mathematicians since Darwin suggested that female preference for exaggerated courtship displays drives the sexual selection of these ornaments. We propose a minimal mathematical model that incorporates two components of ornament evolution: an intrinsic cost and/or benefit of ornamentation to an individual, and a social benefit of relatively large ornaments within a population. Using bifurcation analysis and perturbation theory, we show that on an evolutionary time scale, identically healthy animals will split into two niches, one with large ornaments and one with small. This result may explain why ecologists have observed bimodal distributions of ornament size in several species.

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CP5

Mathematical Models of Seasonally Migrating Populations

Predator-prey systems that allow for one or more species to undergo mass migration open up a range of new possibilities from a dynamical point of view. We consider two different approaches to modelling problems of this type, namely, ordinary and partial differential equations. In both cases the inclusion of time switches is key to understanding their behaviour and allows us to consider the effects of timing mismatches brought about by changing climatic conditions.

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CP5

A Model for Mountain Pine Beetle Outbreaks in An Age Structured Forest: Approximating Severity and Outbreak-Recovery Cycle Period

We develop a system of difference equations to model (temperature-driven) mountain pine beetle infestation in an age-structured forest. Equilibrium stability analysis indicates the existence of periodic outbreaks that intensify as growth rates increase. Analytical methods are devised to predict outbreak severity, duration, and frequency. The model predicts cycle periods that fall within observed outbreak period ranges. To assess future beetle impact on forests, we predict severity of outbreaks in the face of changing climate.

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CP5

Host-Mediated Responses on the Dynamics of Host-Parasite Interaction

The regulation of helminth populations within hosts depends on host age, immunity and density-dependent constraints. Laboratory infections reveal that rabbit immunity limits worm growth and reduces fecundity. Continuous natural exposure of rabbits to worms generates a negative relationship between rabbit age and worm fecundity. Using an age-structured population model we show how these regulatory factors stabilize the dynamical behaviour of between-host transmission via egg shedding through maintaining a self-sustained oscillation in rabbit generations.

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CP5

Geometric Dissection of a Model for the Dynamics of Bipolar Disorders

We study a model for the dynamics of bipolar disorders developed by A. Goldbeter. The model is four-dimensional and not in the standard form of slow-fast systems. The geometric analysis of the model is based on identifying and using hierarchies of local approximations based on various - hidden – forms of time scale separation. A central tool in the analysis is the blow-up method which allows the identification of a complicated singular cycle.

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CP6

Continuation of Bifurcations in Physical Experiments

A good mathematical model for a specific physical system can be hard to create. Fortunately, the low cost and easy availability of high-speed electronics now enables real-time integration of numerical methods and physical experiments. This opens up a wide range of new possibilities in experimental nonlinear dynamics. Here we outline the current state-of-the-art in control-based continuation, a method for tracking the solutions and bifurcations directly in a physical experiment.

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CP6

Structuring and Stability of Solutions of the Static Cahn-Hilliard Equation

We use the variational form of the 2D Cahn-Hilliard equation to obtain numerically the steady non-linear solutions of films of confined polymer blends with a free deformable surface. Varying the average composition and geometry of the films we find a rich morphology of solutions in the form of laterally structured films, layered, droplets over the substrate and free surface, and checkerboard structures. We show that laterally structured films are energetically favorable and that most of the solutions appear through pitchfork bifurcations.

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CP6

Escape from Potential Wells in Multi-Degree of Freedom Systems: Phase Space Geometry and Partial Control

Predicting the escape from a potential energy well is a universal exercise, governing myriad engineering and natural systems, e.g., buckling phenomena, ship capsize, and human balance. For such systems, tube dynamics provides the phase space criteria for escape. We consider a control problem where the goal is to avoid escape in the presence of large disturbances which are greater in magnitude than the controls by implementing a safe-set-sculpting algorithm which explicitly incorporates tube dynamics.

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CP6

Periodic Social Niche Construction

Social niche construction describes the creation of social networks and institutions that influence individual fitness. Niche construction involves multiple timescales, including the relatively short time required to build a niche, and the longer time required to learn how to build a niche. We explore a number of learning rules for niche construction in relation to competition between constructing species or agents, in particular the dynamics of institutional switching, as the system undergoes a Hopf-bifurcation. Hysteresis in key competition parameters provides evidence of top-down causal memory from the institutions, leading to increased resistance to change between states. This is due to the different stability criteria for a periodic solution as dictated by Floquets theory. We also find evidence for greater stability in a two-institution than a single institution setting. We relate these results to prior discussion of stability induced in bi-polar versus unipolar social systems.

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CP6

Experimental Verification of Criteria for Escape from a Potential Well in a Multi-degree of Free-

dom System

Criteria and routes of escape from a potential well have previously been determined for 1 degree of freedom (DOF) mechanical systems with time-varying forcing, with reasonable agreement with experiments. When there are 2 or more DOF, the situation becomes more complicated, but there is still a method, tube dynamics, for determining the phase space states which will escape. Here, we verify tube dynamics for a 2 DOF experiment of a ball rolling on a surface.

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CP6

Sensitivity of the Dynamics of the General Rosenzweig-MacArthur Model to the Mathematical Form of the Functional Response: a Bifurcation Theory Approach

We revisit the Rosenzweig-MacArthur predator-prey model to help explain sensitivity to the mathematical forms of three functional responses (Holling type II, Ivlev, and Trigonometric). We consider both local and global dynamics and determine possible bifurcations with respect to variation of the carrying capacity of the prey. We provide an analytic expression that determines the criticality of a Hopf bifurcation and revisit the ranking of the functional responses, according to their potential to destabilize the dynamics of the model.

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CP7

Numerical Simulations of Nonlinear Dynamics of Beams, Plates, and Shells

Solution of nonlinear structural dynamics poses a challenging problem and often requires the use of computers in order to obtain a quantitative solution. Such simulations are usually computationally expensive and are typically performed only as academic research. The current study serves two purposes: i) it presents simple semi-implicit numerical formulations, which are computationally efficient, simple to use, and can be used in nonlinear dynamics and chaos simulations ii) it serves as a good introduction to numerical studies of nonlinear structural dynamics for graduate students and upper division undergraduate students. Numerical formulations along with results are presented for nonlinear oscillators, beams, von Karman plates, and thin shells.

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CP7

A New Mathematical Explanation of What Triggered the Catastrophic Torsional Mode of the Tacoma Narrows Bridge

We suggest a mathematical model for the study of the dynamical behavior of suspension bridges which provides a new explanation for the appearance of torsional oscillations during the Tacoma collapse.

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CP7

Global Attractors for Quasilinear Parabolic-Hyperbolic Equations Governing Longitudinal Motions of Nonlinearly Viscoelastic Rods

We prove the existence of a global attractor and estimate its dimension for a general family of third-order quasilinear parabolic-hyperbolic equations governing the longitudinal motion of nonlinearly viscoelastic rods subject to interesting body forces and end conditions. The simplest version of the equations has the form $w_{tt} = n(w_x, w_{xt})_x$ where n is defined on $(0, \infty) \times \mathbb{R}$ and is a strictly increasing function of each of its arguments, and with $n \to -\infty$ as its first argument goes to 0. This limit characterizes a total compression, a source of technical difficulty, which delicate a priori estimates prevent. (These estimates simplify and generalize earlier versions.) We determine how the dimension of the attractor varies with the several parameters of the problem, giving conditions ensuring that it is small. These estimates illuminate asymptotic analyses of the governing equation as parameters approach limits.

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CP7

Revision on the Equation of Nonlinear Vibration of the Cable with Large Sag

The problem in the conventional cable theory about the relation between the chord-line component of dynamical cable tension and the deflection is discussed. The expression of the chord-line component of dynamical cable tension is rationally revised based on the proposed compatibility equation. The equation of motion of cable in time and space is then formulated with the corrected expression of chord-line component of cable internal force and reduced to nonlinear multi-degree-of-freedom system with Galerkin's method. Some numerical results are presented and discussed. The upper limit of the sag-span ratio for which the conventional equation of cable motion can give acceptable

results is investigated.

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CP7

Control Strategies for Electrically Driven Flapping of a Flexible Cantilever Perturbed by Low Speed Wind

Control parameters for the effect of low speed wind perturbations to the electrically driven flapping of a flexible cantilevered beam are studied both experimentally and numerically. The experiments consist of varying the applied potential (1kV-9kV) between the gap (15mm-35mm) separating a conducting plastic cantilever and a rigid ground electrode. Other inputs are the frequency (1Hz-8Hz), the input signal type (sine, square and triangle) and wind speed (1mph-8mph). Numerical data is produced using the dynamic Euler-Bernoulli beam equation with viscous damping and gravitational effects. The electrical load appears as a non-linear term in the otherwise linear equation. The numerical and experimental data for the effects of electrical load, frequency and wind speed on vibrational amplitude of the cantilever will be used to introduce control strategies for these systems.

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CP8

Coexistence of Multiannual Attractors in a Disease Interaction Model: Whooping Cough Revisited

Incidence of whooping cough (WC) exhibits variable dynamics with periodicity 2-5 years. We propose an alternative model of WC as interacting strains via age-dependent convalescence. The model exhibits several stable multiannual coexisting attractors. Also, perturbation due to case-importation and noise in transmission switches the system from one dynamical regime to the other. This study suggests that variable dynamics of WC could be an emergent property of the interacting system, which is not observed earlier.

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CP8

Examining Ebola Transmission Dynamics and Forecasting Using Identifiability and Parameter Estimation

The ongoing Ebola epidemic in West Africa is larger than all previous Ebola outbreaks combined. Here I will discuss our ongoing work developing mathematical models of the Ebola epidemic, using a range of identifiability and parameter estimation approaches. We used these models to examine uncertainty in forecasting disease dynamics, and evaluated a range of questions involving spatial spread, alternative intervention strategies, and contributions to transmission by different infectious stages (early-stage, late-stage, and funeral transmission).

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CP8

How Radiation-Induced Dedifferentation Influences Tumor Hierarchy

Evidence indicates solid tumors exhibit cellular hierarchy where only a fraction of cells are able to maintain and regrow the tumor. Recent discoveries indicate that, besides these inherent cancer stem cells, other cells can dedifferentiate to a stem-like state after radiation exposure. We modify an ODE lineage model to include feedback, radiation, and dedifferentiation. Setting parameters with experimental data, we observe an elevated dedifferentiation rate for irradiated cells that can profoundly impact long-term population size.

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CP8

Order Reduction and Efficient Implementation of Nonlinear Nonlocal Cochlear Response Models

The cochlea is shown to exhibit active nonlinear spatiotemporal response dynamics. To model such phenomena, it is often necessary to incorporate cochlear fluid-membrane interactions. This results in both high-order model formulations and computationally-intensive solutions that limit their practical use (for psychoacoustic audio signal processing) even for simple single-tone brief inputs. In this paper, we reformulate an existing nonlinear cochlear model into sparse state-space (SS) models that are of considerably lower order (factor of 8) and are computationally simpler (factor of 25) with little reduction in accuracy.

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CP8

Periodic Outbreaks in Models of Disease Transmission with a Behavioral Response

Recently there has been increasing interest in the effects of behavioral responses to information on outbreaks of infectious diseases. Such a response can drive the infection to low endemic levels even if it wanes over time and the infection does not confer immunity upon recovery. This talk will report on recent results on the question whether a waning behavioral response provides sufficient protection against subsequent flare-ups of the infection.

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CP8

Competition and Invasion of Dengue Viruses in Vaccinated Populations

The complex competitive landscape that exists between the four dengue serotypes will change in unforeseeable ways with the soon-to-be released commercial vaccines. Here, we use a compartmental dengue transmission model incorporating mass vaccination to investigate the possibility of serotype reintroduction in locations where one or more serotypes are absent. We show that the widespread application of fully sterilizing vaccines can have the unintended effect of facilitating the reintroduction of missing serotypes.

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CP9

$\mathcal{C}^\infty$ Regularisation of Local Singularities of Filippov Systems

We study the Sotomayor-Teixeira regularization of a general visible fold singularity of a Filippov system. In the case that the regularized system is $\mathcal{C}^{p-1}$ the deviation from the Fenichel manifold is $O(\varepsilon^{\frac{p}{2p-1}})$. We extend these results to the case where the regularized vector field is analytic. In this case the regularized vector field and the Filippov one are different in the whole phase space, but this is just a technical problem that will not change the final result.

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CP9

Filippov Unplugged - Part 2

Following on from Filippov Unplugged part 1, we will present results from "Differential equations with discontinuous righthand sides" that hold in n-dimensional nonsmooth systems. Focussing on issues of topological equivalence and structural stability, we will identify basic topological classes of singularities that can occur, as well as the bifurcations that ensue. Practical examples, rooted in real applications, will be given to illustrate the talk.

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CP9

Filippov Unplugged — Part 1

Almost every paper on nonsmooth systems references the book by Filippov "Differential equations with discontinuous righthand sides' (Kluwer, 1988). The aim of this talk is to direct attention toward results therein that are relevant to the modern audience, yet do not appear to be widely known. In particular, we will focus on two-dimensional flows, and discuss how we must fundamentally revise our notions of singularities, codimension, separatrices, structural stability, topological equivalence and bifurcations.

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CP9

On the Use of Blow Up to Study Regularizations of Singularities of Piecewise Smooth Dynamical Systems

This talk will demonstrate the use of the blow up method of Krupa and Szmolyan to study the regularization of singularities of piecewise smooth dynamical systems. We will primarily focus on the regularization of the two-fold bifurcation and the perturbation of associated limit cycles, pseudo-equilibria, and canard-like orbits connecting stable sliding with unstable sliding. We will also present results on how the regularization function can introduce additional bifurcation.

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CP10

Curve Evolution in Second-Order Lagrangian Systems

A second-order Lagrangian system is a generalization of a classical mechanical system for which the Lagrangian action depends on the second derivative of the state variable. Recent work has shown that the dynamics of such systems can be substantially richer than for classical Lagrangian systems. In particular, topological properties of the planar curves obtained by projection onto the lower-order derivatives play a key role in forcing certain types of dynamics. However, the application of these techniques requires an analytic restriction on the Lagrangian that it satisfy a twist property. Here we approach this problem from the point of view of curve shortening in an effort to remove the twist condition.We prove the existence of simple periodic solutions for a general class of systems without requiring the twist condition. Further, our results provide a framework in which to try to further extend the topological forcing theorems to systems without the twist condition.

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CP10

Tensor of Green of Coupled Thermoelastodynamics

Some problems of coupled thermoelastodynamics are considered. Method of boundary integral equations is used for solution of system of integral equations, fundamental tensors of stresses received by using of apparate of generalized functions.

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CP10

Periodic Eigendecomposition and Its Application in Nonlinear Dynamics

As an extension of periodic Schur decomposition, periodic eigendecomposition is capable of calculating Floquet spectrum and Floquet vectors along periodic orbits in chaotic systems accurately. Its effectiveness, and in particular its ability to resolve eigenvalues whose magnitude differs by hundreds of orders, is demonstrated by applying the algorithm to computation of the full linear stability spectrum of periodic solutions of Kuramoto-Sivashinsky system. Also, its efficiency is compared with the existing covariant vectors algorithm.

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CP10

Error Assessment of the Local Statistical Linearization Method

We determine probability density functions of multidimensional stochastic differential equations by means of the Local Statistical Linearization method. The core of this method is the approximation of a non-Gaussian probability density by superposition of Gaussian densities. For this, the evolutions of local Gaussian densities are calculated and used in a time stepping scheme. Moreover, we provide error evolutions using accurate Monte Carlo simulations, Stochastic Averaging and available analytical solutions.

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CP10

Geometric Phase in the Hopf Bundle and the Sability of Non-Linear Waves

Building on the Evans function, we have proven a related, alternative form of analysis that uses the Hopf bundle to determine the stability of traveling waves. The total space of the Hopf bundle is S^{2n-1} and it is naturally embedded in C^n. The dynamical system associated with the linearized operator for a PDE induces a winding number through parallel transport in the fibre, S^1. Our method uses parallel transport to count the multiplicity of eigenvalues.

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CP10

Computation of Cauchy-Green Strain Tensor Using Local Regression

The Cauchy-Green strain tensor provides an effective tool for understanding unsteady flows. We propose a new method for computing the CG strain tensor using a local quadratic regression (LOESS) technique. We compare this LOESS method with several classical methods using closed form flows, noisy flows, and simulated time series. In each case the CG strain tensor produced by the LOESS method is remarkably accurate and robust compared to classical

methods.

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CP11

Odd-Number Limitation for Extended Time-Delayed Feedback Control

Time-delayed feedback control is a simple and established method to stabilize unstable periodic orbits within a chaotic attractor. Here we prove a generalization of the well-known odd-number limitation of this control method to the case of autonomous systems. This result is further generalized to the extended version of time-delayed feedback control. We uncover the important role played by the period of the orbit that is induced by mismatching the delay time of the control scheme.

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CP11

Approximate Controllability of An Impulsive Neutral Fractional Stochastic Differential Equation With Deviated Argument and Infinite Delay

We proved the approximate controllability of an impulsive fractional stochastic neutral integro-differential equation with deviated argument and infinite delay. We used Schauder fixed point theorem and fundamental assumptions on system operators. The inverse of controllability operator fails to exist in infinite dimensional space in case generated semigroup is compact. Therefore, the need to assume the invertibility of controllability operator is removed. Lipschitz continuity is also not required. Specifically we studied the following remote control dynamical system

$$\begin{aligned} {}^cD_t^q[x(t)+g(t,x_t)] &= A[x(t)+g(t,x_t)]+Bu(t)+f(t,x(a(x(t),t)),u(t)) \\ &+ \int_{-\infty}^{t} G(x_s)dW(s), t\in J=[0,T], t\neq t_k, k=1,...,m \\ x_0(t) &= \phi(t), \qquad t\in J_1=(-\infty,0] \\ x(t_k^+)-x(t_k^-) &= I_k(x(t_k)), \qquad k=1,...,m, \end{aligned}$$

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CP11

Chaos in Biological Systems with Memory and Its Controllability

Biological systems, a neuron, the brain, the heart, a human being, a society .., are systems with memory (in many cases power-law). This implies a possibility of their description by fractional differential equations or maps with power-law memory. Nonlinear systems with power-law memory demonstrate new features, including cascade of bifurcations type behavior (with fixed parameters). This behavior could be related to the evolution of chronic diseases, epileptic seizures, and evolution of the human society. In nonlinear systems with power-law memory chaos can be controlled by changing nonlinearity parameter and also by changing a memory parameter of a system.

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CP11

Discrete-Time Structure-Preserving Optimal Ergodic Control

Trajectories are ergodic with respect to a measure when the amount of time spent in a neighborhood is proportional to the measure evaluated over the neighborhood, making ergodicity an appropriate metric for searching a domain. Ergodic control in higher dimensional configuration spaces requires discretization of the optimal control formulation. Recent works have shown advantages of structure-preserving variational integrators in control and estimation of mechanical systems. Here we develop a discrete-time variational optimal ergodic control scheme.

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CP11

Mathematical Study of the Effects of Travel Costs on Optimal Dispersal in a Two-Patch Model

How might organisms constrained by perceptual limitations or imperfect information use resource information optimally in habitat selection? We analyze a general ordinary differential equation model of a single species in a two-patch heterogeneous environment. Global stability analysis yields an evolutionarily stable information use strategy that depends on the magnitude of the constraints and the heterogeneity of the resources. Incorporating travel costs into the model yields a different strategy that is locally convergent stable

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CP11

Computing Bisimulation Functions Using SoS Optimization and δ-Decidability over the Reals

We present BFComp, an automated framework based on Sum-Of-Squares (SOS) optimization and δ-decidability over the reals to compute Bisimulation Functions (BFs) that characterize input-to-output stability (IOS) of dynamical systems. BFs are Lyapunov-like functions that decay along the trajectories of a given pair of systems, and can be used to establish the stability of the outputs with respect to bounded input deviations. In addition to establishing IOS, BFComp is designed to provide tight bounds on the squared output errors between systems whenever

possible. For this purpose, two SOS optimization formulations and δ-decidability-based Satisfiability Modulo Theory are employed. We illustrate the utility of BFComp on a feedback-based canonical cardiac-cell model, showing that the four-variable Markovian model for the slow Potassium current I_{Ks} can be safely replaced by an approximately one-variable Hodgkin-Huxley-type approximation.

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CP12

Empirical Validation of Conceptual Climate Models

Conceptual climate models are useful for testing hypotheses regarding the processes underlying observations; but they generally can only qualitatively match the empirical records. Models based on substantially different underlying physics can have comparable correlations with any given observation; more robust model validation procedures are needed. Using the Mid-Pleistocene Transition as a test case, we will show how modern time-series-analysis techniques can improve validation by extracting subtler features of the observations and models.

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CP12

Modified Lorenz Equations for Rotating Convection

We derive and examine systems of nonlinear differential equations similar to the Lorenz equations. In particular, starting from the partial differential equations describing two-dimensional Rayleigh-Benard convection we derive systems of ordinary differential equations that are slight modifications of Lorenz' original system. These new systems of equations incorporate the effects of rigid body rotation. We investigate the role that rotation has on the dynamics of these reduced models.

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CP12

On the Geometry of Attractors in Ageostrophic Flows with Viscoelastic-Type Reynolds Stress

Progress utilizing other closure protocols appear in this research and innovation. Although this article is motivated by challenges in partial differential equations, we consider a two-mode Faedo-Galerkin approximation(Ed Lorenz ansatz sense) given by a system of singularly perturbed ordinary differential equations in R^4:

$$Ro\frac{dX}{dt} = Y - EkX - \lambda EkW,$$

$$\frac{dY}{dt} = \varepsilon X + X - Y - XZ,$$

$$\frac{dZ}{dt} = -bZ + XY,$$

$$We\frac{dW}{dt} = r(\delta\lambda X - W).$$

It is shown that the equilibrium point at the origin is asymptotically stable and attractive by the LaSalle invariance principle. Utilizing center manifold calculations, we show existence of supercritical pitchfork bifurcation and Poincare-Andronov-Hopf bifurcation. In order to utilize geometric singular perturbation theory and Melnikov techniques, we perturb the problem and carry the nonlinear analysis further to the question of the persistence of inclination-flip homoclinic solutions. We present a geometric approach to the problem which gives more refined a priori energy type estimates on the position of the invariant manifold and its tangent planes as the manifold passes close to a normally hyperbolic piece of a slow manifold. The main object of this result enables detection of chaotic attractors in singularly perturbed dynamical systems as depicted using the DsTool(Dynamical systems Tool) package program of Worfolk *et al.*

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CP12

Baroclinic Instability in An Initially Stratified Rotating Fluid

Motivated by the large-scale atmospheric and oceanic circulation, we study the characteristics of density-driven convective flow in an annular, tabletop-size rotating laboratory tank, filled with water. Horizontal and vertical density gradients are induced by differential heating at the sidewalls and salinity stratification, respectively. These boundary conditions, together with the rotation of the tank, yield an interesting interplay between double-diffusive convection and baroclinic instability.

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CP12
Gradual and Abrupt Regime Shifts in Drylands

The response of ecosystems to climatic changes and anthropogenic disturbances are crucial to our understanding of these systems. Transitions in drylands due to these perturbations may take various forms, in particular due to the patterned nature of patchy vegetation. I will discuss multistability in these systems, owing to localized states and patterns with various wavelength, and possible transitions in them. A case study of fairy circles in Namibia will be presented as a concrete example.

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CP13
Localized States in Periodically Forced Systems

The generalized Swift–Hohenberg equation with a quadratic-cubic nonlinearity is used to study localized pattern formation in the presence of time-periodic parametric forcing. Regions of parameter space with distinct dynamics result from resonances between the period of the forcing and the time it takes the state to nucleate/annihilate wavelengths of the pattern. The non-trivial structure of these regions can be understood qualitatively, and in some cases quantitatively, by asymptotic arguments.

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CP13
Multicluster and Traveling Chimera States in Nonlocal Phase-Coupled Oscillators

We study a nonlocal phase-coupled oscillator model in which chimera states develop from random initial conditions. Several classes of chimera states have been found: (a) stationary multi-cluster states with evenly or unevenly distributed coherent clusters (b) a coherent state traveling with a constant speed or in a stick-slip fashion (c) chimera states traveling with a constant speed. A self-consistent continuum description of these states is provided and their stability properties are analyzed through a combination of linear stability analysis, numerical continuation, and direct numerical simulation. Heterogeneities in the natural frequency of the oscillators select the location of the coherent clusters and may lead to their breakup. Pinning of traveling states by heterogeneities may occur, followed by depinning as the heterogeneity decreases.

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CP13
Chimera States on the Route from Coherent State to a Rotating Wave

We discuss the occurrence of chimera states on the route from coherent via solitary states to the rotating wave in the networks of non-locally coupled pendulum-like nodes. We identify the wide region in parameter space, in which a new type chimera state, imperfect chimera state, which is characterized by a certain number of oscillators escaped from synchronized chimeras cluster appears. We describe a novel mechanism for the creation of chimera states via the appearance of the so-called solitary states. Our findings reveal that imperfect chimera states represent characteristic spatio-temporal patterns at the transition from coherence to incoherence.

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CP13
Emergent Rhythmic Behavior of Mixed-Mode Oscillations in Pulse-Coupled Neurons

Our study is motivated by the experimental observation of fast and slow rhythms in the mammalian olfactory system. We develop a minimal model in which the interaction of three relevant populations of neurons is reduced to an effective pulse-coupling within a single population of mixed-mode oscillators. This pulse-coupling features multiple pulses with distinct propagation delays. We explore the dynamics of the system as a function of the shapes and delays of the pulses.

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CP13

Onset and Characterization of Chimera States in Coupled Nonlinear Oscillators

Role of symmetry breaking in nonlocal and global couplings of networks of identical nonlinear oscillators for the occurrence of chimera mediated transitions between desynchronized and synchronized states will be discussed. We will also distinguish between amplitude chimera and frequency chimera states in this process and identify the conditions under which chimera death states can arise. New rigorous quantitative measures to distinguish the above collective states in terms of strength of incoherence and discontinuity measure will be presented.

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CP14

Reduced Modeling of Exact Coherent States in Shear Flow

In parallel shear flows, the lower branch solution follows simple streamwise dynamics. A decomposition of this solution into Fourier modes in this direction yields modes whose amplitudes scale with inverse powers of the Reynolds number. We use this scaling to derive a reduced model for exact coherent structures in general parallel shear flows. The reduced model is regularized by retaining higher order viscous terms. Both lower branch and upper branch solutions are captured and studied.

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CP14

Stratified Shear Turbulence Experiments

We report experiments on stratified wall-bounded shear flows in which we determine both the velocity and density fields. The flows undergo Kelvin-Helmholtz and Holmboe instabilities depending on the strength of the stratification and shear. We characterize the instabilities by the Richardson number dependence of a local Thorpe length that defines an intermittency fraction for the density interface and allows for an evaluation of the probability distribution of Thorpe length. We discuss applications to ocean overflows.

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CP14

Effects of Fluid Dynamics on Experiments with Compressed/ Expanded Surfactant Monolayers

Monolayer experiments frequently measure surface rheological properties by periodically modulating surfactant concentration with two slightly immersed solid barriers that control the free surface area of a shallow liquid layer. Because the modulation is slow, most theoretical studies ignore fluid dynamics in the bulk. We present a long wave theory that also takes fluid dynamics and symmetries into account. A nonlinear diffusion equation for surfactant concentration that includes free surface deformation shows that fluid dynamics can be an important source of irreversibility and help explain experimental observations.

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CP15

Noisy-Bar Problem

We have all experienced the inability to hear and understand our conversation partner in a crowded room. The difficulty tends to be most apparent in a crowded bar or a club setting. Aside from presenting a social inconvenience, this problem is also closely connected to the issue of signal to noise ratio in networked electronics. In this talk I will present a simple dynamical systems model that explains the transition from a quiet to loud environment.

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CP15

Embedology for Control and Random Dynamical Systems

We introduce a data-based approach to estimating key quantities which arise in the study of nonlinear control systems and random nonlinear dynamical systems. Our approach hinges on the observation that much of the existing linear theory may be readily extended to nonlinear systems - with a reasonable expectation of success- once the nonlinear system has been mapped into a high or infinite dimensional reproducing kernel Hilbert space. In particular, we embed a nonlinear system in a reproducing kernel Hilbert space where linear theory can be used to develop computable, nonparametric estimators approximating controllability and observability energy functions for nonlinear systems, and study the ellipsoids they induce. It is then shown that the controllability energy estimator provides a key means for approximating the invariant measure of an ergodic, stochastically forced nonlinear system. In all cases the relevant quantities are estimated from simulated or observed data.

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CP15

Faster Sensitivity Estimates for Stochastic Differential Equations

Estimating the sensitivity of model predictions to parameter variations is a common task in scientific computing. When the model in question takes the form of a stochastic differential equation, sensitivity estimates can be computationally expensive, particularly if the system at hand is chaotic. In this talk, I will describe a class of algorithms for speeding up sensitivity estimates for models of noisy, chaotic systems.

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CP15

Noise Shaping and Pattern Discrimination in Recurrent Spiking Neuronal Networks

The enhancement of pattern discrimination is considered a common step in early sensory processing by the brain, often attributed to a recurrent network. It has been suggested that noise correlations arising from the common feedback within recurrent spiking networks may interfere with the intended pattern discrimination. We show that recurrent excitatory-inhibitory networks with reciprocal connections, as they arise in the olfactory system, can reshape the noise such that the network can enhance pattern discriminability efficiently.

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CP15

Zero Density of Open Paths in the Lorentz Mirror Model for Arbitrary Mirror Probability

The Lorentz mirror model consists of a particle bouncing off randomly-oriented mirrors placed at integer lattice points, and is thus a key model of deterministic dynamics in a quenched random environment. We will present efficient numerical simulations to count closed and open paths in the Lorentz mirror model, and arguments based on the results of those simulations [A.S. Kraemer & D.P. Sanders, *Journal of Statistical Physics* **156**, 908–916], to show that the density of open paths in a finite box tends to 0 as the box size tends to infinity, for any probability $p > 0$ of placing a mirror at a point.

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CP15

Power System Stochastic Modeling

We develop and test recent methods in power systems simulation. A stochastic Runge-Kutta single-step solver is proposed; error coefficients and order conditions are derived. A new method of retrieving the algebraic system variables after topological changes (i.e. line tripping) in the model system is examined. The stability behavior of the system is studied under stochastic forcing and topological disturbances.

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CP16

Effects of Network Structure on the Synchronization of Hamiltonian Systems

Hamiltonian systems exhibiting long-range interactions are frequently modeled using the Hamiltonian Mean Field (HMF) model. Past research on the HMF has focused on the all-to-all case where each rotor is connected to every other rotor. We study the HMF on complex networks of interactions amongst the rotors. We find that although the network structure impacts the onset of rotor synchronization and the path to synchrony, the maximum possible synchrony is fairly independent of network structure.

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CP16

Transient Spatiotemporal Chaos in a Network of Coupled Morris-Lecar Neurons

Spatiotemporal chaos collapses to either a rest state or a propagating pulse solution in a ring network of diffusively coupled, excitable Morris-Lecar neurons. The addition of weak excitatory synapses can increase the Lyapunov exponent, expedite the collapse, and promote the collapse to the rest state rather than the pulse state. A pulse solution may no longer be asymptotic for certain network topologies and (weak) synapses.

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CP16

Consequence of Symmetry Breaking in Two Coupled Kuramoto Networks

We explore symmetry breaking in a two-population Kuramoto network, using the ansatz of Ott and Antonsen [Chaos 18, 037113 (2008)]. We find that the system is a generalized formulation for a single population of symmetrically-coupled, bimodally-distributed oscillators. We explore this systems equilibria and invariant sets and characterize the bifurcations of both the incoherent and partially-coherent states. We then identify and break several symmetries present in this system, to see how the dynamics change.

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CP16

Control of Stochastic and Induced Switching in Biophysical Complex Networks

While the response of biological systems to noise has been studied extensively, there has been limited understanding of how to exploit these fluctuations to induce a desired cell state. Here we present a method based on the Friedlin-Wentzell action to predict and control noise-induced switching between different attracting states in genetic regulatory networks. We utilize this methodology to identify new candidate strategies for cancer therapy in a coupled ODE model of the cell death pathway.

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CP16

Studies of Stable Manifolds of a Spatially Extended Lattice Kuramoto Model

We study the steady state solution of the 1D and 2D spatially extended Kuramoto model with nearest-neighbor coupling for a range of system sizes. Past the critical coupling σ_c, different possible steady states can appear including phase coherence (synchronization), and phase locking (traveling wave states). We characterize the terminal behavior of a space of initial conditions for a variety of boundary conditions: periodic, zero-flux and free.

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CP17

Efficient Kernel Algorithm for the Dynamic Mode Decomposition of Observed Data

The dynamic mode decomposition (DMD) is a recently proposed algorithm for decomposing time series data observed from nonlinear dynamical systems. We extend the DMD by using a statistical technique called the kernel method. Our extended DMD can compute the mode decomposition significantly faster and more accurately than other methods. In addition, we theoretically discuss the sufficient condition for the modes to be reconstructed from observed time series. We illustrate the validity and usefulness of our method by numerical examples.

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CP17

Perturbing the Cat Map: Mixed Elliptic and Hyperbolic Dynamics

Arnolds cat map is a prototypical dynamical system with

uniformly hyperbolic dynamics. We study a family of maps homotopic to the cat map that has a saddle and a parabolic fixed point. Lerman conjectured that this map has a mixed phase space. We present some evidence in support. The elliptic orbits are confined to a channel bounded by manifolds of the fixed points. The complement appears to have positive measure with positive Lyapunov exponents.

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CP17

Invariant Manifolds and Space Mission Design in the Restricted Four-Body Problem

Invariant manifolds play a crucial role in designing low-energy trajectories of a spacecraft. We consider the four-body problem of Sun, Earth, Moon and a spacecraft by regarding the system as a coupled system of distinct RC3BPs with perturbations, namely, the systems of Sun-Earth-S/C+ (Moon perturb) and Earth-Moon-S/C+ (Sun perturb). We clarify tube-like invariant manifolds of each perturbed system and design a transfer trajectory from Earth to Moon by patching trajectories associated with the invariant manifolds.

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CP17

Mixing on a Hemisphere

Motivated by mixing in 3D rotated granular flows, we study the nonlinear dynamics of piecewise isometries (PWI) on a hemispherical shell for different rotation protocols. Mappings of singularities, termed the exceptional set, E, cover the hemisphere's surface in a variety of complex patterns and explain the ultimate degree of mixing but not the rate of mixing. To understand the mixing rate, we explore a Lyapunov exponent inspired method based on the partitioning property of PWI.

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CP17

Classification of Critical Sets and Images for Quadratic Maps of the Plane

Real quadratic maps of the plane form a 12-parameter family and exhibit a huge range of complicated dynamics. To consider the whole class of maps together, we consider only critical sets (J_0) and their images (J_1). J_0 is a possibly degenerate conic section. Possibilities for J_1 are surprisingly restricted. We study this classification with a hierarchical structure - first via a normal form for homogeneous quadratic maps, and then for linear perturbations of these homogeneous maps.

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CP17

The Existence of Horseshoe Dynamics in Three Dimensional Lotka-Volterra Systems

We prove the existence of horseshoe dynamics in three dimensional Lotka-Volterra systems. The proof uses a Shilnikov-type structure adapted to the geometry of the these systems.

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CP18

Inferring Causal Structures in Complex Systems Via Causation Entropy

Perhaps the most fundamental question in science in complex systems is to infer causes from influences between many coupled elements. Empirically inferring causal structure in complex systems by means of statistical and information theoretic techniques applied to time series data is a highly challenging and sensitive problem. We report here on our latest results of casual coupling inferences within the framework of the Optimal Causation Entropy (oCSE) approach, together with example applications.

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CP18

Robustness of Nonlinear Models

We propose an algorithm to test the robustness to parameter variation of complex nonlinear models. In order to find the minimal parameter perturbation that can destroy a nominal solution, the algorithm uses numerical continuation techniques to move towards the closest bifurcation point to the nominal parameter values, then solves a constrained optimization problem to identify the closest point of the bifurcation manifold to the nominal parameters.

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CP18

A New Filter for State Estimation in Neural Mass Models

The presentation will introduce a new filter for state estimation of neural mass models. The ability to estimate and track states in large-scale neural models is critical for developing robust therapies via model-based feedback control using electrical stimulation. Model-based control is particularly important for diseases such as epilepsy, where pathologies are highly patient-specific. The new filter is similar to the unscented Kalman filter, where a Gaussian approximation is used. However, the mean and covariance of the state estimates are propagated analytically. The analytic results lead to an increase in estimation accuracy and a decrease in computational demands. The development of the new methods presented in this presentation will facilitate the development of large-scale patient-specific computational model of neurological diseases and open the door to the possibility of novel therapies.

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CP18

Hysteresis Effects in Pedestrian Flows

We model a crowd of pedestrians as point particles mutually interacting through 'social' forces and forces from constraining walls and obstacles. In counterstreaming constricted flows, blocking evolves through a Hopf bifurcation into oscillatory flows. In flows around an obstacle, we find that a simple local correlation term in the social force gives rise to hysteresis, with obstacle position as the parameter. We have performed experiments to compare with the dynamical model.

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CP18

Dynamics of Correlated Novelties

One new thing often leads to another. Kauffman and others have hypothesized that this correlation between novelties is important for understanding anything that evolves: life, technology, language, etc. Ill discuss a simple model that predicts the dynamical fingerprints of correlated novelties (they take the form of certain statistical signatures) and then test the predictions against enormous data sets of human activity (listening to songs, writing words in books, making up tags, and editing Wikipedia pages).

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CP18

Systems with Hidden Slow Fast Dynamics

Examples of biochemical systems with complicated non-obvious slow fast structures will be presented. In suitable scalings or blow-ups hidden slow manifolds organizing the dynamics can be found and utilized in the analysis of the dynamics.

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CP19

A Dynamical and Algebraic Study of a Family of Lienard Equations Transformable to Riccati Equations

In this talk we present some algebraic and dynamical results corresponding to the five parameter differential equation

$$yy' = (\alpha x^{2k} + \beta x^{m-k-1})y + \gamma x^{2m-2k-1} \quad y' = \frac{dy}{dx},$$

being $a, b, c \in \mathbb{C}$, $m, k \in \mathbb{Z}$ and

$$\alpha = a(2m+k)x^{m+k-1} \quad \beta = b(2m-k)x^{m-k-1}, \quad \gamma = -(amx^{4k}+cx^{2k}+bm).$$

This equation is a foliation of a five parameter Lienard equation, which is transformed into a Riccati equation. These transformations are used to do an algebraic analysis about the obtaining of explicit solutions (in differential

Galois sense) of the Lienard equation, as well the obtaining of some elements from Darboux theory of integrability: invariant algebraic curves, first integrals, cofactors, etc.. of the Lienard vector field. Finally, a qualitative analysis is presented (type of critical points, Lyapunov functions, etc..)

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CP19

New Asymptotics of Homoclinic Orbits Near Bogdanov-Takens Bifurcation Point

We derive explicit asymptotics for the homoclinic orbits near a generic Bogdanov-Takens (BT) point, with the aim to continue the branch of homoclinic solutions that is rooted in the BT point in parameter and state space. We present accurate second-order homoclinic predictor of the homoclinic bifurcation curve using a generalization of the Poincaré-Lindstedt (P-L) method. We show that the P-L method leads to the same homoclinicity conditions as the classical Melnikov technique, the branching method and the regular perturbation method (R-P). The R-P method shows a "parasitic turn" near the saddle point. The new asymptotics based on P-L do not have this turn, making it more suitable for numerical implementation. We show how to use these asymptotics to calculate the initial homoclinic cycle to continue homoclinic orbits in two free parameters. The new homoclinic predictors are implemented in the Matlab continuation package MatCont to initialize the continuation of homoclinic orbits from a BT point. Several examples in the case of multidimensional state spaces are included.

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CP19

Periodic Orbit Theory of Continuous Media

Nonlinear PDEs of a wide range, from Navier-Stokes equations for viscous fluids to the Yang-Mills equations for gauge fields, can exhibit chaos. One can use high dimensional exact coherent solutions of these systems to predict physical observables by utilizing trace sums over relative periodic orbits. These trace formulas are exact for classical systems, but, as we shall demonstrate on several applications, their convergence can be highly nontrivial.

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CP19

Metric Invariance Entropy and Conditionally Invariant Measures

Invariance entropy is a measure for the data rate needed to make a subset of the state space of a control systems invariant. Here a notion of metric invariance entropy is constructed with respect to a conditionally invariant measure for control systems in discrete time. It is shown that the metric invariance entropy is an invariant under conjugations and that the topological invariance entropy (also called feedback entropy) provides an upper bound.

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CP19

A Fast Explicit Method for Computing Invariant Solutions of High-Dimensional Dynamical Systems with Continuous Symmetries

Given a dynamical system with a continuous symmetry, we construct a perturbed system whose trajectories converge to the invariant solutions of the original dynamical system. The perturbation term is a measure of the curvature of the trajectories and is readily computable from the equations of motion. The computational cost is therefore reduced considerably compared to algorithms based on Newton's iterations or variational methods.

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CP19

Dimensionality Reduction of Collective Motion by Principal Manifolds

Current nonlinear dimensionality reduction methods as applied to collective motion of agents may exhibit unfaithful embedding, due to limitations of control over the mapping between original and embedding spaces. We propose an alternative approach by minimizing the orthogonal error while topologically summarizing the high-dimensional data. We construct embedding coordinates in terms of geodesic distances along smoothed principal curves, such that, the mapping between original and embedding spaces is defined in terms of local coordinates.

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CP20

On the Numerical Integration of One Nonlinear Parabolic Equation

In the present paper author considers initial-boundary problem to following nonlinear parabolic equation:

$$\frac{\partial U}{\partial t} = \frac{\partial}{\partial x}\left(k\left(\frac{\partial U}{\partial x}\right)\frac{\partial U}{\partial x}\right) + f\left(x,t,U\right),\ (x,t) \in (0,\,1)\times(0,\,T],\ T > 0.$$

For the mentioned problem author constructs the corresponding difference scheme and in certain conditions proves the convergence of its solution to the solution of the source problem with the convergence rate $O\left(\tau + h^2\right)$. For the same difference scheme in the same conditions the existence and uniqueness of its solution is proved.

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CP20

A Continuous Model for the Pathfinding Problem with Self-Recovery Property

We propose a model which is capable of finding a path connecting two specified vertices which are connected by unidirectional edges. The system has a self-recovery property, i.e., the system can find a path when one of the connections in the existing path is suddenly terminated.

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CP20

Patterns on Curved Backgrounds: the Influence of Local Curvature on Pattern Formation

We indicate how the concepts and approaches developed in the context of the (linear) theory of patterns on flat backgrounds (such as $\mathbb{R}^2$) can be extended to more general surfaces with nonvanishing curvature. The influence of local curvature on the appearance and dynamics of patterns is demonstrated by a number of example surfaces, where it is clear that surface curvature can have nontrival and surprising effects.

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CP20

Nonlinear Behaviors As Well As Bifurcation Mechanism in Switched Dynamical Systems

Dynamical model of a typical centrifugal flywheel governor system with periodic switches between two forms of external torque has been established. Two types of bifurcation can be observed in the autonomous subsystem, where the Hopf bifurcation may lead to the occurrence of periodic oscillation, while the fold bifurcation may result in the disappearance of the equilibrium points. The dynamics often behaves in periodic oscillations with the same frequency as the periodic switch. Generalized Hopf bifurcation may lead to the alternation of the behaviors between periodic movements and quasi-periodic oscillations.

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CP20

Gpu-Based Computational Studies of the Interaction Between Reentry Waves and Gap Junctional Uncoupling in Cardiac Tissues

The obstruction of coronary flow can cause cardiac arrhythmias including ventricular tachycardia and ventricular fibrillation. Gap junctional uncoupling associates with this process but to date the detailed underlying mechanism remains unclear. Our project investigates the dynamic relationship between gap junctional uncoupling and cardiac arrhythmia using GPU computing. This study promises to deepen our understanding of this phenomenon and could enable us to control cardiac arrhythmia by manipulating the gap junctional coupling.

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CP21

β_1-Adrenergic Regulation of Action Potential and Calcium Dynamics in a Model of Mouse Ventricular Myocytes

A detailed experimentally-based compartmentalized model of the β_1-adrenergic signaling system in mouse ventricular myocytes is developed. Model simulations reproduced experimental data on phosphorylation dynamics of major ionic currents and calcium binding proteins, voltage-clamp data on ionic currents, modulation of the cardiac mouse action potential and calcium transients by the β_1-adrenergic signaling system. Action mechanisms of phosphodiesterase and protein kinase A inhibitors on the mouse action potential and calcium dynamics at the cellular level are discussed.

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CP21

A Mathematical Model for Frog Population Dynamics with Batrachochydrium Dendrobatidis (Bd) Infection

Chytridiomycosis is a disease that poses a serious threat to frog populations worldwide. Several studies confirmed that inoculation of *Janthinobacterium lividum* (*Jl*) can inhibit the disease. In this talk, I present a mathematical model of a frog juvenile-adult population infected with chytridiomycosis caused by the fungal pathogen *Batrachochydrium dendrobatidis* (*Bd*) to investigate on how the inoculation of anti-*Bd* bacterial species *Jl* could reduce *Bd* infection on frogs.

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CP21

A Model of Heart Rate Dynamics for Changes in Exercise Intensity

A nonlinear dynamical systems model for heart rate is investigated for changes in exercise intensity. The model equilibria are used to determine the instantaneous heart rate of an individual during acute bouts of exercise that vary in intensity (power output) and cadence. Theoretical predictions show good agreement with laboratory cycling tests that were performed on several healthy adults.

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CP21

The Evolutionary Dynamics of Gamete Recognition Genes

Fertilization of gametes in broadcast spawners such as sea urchins and abalone is modeled as a random walk process with successful fertilization depending on variables such as binding efficiency, sperm and egg concentration, and physical characteristics of gametes. We develop a dynamical system modeling the evolution of binding genes and illustrate the conditions under which less efficient binding is favored. The stability of different binding strategies exhibits a complex series of bifurcations with increasing sperm concentration.

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CP21

Spike Time Dependent Plasticity in a Spiking Neural Network

To determine which inputs for a neuron are important and which information a neuron should listen to is an important problem during brain development and during learning. Spike-Timing Dependent Plasticity (STDP) is a physiological adaptation mechanism of synaptic regulation which make a neuron to determine which neighboring neurons are worth by potentiating those inputs and depressing the other. We work on obtaining a good mathematical understanding of Spike-Timing Dependent Plasticity (STDP). This involves understanding why STDP works so well and the significance of factors like STDP type, learning window and scaling under increasing network size. The mathematical model we construct, by using phase oscillators is a good example of discrete adaptive asynchronous network. This is a joint work with Mike Field from Rice University.

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CP22

Computational Topology Techniques for Characterizing Time Series Data

Full and accurate reconstruction of dynamics from time-series data—e.g., via delay-coordinate embedding—is a real challenge, but useful information can be gleaned from incomplete embeddings. We apply computational topology to a sequence of lower-dimensional embeddings of the data. Even though the full topology cannot be computed from these incomplete reconstructions, we conjecture that there are some results that can be computed from a *sequence* of such reconstructions, and that these are useful in time-series analysis.

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CP22

Plankton Models with Time Delay

We consider a three compartment (nutrient-phytoplankton-zooplankton) model with nutrient recycling. When there is no time delay the model has a conservation law and may be reduced to an equivalent two dimensional model. We consider how the conservation law is affected by the presence of a state dependent time delay in the model. We study the stability and bifurcations of equilibria when the total nutrient in the system is used as the bifurcation parameter.

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CP22

Noise, Chaos and Entropy Generation in a Time-Delayed Dynamical System

Dynamical chaos and single photon detection are two physical sources of randomness employed to generate fast, cryptographically secure random numbers. We present an experimental system with both types of randomness: an electro-optic feedback loop incorporating a single-photon detector. We describe how the dynamics change from shot noise to deterministic chaos as the photon rate increases, and how the entropy rate can reflect either chaos or shot noise depending on sampling rate and resolution.

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CP22

Stochastic Delay in Gene Regulation: Exact Stability Analysis

Gene regulatory networks consist of interacting genes and proteins and they control the response of cells to environmental stimuli. The biochemical reactions involved in gene expression take finite time which lead to time delays that vary stochastically due to the inherent intracellular noise. In this talk we analyze the dynamics of systems with stochastic delays and derive exact stability conditions of equilibria based on the second moment dynamics.

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CP23

Noise and Determinism of Stimulated Brillouin Scattering Dynamics in Optical Fiber

Stimulated Brillouin scattering (SBS) is a noise-initiated nonlinear optical phenomenon that occurs in optical fiber. We present numerical modeling and experimental observations of SBS in single-mode optical fiber. We employ several statistical methods to quantify and examine the roles of determinism and stochasticity of SBS using time-delay embedding, false near neighbors and Hurst exponents. Experimental and theoretical results display a transition in the nature of statistical fluctuation properties from lower to higher input powers.

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CP23

Vector Rogue Waves and Dark-Bright Boomeronic Solitons in Autonomous and Non-Autonomous Settings

In this talk, I will discuss the dynamics of vector rogue waves and dark-bright solitons in two-component nonlinear Schrödinger (NLS) equations with variable coefficients. Using a suitable transformation for the wave functions, the two-component NLS system is converted into the well-known integrable Manakov system. Then, the vector rogue and dark-bright boomeron-like soliton solutions of the latter are converted back into ones of the original non-autonomous model. Using direct numerical simulations, I will present the formation and existence of such soliton solutions in the non-autonomous case.

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CP23

Control of Extreme Events in the Bubbling Onset of Wave Turbulence in the Forced and Damped Non-Linear Schrödinger Equation

The existence of high amplitude intermittent fluctuation in many non-linear dynamical systems constitutes a problem of great relevance in different fields of science. In this work we show the existence of an intermittent transition from temporal chaos to turbulence in a spatially extended dynamical system, namely the forced and damped one-dimensional non-linear Schrödinger equation. For some values of the forcing parameter the system dynamics intermittently switches between ordered states and turbulent states, which may be seen as extreme events in some contexts. In a Fourier phase-space the intermittency takes place due to the loss of transversal stability of unstable periodic orbits embedded in a low-dimensional chaotic attractor. We mapped these transversely unstable regions and locally perturbed the system in order to significantly reduce the occurrence of extreme events of turbulence.

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CP23

Reducibility of One-dimensional Quasi-periodic Schrödinger Equations

Consider the time-dependent linear Schrödinger equation

$$i\dot{q}_n = \epsilon(q_{n+1}+q_{n-1})+V(x+n\omega)q_n+\delta\sum_{m\in Z} a_{mn}(\theta+\xi t)q_m, \quad n \in Z,$$

where V is a nonconstant real-analytic function on T, ω satisfies a certain Diophantine condition and $a_{mn}(\theta)$ is real-analytic on T^b, $b \in Z_+$, decaying with $|m|$ and $|n|$. We prove that, if ϵ and δ are sufficiently small, then for a.e. $x \in T$ and "most" frequency vectors $\xi \in T^b$, it can be reduced to an autonomous equation. Moreover, for this non-autonomous system, "dynamical localization" is maintained in a quasi-periodic time-dependent way.

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CP23

Numerical Continuation of Invariant Solutions of the Complex Ginzburg-Landau Equation

We compute solutions of the complex Ginzburg-Landau equation (CGLE) invariant under the action of the 3-dimensional Lie group of symmetries $A(x,t) \to e^{i\theta}A(x+\sigma, t+\tau)$. From an initial set of such solutions we obtain a sequence of new sets of invariant solutions via numerical continuation along paths in the parameter space of the CGLE. Solutions are obtained by solving an underdetermined system of nonlinear algebraic equations resulting from use of a spectral-Galerkin discretization in both space and time of the CGLE and the use of a path following method. The set of initial solutions led to distinct, new invariant solutions of the CGLE in the final parameter region. All the solutions are unstable, and have multiple modes and frequencies active, respectively, in their spatial and temporal spectra. Symmetry gaining/breaking behavior associated with the spatial reflection symmetry $A(x,t) \to A(-x,t)$ was common in the parameter regions traversed.

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CP23

Nonlinear Oscillations and Bifurcations in Silicon Photonic Resonators

Silicon microdisk resonators are micron-scale optical devices in which optical, thermal, electron/hole, and mechanical effects interact to produce a wide range of dynamical phenomena. In the strongly nonlinear regime, we demonstrate the presence of Hopf and homoclinic bifurcations leading to the onset and destruction of self-sustained oscillations. We further show that the six-dimensional system of equations governing microdisk behavior can be reduced to a nearly-one-dimensional relaxation-oscillator system, and qualitative dynamics are well represented by a toy model.

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CP24

Finding the Stokes Wave: From Low Steepness to Almost Limiting Wave

A Stokes wave is a fully nonlinear wave that travels over the surface of deep water. We solve Euler equations with free surface in the framework of conformal variables via Newton Conjugate Gradient method and find Stokes waves in regimes dominated by nonlinearity. By investigating Stokes waves with increasing steepness we observe peculiar oscillations occur as we approach Stokes limiting wave. Finally by analysing Pade approximation of Stokes waves we infer that analytic structure associated with those waves has branch cut nature.

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CP24

Blow-Ups in Nonlinear Pdes, Composite Grid-Particle Methods, and Stochastic Particle Systems

I will discuss a numerical method best suited for solving evolution PDEs exhibiting singular and multiscale behavior (shocks or blow-ups). This method employs representation of solution simultaneously as a field (discretized on a grid or via finite elements) and a particle system. The field and the particles exchange mass according to criteria based

on the types of singularities that are formed in a given system. Examples with Keller-Segel equations of bacterial chemotaxis, Fisher-Kolmogorov, Burgers, and a few other equations will be presented.

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CP24

Singularities of the Stokes' Wave: Numerical Simulation

Two-dimensional potential flow of the ideal incompressible fluid with free surface and infinite depth can be described by a conformal map of the fluid domain into the complex lower half-plane. Stokes wave is the fully nonlinear gravity wave propagating with constant velocity.

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CP24

Branch Cut Singularity of Stokes Wave

Stokes wave is the fully nonlinear gravity wave propagating with the constant velocity. We consider Stokes wave in the conformal variables which maps the domain occupied by fluid into the lower complex half-plane. Then Stokes wave can be described through the position and the type of complex singularities in the upper complex half-plane.

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CP24

Coupled Parametrically Forced Oscillators and Modulated Cross-Waves

Recent experiments and theory for subharmonic cross-waves in horizontally vibrated containers found slowly modulated (quasiperiodic) solutions that cycle between balanced and one-sided excitation. We analyze a generalized model of coupled parametrically forced oscillators with arbitrary relative phase to understand how these solutions arise, depending on coupling and forcing, and relate this to an exchange symmetry permitted by specific forcing phases. A complex bifurcation scenario involving secondary modes and homoclinic bifurcations emerges in many cases.

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CP25

Jetting-BubblingTransition in Microflows

Gas-liquid flows in microchannels are found to be primarily of two types - jetting and bubbling. The dynamics of gas-liquid micro flows is captured using viscous potential flow (VPF) theory. A linear stability analysis is carried out and the jetting to bubbling transition is predicted using the Briggs criterion of absolute-convective instability transition. We study the effect of the wide parameter space (Reynolds number, Weber number, density ratio, viscosity ratio and confinement) on this transition.

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CP25

Finding Model Parameters Without Prior Knowledge of Solve-Able Regions: A Solar Thermochemistry Case-Study

Reduction of cobalt oxide nanoparticles is the first step in a solar thermochemical process to sustainably produce hydrogen from water with concentrated sunlight. Using non-isothermal reaction data from the process as a case-study, we demonstrate a two-stage particle-swarm optimization method to find kinetic parameters in the shrinking core model without a valid initial guess or bounding under multiple, simultaneous rate-limiting conditions. The technique developed is broadly applicable to identifying parameters in data-fitting numerically intractable models.

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CP25

Experiments on a Pinball-Like Oscillator

The response of a harmonically-excited mechanical system in which a severe nonlinearity occurs due to an impact is presented. The system receives a discrete input of energy at the impact condition: it is kicked. This is reminiscent of the unpredictability of the classic pinball machine. Close correlation is obtained between a mechanical experiment and numerical simulation, including unusual bifurcation sequences and co-existing responses.

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CP25

Exploring the Hyperbolicity of Chaotic Rayleigh-Bénard Convection

Covariant Lyapunov vectors allows us to quantify the direction of the stable and unstable manifolds of the tangent space for the high-dimensional chaotic dynamics of Rayleigh-Bénard convection. The principal angle between these manifolds can be used to determine the hyperbolicity of the dynamics. We use numerical simulations to compute the covariant Lyapunov vectors of Rayleigh-Bénard convection to probe fundamental features of the dynamics of an experimentally accessible and high-dimensional system.

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CP25

Snakes on An Invariant Plane: Coupled Translational-Rotational Dynamics of Flying Snakes

Flying snakes of the genus *Chrysopelea* use body flattening and three-dimensional body undulations in a dynamic yet controlled glide through air. Given this complexity, salient body dynamics relevant to glide stability are unknown. We investigate a tandem airfoil model with snake-like features to better understand aerodynamic effects of undulation and translational-rotational mechanical coupling on motion and stability during a glide. We elucidate some dynamical phenomena that occur including bifurcations, limit cycles, and a gliding manifold.

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CP26

Constant Rebalanced Portfolio Strategy Is Rational in a Multi-Group Asset Trading Model

We evaluate the performance of various trading strategies within the context of the multi-group asset flow differential equations model. We consider scenarios in which strategies vary continuously and slowly, and derive mathematical justification for constant rebalanced portfolio (CRP) strategies. The CRP strategy minimizes investment risks as investor wealth is maintained when the price moves from and then returns to its original value; non-CRP strategies may be exploited by others resulting in a loss of wealth.

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CP26

How Monetary Policy Can Cause Forecasting Uncertainty

Federal Reserve Chairwoman Yellen seems to be guided by a rule that keeps interest rates low (high), when the economy is operating below (above) its trend. Instead of stabilizing the economy, the unintended consequence of the Yellen Rule is greater uncertainty, due to nonlinear feedback. The resulting forecast errors can be modeled by applying a Sprott nonlinear dynamical system of simple chaos, perturbed by random noise and shocked by excess demand for real money.

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CP26

Non-Smooth Dynamics and Bifurcations in a Model of Electricity Market

This paper proposes a model for the supply and demand of electricity in a domestic market based on system dynamics. Additionally, the model shows piecewise-smooth differential equations. Mathematical analysis and simulation explain some counter-intuitive dynamics which also were detected in practice. Then, a general model is proposed, which is closer to real electricity markets. Discontinuities have a large effect on the qualitative analysis. A first result to be noted is the use of asynchronous maps for understanding what happens when parameters are varied, leading to non-smooth bifurcations. To our knowledge. there are still no reports in the literature about its use in socio-economic market systems. The other noteworthy result in this research is the effect that the *ROI* (Investment returns) has on the system dynamics since it leads to different surfaces whose slope change according to the parameters.

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CP27

Towards Understanding Mechanisms of Pain Transmission: a Systems Theoretic Approach

Pain is a universal experience. Motivated by a lack of understanding of pain mechanisms, we develop a reduced low-dimensional model of the dorsal horn circuit—the first central relay of sensory inputs to the brain. We determine how a cellular switch of firing patterns in dorsal horn transmission cells—tonic, plateau, endogenous bursting—contributes to a functional switch of information transfer—faithful transmission, enhancement, or blocking of nociceptive information.

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CP27

Optogenetic Stimulation of a Meso-Scale Human Cortical Model

Mesoscale models of cortical activity provide a means to study neural dynamics at the level of neuron populations, and offer a safe and economical way to test the effects and efficacy of stimulation techniques on the dynamics of the cortex. Here, we use a physiologically relevant mesoscale model of the cortex, consisting of a set of stochastic, highly non-linear partial differential equations, to study the hypersynchronous activity of neuron populations during epileptic seizures. We use optogenetic stimulation to control seizures in a hyperexcited cortex, and to induce seizures in a normally functioning cortex. The high spatial and temporal resolution this method offers makes a strong case for the use of optogenetics in treating epileptic seizures. We use bifurcation analysis to investigate the effect of optogenetic stimulation in the meso scale model, and its efficacy in suppressing the non-linear dynamics of seizures.

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CP27

Assessing the Strength of Directed Influences Among Neural Signals

Inferring Granger-causal interactions between processes promises deeper insights into mechanisms underlying network phenomena, e.g. in the neurosciences where the level of connectivity in neural networks is of particular interest. Renormalized partial directed coherence can be used to investigate Granger causality in such multivariate systems. A major challenge in estimating respective coherences is a reliable parameter estimation of vector autoregressive processes. We discuss improvements of the estimation procedure that are particularly relevant in the neurosciences.

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CP27

Analysis of Cholera Epidemics with Bacterial Growth and Spatial Movement

In this work, we propose novel epidemic models for cholera dynamics by incorporating a general formulation of bacteria growth and spatial variation. In the first part, a generalized ODE model is presented and it is found that bacterial growth contributes to the increase of the basic reproduction number. With the derived basic reproduction number, we analyze the local and global dynamics of the model. Particularly, we give a rigorous proof on the endemic global stability by employing the geometric approach. In the second part, we extend the ODE model to a PDE model with the inclusion of diffusion to capture the movement of human hosts and bacteria in a heterogeneous environment. The disease threshold of this PDE model is studied again by using the basic reproduction number. The results on the threshold dynamics of the ODE and PDE models are compared, and verified through numerical simulation.

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CP27

Benefits of Noise in Synaptic Vesicle Release

Noise is not only a source of disturbance but can also be beneficial for neuronal information processing. The release of neurotransmitter vesicles in synapses is an unreliable process, especially in the central nervous system. Here we study the effect of the probabilistic nature of this process and show that how stochasticity in vesicle docking and release can be beneficial for synaptic transmission.

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CP27

Growth Dynamics for Pomacea Maculata

Pomacea maculata is a relatively new invasive species to the Gulf Coast region and potentially threatens local agriculture (rice) and ecosystems (aquatic vegetation). The population dynamics of *Pomacea maculata* have largely been un-quantified. We directly measured the growth rates of individually marked snails grown in a common tank to quantify their growth patterns. However, due to large intra- and inter- individual variability and sample size, we were not able to get statistically rigorous estimates (i.e., tight confidence intervals) on overall growth dynamics. However, we were able to use a model comparison statistic to determine that there are distinct growth stages. Further, these data

strongly suggest that male and female growth dynamics, size distributions, and overall weights, are notably different with females being generally larger. We performed simulation studies based on observed variability, and are using these models to design additional lab experiments and field studies.

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CP28

Optimal Control of Building's Hvac System with on-Site Energy Storage and Generation System

Commercial and residential buildings consume more than 40% of the total energy in most countries, and HVAC (Heating Ventilation and Air Conditioning) systems typically consume more than 50% of the building energy consumption. A recent study indicates that optimal control of HVAC system can achieve energy savings of up to 45%. Therefore, optimized control of HVAC system can potentially reduce significant amount of energy consumption of buildings. In this work, we describe a model predicted control (MPC) framework that optimally computes the control profiles of the HVAC system considering the dynamic demand response signal, on-site storage of electricity, on-site generation of electricity, greenhouse gas emission as well as occupants comfort. The approach would determine how to power the HVAC system from the optimal combination of grid electricity, on-site stored electricity and on-site generated electricity.

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CP28

Optimal Treatment Strategies for HIV-TB Co-Infected Individuals

Initiating anti-HIV treatment during ongoing TB treatment for HIV-TB co-infected individuals has advantages and disadvantages. Here, we develop a dynamical system (system of ODEs) that helps identify an ideal treatment strategy for HIV-TB co-infected individuals. Using our model, we formulate and analyze an optimal control problem in order to determine a HIV-TB treatment protocol that provides a minimum cumulative burden from this co-infection.

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CP28

Towards a Structural Theory of Controllability of Binary Networks

Almost all complex networks satisfy structural controllability theory except for some special networks which form a set of Lesbesgue measure zero. A important class of networks is ***binary networks***, that is networks for which all of the existing connections have the same associated weight. However, these networks often do not satisfy structural controllability theory. We focus on this class of networks and propose some graphical tools that can be used to characterize the structural controllability of binary networks.

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CP29

Stripe to Spot Transition in a Plant Root Hair Initiation Model

A generalised Schnakenberg system with source and loss terms and a spatially dependent coefficient of the nonlinear term is studied in 2D. The system captures active and inactive forms of the kinetics of a small G-protein ROP, which are catalysed by a gradient of the plant hormone auxin. Localised stripe-like solutions of active ROP occur for high enough total auxin concentration and lie on a complex bifurcation diagram of single and multi-pulse solutions. Transverse stability computations show that these 1D solutions typically undergo a transverse instability into spots. The spots so formed typically drift and undergo secondary instabilities such as spot replication. A 2D numerical continuation analysis is performed that shows the various stable hybrid spot-like states can coexist. Upon describing the dispersion relation of a certain non-local eigenvalue problem, the parameter values studied lead to

an analytical explanation of the initial instability.

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CP29

Symmetry Groups and Dynamics of Time-Fractional Diffusion Equation

In science and engineering the processes in which both spatial and temporal variations occur are often known as diffusion. Mostly diffusion process is anomalous due to the heterogeneous nature of medium therefore it can be best described in terms of fractional derivatives. We propose a new approach to construct the symmetry groups of fractional diffusion equation and using these groups we provide some interesting physical interpretation to understand the dynamics of anomalous diffusion.

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CP29

Onset of Singularities in the Pattern of Fluctuational Paths of a Nonequilibrium System

A generic feature of systems away from thermal equilibrium is the occurrence of singularities in the patterns of most probable trajectories followed in rare fluctuations to remote states in phase space. We study how the singularities emerge as the system is driven away from thermal equilibrium by an increasingly strong perturbation. We find where there is a threshold in the perturbation strength and the scaling of the singularity location if there is no threshold.

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CP29

Polynomial Mixing Rates of Particle Systems

In this talk I will present our results on polynomial mixing rates of some particle systems that are derived from the study of microscopic heat conduction. We rigorously prove that an energy dependent Kac-type model admits polynomial mixing rates $\sim t^{-2}$. In the end, I will show that similar slow (polynomial) mixing rates appear in many other microscopic heat conduction models.

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MS1

Nonlinearity Saturation as a Singular Perturbation of the Nonlinear Schrödinger Equation

Saturation of a Kerr-type nonlinearity in the generalized nonlinear Schrödinger equation (NLS) can be regarded as a singular perturbation which regularizes the well known blow-up phenomenon in the cubic NLS. An asymptotic expansion is proposed which takes into account multiple scale behavior both in the longitudinal and transverse directions. We find that interaction of a solitary wave and an adjacent wave field is governed by behavior of eigenfunctions of the linearized fast-scale operator. In one dimension, the solitary wave acts solely to reflect impinging waves and accelerates by an elastic transfer of momentum. In two dimensions, the solitary wave can be made transparent to the ambient field for a certian value of wave power. This is joint work with Jordan Allen-Flowers.

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MS1

Dark-Bright, Dark-Dark, Vortex-Bright and Other Multi-Component NLS Beasts: Theory and Recent Applications

Motivated by recent work in nonlinear optics, as well as in Bose-Einstein condensate mixtures, we will explore a series of nonlinear states that arise in such systems. We will start from a single dark-bright solitary wave, and then expand our considerations to multiple such waves, their spectral properties, nonlinear interactions and experimental observations. A twist will be to consider the dark solitons as effective potentials that will trap the bright ones, an approach that will also prove useful in characterizing the bifurcations and instabilities of the system. Beating, so-called dark-dark soliton variants of such states will be touched upon. Generalizations of all these notions in higher dimensions and, so-called, vortex-bright solitons will also be offered.

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MS1

Bifurcation and Competitive Evolution of Network Morphologies in the Strong Functionalized Cahn-Hilliard Equation

The Functionalized Cahn Hilliard (FCH) is a higher-order free energy for blends of amphiphillic polymers and solvent which balances solvation energy of ionic groups against elastic energy of the underlying polymer backbone. Its gradient flows describe the formation of solvent network structures which are essential to ionic conduction in polymer membranes. The FCH possesses stable, coexisting

network morphologies and we characterize their geometric evolution, bifurcation and competition through a center-stable manifold reduction which encompasses a broad class of coexisting network morphologies. The stability of the different networks is characterized by the meandering and pearling modes associated to the linearized system. For the H^{-1} gradient flow of the FCH energy, using functional analysis and asymptotic methods, we drive a sharp-interface geometric motion which couples the flow of co-dimension 1 and 2 network morphologies, through the far-field chemical potential. In particular, we derive expressions for the pearling and meander eigenvalues for a class of far-from-self-intersection co-dimension 1 and 2 networks, and show that the linearization is uniformly elliptic off of the associated center stable space.

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MS1

Nonlinear Stability of Source Defects

Defects are interfaces that mediate between two wave trains. Of particular interest in applications are sources for which the group velocities of the wave trains to either side of the defect point away from the interface. While sources are ubiquitous in experiments, their stability analysis presents many challenges. In this talk, I will discuss nonlinear-stability results for sources that rely on pointwise estimates.

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MS2

Dynamics of Autonomous Boolean Networks

Autonomous Boolean networks are known to display complex dynamics, originating from the absence of an external clock, internal time delays and the non-ideal behaviour of the logic gates. We study experimentally such networks on a field-programmable gate array (FPGA). In particular, we show that networks consisting of only a few logic elements can produce long transients. We demonstrate how these transients can be used to successfully perform reservoir computing, a new machine learning paradigm.

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MS2

Gene Network Models Including mRNA and Protein Dynamics

Qualitative models of gene regulatory networks have generally considered transcription factors to regulate directly the expression of other transcription factors, without any intermediate variables. In fact, gene expression always involves transcription, which produces mRNA molecules, followed by translation, which produces protein molecules, which can then act as transcription factors for other genes. Suppressing these multiple steps implicitly assumes that the qualitative behaviour does not depend on them. Here we explore a class of expanded models that explicitly includes both transcription and translation, keeping track of both mRNA and protein concentrations. We mainly deal with regulation functions that are steep sigmoids or step functions, as is often done in protein-only models. Our results thus show that including mRNA as a variable may change the behavior of solutions.

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MS2

Database for Switching Networks As a Tool for Study of Gene Networks

Continuous time Boolean networks, or switching networks, represent an attractive platform for qualitative studies of gene regulation, since the dynamics at fixed parameters is relatively easily to compute. However, it is quite difficult to analytically understand how changes of parameters affect dynamics. Database for Dynamics is an excellent tool for studying these models, as it rigorously approximates global dynamics over a parameter space. The results obtained by this method provably capture the dynamics a predetermined spatial scale. We combine these two approaches to present a method to study switching networks over a parameter spaces. We apply our method to experimental data for cell cycle dynamics.

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MS2

Evolution of Gene Networks

Genetic activity is partially regulated by a complicated network of proteins called transcription factors. An outstanding scientific puzzle is to understand how this genetic network can evolve. I discuss evolution of dynamics in simplified models of genetic networks. By changing the logical structure randomly, it is possible to evolve the networks in an effort to identify networks that display rare dynamics - e.g. networks with long stable cycles or with a high level of topological entropy. In the context of the models, it is possible to estimate optimal mutation rates. The theoretical models pose the problem of how evolution can robustly take place in organisms.

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MS3

Controlling Long-Term Spatial Distributions of Autonomous Vehicles in Stochastic Flow Environments

We present a control strategy for aquatic vessels that leverages the environmental dynamics and noise to efficiently navigate in a stochastic fluidic environment using the theory of large fluctuations. We show that a vehicle's likelihood of transition between regions in the flow can be manipulated by the proposed control strategy, resulting in efficient navigation from one region to another. We then experimentally verify the strategy in a fluid environment using autonomous vehicles.

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MS3

Tracking of Geophysical Flows by Robot Teams: An Experimental Approach

This talk presents our group's recent efforts in using teams of robots to track geophysical fluid features like Lagrangian Coherent Structures. The talk will focus on our development of the multi-robot Coherent Structure Testbed a novel multi-robot experimental testbed capable of creating ocean-life flows in a laboratory setting. I will show experimental results of various single vehicle and multi-robot control strategies for tracking different fluidic features in a flow field and navigating in stochastic flows.

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MS3

Conditional Statistics with Lagrangian Coherent Structures

Coherent structures are ubiquitous in the environment. In order to analyze mixing and transport processes, conditional statistics are typically generated and scaling laws are identified. Classically, these are based on flow domain partitions from Eulerian quantities. However, recent studies show that Eulerian quantities are not invariant subject to arbitrary frame translation and rotation. We show in this talk scalar dispersion and residence time statistics based on Lagrangian partitions, where new scaling law behaviors are identified.

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MS3

Controlled Lagrangian Prediction Using An Ensemble of Flow Models

The technique of controlled Lagrangian prediction (CLP) is developed to employ an ensemble of flow modes to provide odometry-like localization information for underwater vehicles. CLP can then be fused with other underwater localization technology to enable simultaneous localization and map-making (SLAM). Map-making functionality will be performed to update each flow model with the latest sensor information and to decide the best flow model to use that gives the minimum localization error at any given time.

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MS4

Constrained Motion of Point Vortices Interacting Dynamically with Rigid Bodies in Ideal Flow

The equations of motion for the dynamic interaction of rigid bodies and point vortices in ideal flow were only recently derived, in 2002 by Shashikanth et al and in 2003 by Borisov et al. We compare these equations with those obtained by a suitable application of Diracs method of constraints to the N-vortex problem. In 2008, Vankerschaver et al derived the unconstrained equations through symplectic reduction, but several assumptions were made in the analysis. We investigate the possibility of relaxing some of these assumptions.

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MS4

The Poincare-Hopf Theorem in Nonholonomic Mechanics

This talk discusses using the Poincare-Hopf theorem and the technique of Hamiltonization as a means to study the integrability nonholonomic mechanical systems (briefly, mechanical systems subject to non-integrable velocity constraints). We will focus primarily on a generalized Klebsh-Tisserand case of the Suslov problem, and use the aforementioned approach to determine the topology of the (two-dimensional) invariant manifolds, and in particular their genus. The results will be contrasted with those expected of Hamiltonian systems.

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MS4

Discretization of Hamiltonian Incompressible Fluids

The geometry of incompressible, inviscid fluids can be described by Arnold's classic formulation in terms of geodesics on the Lie group of volume-preserving diffeomorphisms. In recent years this formulation has been discretized for computational purposes, creating a geometricnumerical method that obeys a discretized version of Kelvin's circulation theorem. This talk will present an extension of this discretization into the corresponding Hamiltonian view of incompressible inviscid fluids, thereby giving a method based on the vorticity equation. Along the way we will discuss the general principles of this style of discretization, which involves approximating the Lie group of volume-preserving diffeomorphisms by a finite-dimensional Lie-group and then localizing the resulting equations by means of a non-holonomic constraint.

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MS4

The Lie-Dirac Reduction for Nonholonomic Systems on Semidirect Products

We consider Dirac systems with symmetry for nonholonomic mechanical systems on Lie groups with broken symmetry. We show reduction of Lagrange-Dirac systems and Dirac-Hamilton systems in the context of Lie-Dirac reduction with advected parameters. Then, we develop implicit Euler-Poincare-Suslov and Lie-Poisson-Suslov equations with advected parameters with some illustrative examples such as the Chaplygins ball and the second order Rivlin-Ericksen fluids. We also discuss the Dirac reduction on semidirect products by stages on the Hamiltonian side.

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MS5

Combined Effects of Connectivity and Inhibition in a Model of Breathing Rhythmogenesis

The pre-Btzinger complex is an area in the brainstem which generates the breathing rhythm, an essential function for life. We model this area with realistic bursting neurons coupled in a large sparse network. We study how synchronous activity of the population changes due to (1) the number of connections each cell receives (2) the fraction of cells which are inhibitory, and (3) the strength of excitatory and inhibitory synapses. The model is compared to experimental data. We also ask, how do multiple phases of activity arise? Can they arise spontaneously in unstructured networks, or do they require more structured networks like block models?

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MS5

A Complex Networks Approach to Malaria's Genetic Recombination Dynamics

Malaria parasites evade immune systems by sequentially expressing diverse proteins on the surface of infected red blood cells. These camouflage proteins come from rapid genetic recombination that shuffles the genes that encode the proteins. Because this shuffling precludes the use of traditional sequence analysis techniques, we take a new approach by mapping sequences to a network in which each vertex represents a single sequence and constraints on recombination reveal themselves in the networks community structure. We validate this approach on synthetic sequences. Application of this technique to a large set of sequences from both human- and ape-infecting malaria parasites reveals that the observed genetic states of six distinct malaria species have arisen due to recombining and evolving a common set of initial sequence content, dating back prior to the speciation of humans and chimpanzees from their most recent common ancestors.

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MS5

Not-So-Random Graphs Through Wide Motifs

This work focuses on two powerful analytical methods that can model stochastic processes on (and/or of) complex networks: one recasts the problem as a set of ordinary differential equations, and the other amounts to a branching process. Both methods are based on the idea of breaking the network into smaller pieces—hereafter called "motifs"—that may be re-assembled according to specific rules. However, these techniques are limited to random graphs containing no cycles, except for the cycles explicitly represented within the motifs used in their assembly. This is a major problem for real-world phenomenons (such as cascading failures due to flows reorganization) that fundamentally depend on the presence of cycles much longer than what these motifs-based methods allow. In this work, I will present recent developments concerning "wide motifs", which generalize both the concepts of "motifs" and "tree decomposition". By opposition to traditional motifs, cycles may be broken into pieces to span multiple wide motifs, thus allowing for cycles of arbitrarily long lengths that may share intricate overlaps. This perspective can be used for a broad spectrum of networks, spanning from deterministic structures to random graphs, thus blurring the line between these extremes. The approach broadens the class of problems that can be approached analytically and introduces new challenges in the detection and characterization of network structures. Conceptual similarities with "belief propagation" algorithms and the "tensor network" representation of entangled quantum states should allow for these different fields to cross-fertilize.

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MS5

Causal Network Inference by Optimal Causation Entropy

The abundance of time series data, which is in sharp contrast to limited knowledge of the underlying network dynamic processes that produce such observations, calls for a general and efficient method of causal network inference. We develop mathematical theory of Causation Entropy (CSE), a model-free information-theoretic statistic designed for causality inference. We prove that for a given node in the network, the collection of its direct causal neighbors forms the minimal set of nodes maximizing Causation Entropy, a result we refer to as the Optimal Causation Entropy (oCSE) Principle, for which we develop efficient algorithms. Analytical and numerical results for Gaussian processes on large random networks highlight that inference by oCSE outperforms previous leading methods including Conditional Granger Causality and Transfer Entropy. Interestingly, our numerical results also indicate that the number of samples required for accurate inference depends strongly on network characteristics such as the density of links and information diffusion rate and not on the number of nodes.

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MS6

Model-Based Glucose Forecasting for Type 2 Diabetics

Type 2 diabetes affects 9 million Americans. While treatment is complex, two important components include quantifying the features of glucose dynamics and forecasting the effect of nutrition on glucose levels. Both topics are addressed in this talk. First, electronic health record data are used to identify features of glucose dynamics that correlate with mortality via a regression. Second, a dual unscented Kalman filter and two mechanistic models are used to forecast glucose using real data.

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MS6

Predicting Recovery of Consciousness in Patients with Brain Injury

Oscillatory electrical activity is associated with information processing in the brain. Patients with severe brain injuries often exhibit disorders of consciousness along with disturbed oscillatory activity. This project was designed to determine whether continuous measures of brain oscillations can be used to predict recovery of consciousness on the time-scale of days. Sparse partial least squares and high-dimensional classification algorithms are used to determine latent variables used for prediction in a novel subset of patients.

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MS6

Assimilating Sleep - Putting the Model to the Data

Over the past four years we investigated tools for data assimilation and forecasting from models of the sleep-wake regulatory system. Ill report on the challenges we now face as we collect data from brainstem cell groups in freely behaving animals and attempting to apply these tools.

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MS6

Time Series Modeling and Analysis Using Electronic Health Record Data

Electronic health record data contain valuable information about biology and health care, but the data hold a number of challenges, including the fact that measurements are sparse and irregular. Furthermore, health care is a highly complex process that makes drawing causal conclusions very difficult. We discuss alternate time parameterizations that may lead to a more stationary time series, and we discuss the use of Granger causality to tease out causes and confounders.

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MS7

Reconstruction of Structural Connectivity in Neuronal Networks Using Compressive Sensing of Network Dynamics

Taking into account the prominence of sparsity in neuronal connectivity, we develop a framework for efficiently reconstructing neuronal connections in a sparsely-connected, feed-forward network model with nonlinear dynamics. Driving the network with a small ensemble of random stimuli, we derive a set of underdetermined linear systems relating the network connectivity to neuronal firing rates. Via compressive sensing, we accurately recover sparse network connectivity and also realistic network inputs distinct from the training set of stimuli.

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MS7

Theoretical Modeling of Neuronal Dendritic Integration

We address the question of how a neuron integrates excitatory (E) and inhibitory (I) inputs from different dendritic sites. For an idealized neuron with an unbranched dendrite, a conductance-based cable model is derived and its asymptotic solutions are constructed. The solutions reveal the underlying mechanisms of a dendritic integration rule discovered in a recent experiment. We then extend our analysis to the multi-branch case and confirm our analysis through numerical simulation of a realistic neuron.

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MS7

Functional Connectomics from Data: Constructing Probabilistic Graphical Models for Neuronal Networks

The nervous system of the nematode Caenorhabditis elegans (C. elegans) is comprised of 302 neurons for which electro-physical connectivity map (i.e. connectome) is fully resolved. Although the static connectome is available, inference of dominant neural pathways that control sensorimotor responses is challenging since neurons are dynamical objects and interactions within the network are also dynamic. In our study, we construct a Probabilistic Graphical Model (PGM) for the C. elegans connectome that represents the 'effective connectivity' between the neurons (correlations) and takes into account the dynamics. The structure of the PGM is learned using Bayesian methods capable of learning the structure of an undirected graphical model from a collection of time series. The collections are obtained by a systematic excitation of neurons in a recently developed computational dynamical model for the C. elegans that simulates single neural responses and interactions between the neurons (synaptic and gap). Bayesian inference methods applied to the constructed PGM allow us to extract neural pathways in the connectome of C. elegans responsible for experimentally well characterized movements of the worm such as forward and backward locomotion. In addition, we show that the framework allows for inference of pathways that correspond to movements that were not fully characterized in experiments and to perform 'reverse-engineering' studies in which a typical setup on the motor neurons layer is imposed and dominant pathways that propagate to the sensory layer through the interneurons layer are being identified.

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MS7

Topology Reconstruction of Neuronal Networks

Current experimental techniques usually cannot probe the global interconnection pattern of a network. Thus, reconstructing or reverse- engineering the network topology of coupled nodes based upon observed data has become a very active research area. Most existing reconstruction methods are based on networks of oscillators with generally smooth dynamics. However, for nonlinear and non-smooth stochastic dynamical systems, e.g., neuronal networks, the reconstruction of the full topology remains a challenge. Here, we present a noninterventional reconstruction method, which is based on Granger causality theory, for the widely used conductance-based, integrate-and-fire type neuronal networks. For this nonlinear system, we have established a direct theoretical connection between Granger causal connectivity and structural connectivity.

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MS8

Investigation of Boussinesq non-linear Interactions

Using Intermediate Models

Nonlinear coupling among wave modes and vortical modes is dissected in order to probe the question: Can we distinguish the wave-vortical interactions largely responsible for formation versus evolution of coherent, balanced structures? It is well known that the quasi-geostrophic (QG) equations can be derived from the Boussinesq system in a non-perturbative way by ignoring wave interactions and considering vortical modes only. One qualitative difference between those two models is the lack of skewness in the QG dynamics. In this talk, non-perturbative intermediate models that include more and more classes of non-linear interactions will be used to identify their role in different qualitative properties of the Boussinesq system. Numerical results will be shown to describe the effect of each class in the transfer of energy between vortical modes and waves, transfer of energy (or the lack of it) between scales, formation of vortices and skewness.

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MS8

Internal Wave Generation by Convection

When a convectively unstable region is adjacent to a stably stratified region, the convection can produce internal waves within the stable region. This is thought to occur in stars, gaseous planets, the Earths atmosphere, oceans and lakes, and possibly even the Earths core. We describe a model for estimating the wave generation by convection based on Lighthills theory, and compare the model to high-resolution simulations using the Dedalus code.

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MS8

Interaction of Inertial Oscillations with a Geostrophic Flow

The interaction between large horizontal scale pure inertial oscillations and small horizontal scale geostrophic field is investigated in this work. As a result of the interaction rapid vertically propagating near inertial waves and trapped or non-propagating inertial oscillations form. The trapped oscillations inherit smaller spatial scales from the geostrophic field and remains in the upper ocean. The near inertial waves propagate into the deep ocean within days, thus allowing the inertial signal to be felt in the deep ocean. The study hence offers an alternate explanation for the age old problem of vertical propagation of near inertial waves and formation of small scale inertial oscillations in an idealized set up. The interaction is however non-energetic, which is consistent with previous works.

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MS8

Interactions Between Near-Inertial Waves and Turbulence in the Ocean

Wind forcing of the ocean generates a spectrum of inertia-gravity waves that is sharply peaked near the local inertial (or Coriolis) frequency. The corresponding near-inertial waves (NIWs) are highly energetic and play a significant role in the slow, large-scale dynamics of the ocean. To analyse this role, we develop a new model of the nondissipative interactions between NIWs and mean flow using a variational implementation of the generalised-Lagrangian-mean formalism. The new model couples the Young & Ben Jelloul model of NIWs with a quasi-geostrophic model in which the relation between potential vorticity and streamfunction is modified by a quadratic wave term. The model reveals that NIWs act as an energy sink for the mean flow: NIWs forced at large scales experience a horizontal scale cascade through refraction and advection; as a result, their potential energy increases at the expense of the mean energy. The implications for ocean energetics are discussed.

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MS9

Local Inference of Gene Regulatory Networks from Time Series Data

Temporal dynamics of gene expression levels may be partially explained by interactions between certain proteins, called transcription factors, which act to either promote or repress RNA-synthesis (transcription) of specific genes. Discovering the regulatory relationships in these transcription networks is a difficult goal of systems biology, but one which promises to greatly enhance experimental design. In this talk, we describe a statistical approach to infer the structure of gene regulatory networks from time series data.

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MS9

Patterns in Discrete Ecological Dynamical Systems Revealed Through Persistent Homology

Persistent homology captures information about a system regarding longevity of topological features, such as level sets of a function. This provides a novel perspective when applied to discrete time dynamical systems. In particular, interesting patterns arise when applied to the logistic map; a common population model. This pattern will be discussed and extended to other systems, including continuous systems.

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MS9

Network Spread and Control of Invasive Species and Infectious Diseases

We introduce a method for coupling vector-based transportation networks (e.g. agents traveling by vehicle) onto a spatially continuous model of a biological epidemic. Analysis for plant invasions yields a unique, stable, steady-state solution with an optimal control for the infected vectors, with network topology affecting the efficacy of the control. Numerical results are shown for the cheatgras invasion of Rocky Mountain National Park based on the presence model of Strickland *et al.* 2014.

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MS9

Topological Data Analysis for and with Contagions on Networks

The study of contagions on networks is central to the understanding of collective social processes and epidemiology. When a network is constrained by an underlying manifold such as Earth's surface (as in most social and transportation networks), it is unclear how much spreading processes on the network reflect such underlying structure, especially when long-range edges are also present. We address the question of when contagions spread predominantly via the spatial propagation of wavefronts (e.g., as observed for the Black Death) rather than via the appearance of spatially-distant clusters of contagion (as observed for modern epidemics). To provide a concrete scenario, we study the Watts threshold model (WTM) of social contagions on what we call noisy geometric networks, which are spatially-embedded networks that consist of both short-range and long-range edges. Our approach involves using multiple realizations of contagion dynamics to map the network nodes as a point cloud, for which we analyze the geometry, topology, and dimensionality. We apply such maps, which we call WTM maps, to both empirical and synthetic noisy geometric networks. For the example of a noisy ring lattice, our approach yields excellent agreement with a bifurcation analysis of the contagion dynamics. Importantly, we find for certain dynamical regimes that we can identify the network's underlying manifold in the point cloud, highlighting the utility of our method as a tool for inferring low-dimensional (e.g., manifold) structure in networks. Our work thereby finds a deep connection between the fields of dynamical systems and nonlinear dimension reduction.

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MS10

Stability Analysis of PDEs with Two Spatial Dimensions Using Lyapunov Methods and SOS

In this talk we consider stability of parabolic linear partial differential equations with polynomial coefficients and two spatial variables. We use Sum-of-Squares, polynomial optimization, and the Positivstellensatz to numerically search for quadratic inhomogeneous Lyapunov functions. Negativity of the derivative is enforced using a new type of slack variable called a "spacing function". The technique was tested numerically on a two-dimensional biological PDE model of population growth model and compared to the analytic solution.

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MS10

Differential Equations with Variable Delay and Their Connection to Partial Differential Equations

Time delay systems can be described by delay differential equations or by a partial differential equation (PDE) with non-local boundary conditions. The domain of the PDE is equal to the state space interval of the delay system. For variable delays a moving boundary appears in the PDE representation. Conditions for a transformation from variable delay (domain) to constant delay (domain) are studied, leading to a fundamental dichotomy of variable delay systems with qualitatively different properties.

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MS10

Delayed Boundary Conditions in Control of Continua

The mechanical model of a basic problem of electroacoustics is considered. The governing PDE is the 1D wave equation with delayed boundary conditions. The system can be transformed into a delay differential equation of neutral type with two delays. The zero-measure regions are constructed analytically in the parameter plane of the gain parameter and the ratio of the delays where the system is exponentially stable. The physical relevance of this peculiar stability chart is highlighted.

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MS10

What Is Wrong with Non-Smooth Mechanics and How Memory Effects Can Fix It?

Non-smooth mechanics has many intricacies. It can provide some surprising predictions or even fail to predict the dynamics past certain singularities. Such singularities where the equations break down include various forms of the Painleve paradox and the two-fold singularity of frictional systems. This talk looks at the reasons why these singularities occur and addresses the issue by adding more physics to the mechanical model. It turns out that finite wave-speed within the mechanical system is sufficient for unique predictions, which can be taken into account with a single correction term dependent only on the wave speed and geometry.

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MS11

Phase Transitions in Models for Social Dynamics

Flocking models abound in the recent mathematical and scientific literature. These models can be applied to organisms which exhibit collective behavior; such models are often applied to insects, fish, birds, and even to humans. I will introduce several flocking models, both deterministic and stochastic, at the microscopic scale. I will then discuss their kinetic and hydrodynamic limits and show that phase transitions can occur on all three scales.

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MS11

A Center Manifold and Complex Phases for a Large Number of Interacting Particles

We investigate a system of ordinary differential equations (ODEs) describing interacting particles, with applications to schools of fish. This model has many advantages over discrete systems of interacting particles and seems to capture the interactions of animals better than the classical discrete Czirok-Vicsek (or boids) model. The main difference is that in our system the animal is allowed to adjust its velocity as well as direction to that of its neighbors. This is the behavior observed in nature and it makes our system more suitable to applications to real animals. The system of ODEs can also be analyzed using methods from dynamical systems and it turns out to have a two-parameter (velocity and direction) asymptotic solution as t becomes large. It also possesses a very rich set of stationary solutions that all are unstable.
In this talk we discuss the center manifold of the migrating state (attractor) and applications to simulations of anchovies off the coast of Peru and Chile. The effects of El Nino will also discussed.

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MS11

Modeling Earthquake Cycles on Faults Separating Variable Materials

We have developed a computational method for studying how the earthquake cycle is affected by heterogeneities in the material surrounding a fault. Finite difference operators satisfying a summation-by-parts rule are applied to the 2D elastodynamic wave equation and weak enforcement of boundary conditions are enforced through the simultaneous-approximation-method. This combined approach leads to a provably stable and high-order accurate method. Non-planar fault geometries, variable materials and inelastic response are incorporated. As a first step we consider the bimaterial problem on planar, vertical strike slip fault. We find that rupture propagates in the preferred direction and we are currently studying the long term behavior of the earthquake cycle and under what conditions rupture in the non-preferred direction (periodically observed on natural faults) is possible.

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MS11

Mathematical Challenges in Ground State Formation of Isotropic and Anisotropic Interaction

In this talk we will present a mathematical framework for studying ground state formation in a general class of kinematic models which are often used to understand the physical, biological and social world. I will first discuss the case of when particles communicate isotropically and, time permitting, will present new developments in the mathematical theory of anisotropic pattern formation.

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MS12

Synchronization over Networks Inspired by Echolocating Bats

While number of organisms have made use of active sensory systems, bats are particularly effective at echolocation, wherein they emit ultrasonic waves and sense echoes to navigate their environment. One of the greatest challenges of echolocating in a group is jamming, which occurs when echoes from an individuals calls become difficult to distinguish from those of its peers. Nevertheless, bats are observed to avoid the negative effects of jamming in behavioral experiments. Drawing inspiration from this phenomenon, we incorporate the effect of jamming into a classical model of synchronization among coupled dynamic systems by superposing a disturbance topology on the communication network. Within this framework, we develop conditions for stochastic synchronization and the rate of convergence to synchronized states.

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MS12

Versatile Vibrations: Partially Synchronized States in Mechanical Systems from Microns to Kilometers

In this talk I'll describe the dynamics of coupled oscillators in three systems: optomechanical microdisk resonators, mechanical metronomes, and pedestrians on suspension bridges. Though drastically different in origin and in scale, the equations of motion share many similarities. I will present analytical and numerical techniques for solving those equations and discuss some unsolved problems and open questions regarding networks of coupled oscillators.

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MS12

Wind-Induced Synchrony Causes the Instability of a Bridge: When Millennium Meets Tacoma

We aim at better understanding the cause of dangerous vibrations and bridges collapsing as a result of wind-induced oscillations at a frequency different from the natural frequencies of a bridge, including the collapse of the Tacoma Narrows Bridge and a long-wave resonance vibration of the Volga Bridge. We propose a synchronization-based mechanism that can explain the shift of the resonant frequency due to wind-induced synchronization of suspension cables/load-bearing elements of a bridge. We also draw parallels between wind-excitation and crowd synchrony and present a bifurcational, analytically tractable model, inspired by the Millennium Bridge case.

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MS12

Network Graph Can Promote Faster Consensus Reach Despite Large Inter-Agent Delays

This presentation stems from the authors work on the interplay between delays, graphs, and dynamical systems. Here, we consider a class of widely-studied linear consensus problem with inter-agent communication delays. For this class of systems, it is known that consensus is guaranteed only if the inter-agent delay is less than a certain margin, known as the delay margin. We investigate how delays and the arising graph formed by agent connectivity can influence

the speed of reach of agents to consensus. Since the solution to this problem is analytically intractable, simulation studies with randomization are systematically performed to investigate it. The three non-trivial findings are as follows: (i) for large inter-agent delays less than the delay margin, there exist some particular graphs that promote considerably faster reach of agents to consensus, (ii) for a given graph, consensus in the presence of larger delays can be reached faster if inter-agent couplings are weaker but not stronger, (iii) for small size networks, there seems to be a way to decide which inter-agent links to remove in order for the agents to reach consensus faster. These preliminary results call for further research in the pursuit of revealing the most immune graphs that also promote large decay rate in system states of various dynamical systems, against the detrimental effects of delays.

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MS13

Stochastic Boundary Conditions for Molecular Dynamics: From Crystal to Melt

Motivated by the need for closure relations in continuum-atomistic simulations, we develop non-periodic molecular dynamic boundary conditions with consistent dynamics to traditional NPT algorithms. A hypothesized stochastic model is employed at the boundary and parameters are fit on the fly via statistical sampling of the interior. Such a method allows us to examine non-traditional computational domains that allow us to focus on interfaces while accounting for local curvatures.

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MS13

Tipping and Warning Signs for Patterns and Propagation Failure in SPDEs

In this talk, I shall report on recent results regarding early-warning signs for pattern formation in stochastic partial differential equations. In particular, it will be shown that classical scaling laws from stochastic ordinary differential equations can be carried over to the SPDE case. This is illustrated in the context of the Swift-Hohenberg equation, analytically and numerically. Furthermore, I shall discuss numerical results for warning signs for the stochastic Fisher-KPP equation in the case of noisy invasion front traveling waves near positive absorption probability events leading to propagation failure. Several interesting potential future directions for dynamical systems analysis of SPDEs will also be sketched.

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MS13

Fluctuating Hydrodynamics of Microparticles in Viscoelastic Fluids

Abstract not available.

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MS13

Low-Damping Transition Times in a Ferromagnetic Model System

Abstract not available.

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MS14

Topological Detection of Structure in Neural Activity Recordings

In biology, observations are often related to variables of interest through unknown monotonic nonlinearities. Detecting structure in the presence of such nonlinearities can be challenging, as eigenvalue-based methods are often misleading. However, algebro-topological tools can provide measurements robust to such transformations, allowing the detection of the presence or absence of intrinsic structure. To demonstrate, we detect the geometric structure arising from hippocampal place cells directly from neural recordings.

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MS14

An Algebro-Topological Perspective on Hierarchical Modularity of Networks

(Joint work with R. Levi and S. Raynor) Recent research by, among others, Bassett and her collaborators, has shown that brain networks exhibit hierarchical modularity, which varies with time during learning. In this talk I will describe work on applying methods from algebraic topology in an attempt to characterize and classify those hierarchically modular graphs that arise as brain networks.

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MS14

The Topology of Fragile X Syndrome

Fragile X syndrome (FXS) is the most common known inherited cause of developmental disability and the most common single-gene risk factor for autism. In this talk I will give a brief description of the algorithm used by Mapper/Iris to produce a Reeb-like graph representation from a dataset, and then describe how its application to MRI data has led to the potential identification of higher and lower functioning subgroups within a population of children with FXS.

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MS14

The Neural Ring: Using Algebraic Geometry to Analyze Neural Codes

Neurons represent external stimuli via neural codes, and the brain infers properties of a stimulus space using only the intrinsic structure of the neural code. We define the neural ring, an algebraic object that encodes the combinatorial data of a neural code. Neural rings can be expressed in a 'canonical form' that translates to a minimal description of code's structure. This provides information about structure in the stimulus space, and how changing the code affects these properties.

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MS15

Modeling Excitable Dynamics of Cardiac Cells

In the past decades many mathematical models of different complexity have been devised describing the excitable dynamics of cardiomyocytes and cardiac tissue. To assess these models their ability to predict experimental cardiac dynamics has to be probed. The model evaluation can be performed in a data assimilation frame work where the model is driven by measured data and after some transient time the input is switched off and the output of the free running model is compared to the true evolution of the experimental system. To assess the fidelity of selected models we employ different state and parameter estimation algorithms, and apply them to experimental data.

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MS15

Reconstructing Dynamics of Unmodeled Variables

Assimilation of data with models of physical processes is a crucial component of modern scientific analysis. In recent years, nonlinear versions of Kalman filtering have been developed, in addition to methods that estimate model parameters in parallel with the system state. We propose a substantial extension of these tools to deal with the specific case of unmodeled variables, when training data from the variable is available. The method uses a stack of several, nonidentical copies of a physical model to jointly reconstruct the variable in question. We demonstrate the ability of this technique to accurately recover an unmodeled experimental quantity, such as an ion concentration, from a single voltage trace after the training period is completed. The method is applied to reconstruct the potassium concentration in a neural culture from multielectrode array voltage measurements.

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MS15

Intramural Forecasting of Cardiac Dynamics Using Data Assimilation

As a first step in reconstructing the three-dimensional propagation and breakup of electrical waves, a data-assimilation system is coupled to a simple model of cardiac electrical dynamics. Data assimilation is a technique common in numerical weather prediction for combining observations with a numerical model to derive an improved estimate of the state of a dynamical system. Here an ensemble Kalman filter is used on synthetic data for both 1D and 3D models.

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MS15

Tracking Neuronal Dynamics During Seizures and Alzheimer's Disease

Observability of a dynamical system requires an understanding of its statethe collective values of its variables. However, existing techniques are too limited to measure all but a small fraction of the physical variables and parameters of neuronal networks. We constructed models of the biophysical properties of neuronal membrane, synaptic, and microenvironment dynamics, and incorporated them into a model-based framework from modern control theory. We demonstrated the meaningful estimation of the dynamics of small neuronal networks using as few as a single measured variable. Specifically, we assimilated noisy membrane potential measurements from individual hippocampal neurons to reconstruct the dynamics of networks of these cells, their extracellular microenvironment, and the activities of different neuronal types during seizures. We used reconstruction to account for unmeasured parts of the neuronal system, relating micro-domain metabolic processes to cellular excitability, and validate the reconstruction of cellular dynamical interactions against actual measurements. Recently, we applied the method to intracellular Ca2+ dynamics using cytoplasmic Ca2+ as an observable to reconstruct and identify the differences between mitochondrial bioenergetics in control and Alzheimers disease states.

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MS16

Feasibility of Micro-Grid Adoptions in Spatially-Embedded Urban Networks

We present a data-driven citywide simulation scheme that combines heterogeneous demand with a complex systems approach. We present micro grid simulations via DC power flow dynamics combined with real (photovoltaic) PV generation and demand profiles of individual buildings in a city, modeled after high temporal-resolution smart-grid data. We explore the efficiency of spatial networks at three different scales from individual buildings to micro-grid neighborhoods to an entire city.

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MS16

Cascading Failures and Stochastic Methods for Mitigation in Spatially-Embedded Random Networks

We have demonstrated that cascading failures are non-self-averaging in spatial graphs, hence predictability is poor and conventional mitigation strategies are largely ineffective. In particular, we have shown that protecting all nodes (or edges) by the same additional capacity (tolerance) can actually lead to larger global failures, i.e., "paying more can result in less", in terms of robustness. Here, we explore stochastic methods for optimal distribution of resources (capacities) subject to a fixed total cost.

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MS16

Spatial Distribution of Population and Scaling in Human Travel

An interesting scaling law connecting the travel time and distance was recently observed in human traveling modes and information spreading. Further we go, faster we do that. Seemingly the spatial distribution of population and the presence of hubs are responsible for this very general phenomenon. Investigating the connection between population density distribution and the mean traveling speed brings new clues to understand this puzzling phenomenon and optimize human travel and information flow.

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MS16

The Brain in Space

Based on experimental evidence here we argue that computing in the brain is based on deeply physical principles in which form follows function: although there is a complex network of computing elements, this network is not an abstract graph, but a physical network embedded both in space and time and these physical properties are just as much part of information processing in the brain as the signals themselves that are being transmitted through the network.

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MS17

On the Role of Stochastic Delays in Gene Regulatory Networks

In gene regulatory networks delays emerge from sequential assembly and accumulation of macromolecules. Furthermore, the stochastic nature of biochemical processes leads to stochastic variations in the delay. This may lead to counter intuitive dynamics where increasing uncertainty can increase the robustness of the system. In this talk we present novel methods that allow us to evaluate the exact stability of equilibria in systems with stochastic delays. We demonstrate these tools on an auto-regulatory network.

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Richard Murray

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MS17

New Mechanisms for Patterns, Transitions, and Coherence Resonance for Systems with Delayed Feedback

Controlling patterns via delayed feedback is an efficient means of pattern resilience. Computations demonstrate complex dynamics for PDE's with Pyragas control. We give a new analysis for stochastic PDE's with delay, capturing novel spatio-temporal pattern mechanisms in the Swift-Hohenberg equation (SHE) with Pyragas control, not observed for the standard SHE. We show that traveling waves appear via coherence resonance-type phenomena and compare these to other multimode patterns generated by delays.

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MS17

Dynamics with Stochastically Delayed Feedback: Designing Connected Vehicle Systems

In this talk we present novel mathematical tools that allow one to evaluate the dynamics of systems where stochacticity appears in the feedback delay. In particular we analyze the mean and second moment dynamics in order to evaluate absolute and convective instabilities in networked system. We apply these methods to networks of vehicles that exchange information via vehicle-to-vehicle (V2V) communication. In such systems stochastic delays appear due to intermittencies and packet loss.

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MS17

Synchronization of Degrade-and-Fire Oscillations Via a Common Activator

In this talk, we examine an experimentally motivated stochastic model for coupled degrade-and-fire gene oscillators, where a core delayed negative feedback establishes oscillations within each cell, and a shared delayed positive feedback couples all cells. We use analytic and numerical techniques to investigate conditions for one cluster and multi-cluster synchrony. A nonzero delay in the shared positive feedback, as expected for experimental systems, is found to be important for synchrony to occur.

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MS18

Homoclinic Snaking Near a Codimension-two Turing-Hopf Bifurcation Point

Spatiotemporal Turing-Hopf pinning solutions near a codimension two Turing-Hopf point are studied. Both the Turing and Hopf bifurcations are supercritical and stable. The pinning solutions exhibit coexistence of stationary stripes of near critical wavelength and time periodic oscillations near the characteristic Hopf frequency. The solution branches are organized in a series of saddle-node bifurcations similar to snaking structures of stationary pinning solutions. Time dependent depinning dynamics outside the saddle-nodes are illustrated. Wavelength variation within the snaking region is discussed, and reasons for the variation are given in the context of amplitude equations. The pinning region is compared favorably to the Maxwell line found numerically by time evolving the amplitude equations

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MS18

Localised Solutions in a Non-Conservative Cell Polarization Model

We study a reaction-diffusion model for cell polarization, which exhibits pinned front solutions as a consequence of mass conservation. When a source and a sink term are added to the model, the front solutions vanish. This gives rise to spike solutions and the snaking scenario. Using numerical and analytical tools, we characterize these behaviours. Finally we investigate the connection between the snaking and front solutions, when the non-conservative

terms tend to zero.

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MS18

Slow Dynamics of Localized Spot Patterns for Reaction-Diffusion Systems on the Sphere

In the singularly perturbed limit corresponding to large a diffusivity ratio between two components in a reaction-diffusion (RD) system, many such systems admit quasi-equilibrium spot patterns, where the solution concentrates at a discrete set of points in the domain. In this context, we derive and study the differential algebraic equation (DAE) that characterizes the slow dynamics for such spot patterns for the Brusselator model on the surface of a sphere. Localized spot patterns can undergo a fast time instability and we derive the conditions for this phenomena, which depend on the spatial configuration of the spots and the parameters in the system. In the absence of these instabilities, our numerical solutions of the DAE system for $N = 2$ to $N = 8$ spots suggest a large basin of attraction to a small set of possible steady-state configurations. We discuss the connections between our results and the study of point vortices on the sphere, as well as the problem of determining a set of elliptic Fekete points, which correspond to globally minimizing the discrete logarithmic energy for N points on the sphere.

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MS18

The Origin of Finite Pulse Trains: Homoclinic Snaking in Excitable Media

Many physical, chemical and biological systems exhibit traveling waves as a result of either an oscillatory instability or excitability. The latter may admit a large multiplicity of stable and spatially localized wavetrains consisting of different numbers of traveling pulses. The existence of these states is related here to the presence of homoclinic snaking in the vicinity of a subcritical, finite wavenumber Hopf bifurcation. The pulses are organized in a slanted snaking structure resulting from the presence of a heteroclinic cycle between small and large amplitude traveling waves. Connections of this type require a multi-valued dispersion relation. This dispersion relation is computed numerically and used to interpret the profile of the pulse group. The different spatially localized pulse trains can be accessed by appropriately customised initial stimuli thereby blurring the traditional distinction between oscillatory and excitable systems.

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MS19

A Geometric Approach to Stationary Defect Solutions

In this talk we consider the impact of a very simple and small spatial heterogeneity on the existence of localized patterns in a system of PDEs in one spatial dimension. The existence problem reduces to the problem of finding a heteroclinic orbit in an ODE in 'time' x, for which the vector field for x ¿ 0 differs slightly from that for x ¡ 0, under the assumption that there is such an orbit in the unperturbed problem. We show that both the dimension of the problem as well as the nature of the linearized system near the endpoints of the heteroclinic orbit has a remarkably rich impact on the existence these defect solutions.

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MS19

Reformulating Spectral Problems with the Krein Matrix

Successful resolution of spectral problems in Hamiltonian systems require that we locate not only the eigenvalues, but we also determine the Krein signature of those which are purely imaginary. The well-known Evans function determines the location and multiplicity of the eigenvalues, but in its classical form it does not allow a determination of the signature. On the other hand, the Krein matrix, and the accompanying Krein eigenvalues, allow us to not only find the eigenvalues, but the graphs can be used to determine the signature. We will briefly consider the construction of the matrix, and discuss its role in applications.

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MS19

Stability in Spatially Localized Patterns

Motivated by numerical stability results on spatially localized patterns in spatially extended systems, we show how the stability of patterns that are formed of nonlocalized fronts can be understood from the spectra of the underlying fronts. We use extended Evans functions to understand the spectral properties of these patterns on the original unbounded domain and on large but bounded domains and compare our results to previous findings on resonance poles and edge bifurcations.

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MS19

Existence of Pearled Patterns in the Planar Functionalized Cahn-Hilliard Equation

The functionalized Cahn-Hilliard (FCH) equation supports planar and circular bilayer interfaces as equilibria which may lose their stability through the pearling bifurcation: a periodic, high-frequency, in-plane modulation of the bilayer thickness. In two spatial dimensions we employ spatial dynamics, a center manifold reduction, normal form analysis and a fixed-point-theorem argument to show that the reduced system admits a degenerate 1:1 resonant normal form, from which we deduce that the onset of the pearling bifurcation coincides with the creation of a two-parameter family of pearled equilibria which are periodic in the in-plane direction and exponentially localized in the transverse direction.

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MS20

Homeostasis As a Network Invariant

The simplest mathematical definition of *homeostasis* is as follows. Suppose a system $\dot{X} = F(X)$ has a stable equilibrium X^0 and the system depends on an input parameter I. Homeostasis occurs when one of the variables of $X^0(I)$ — say the j^{th} — is approximately constant over a broad range of I. We translate finding homeostasis to finding singular points $\frac{\partial X_j^0}{\partial I}(I_0) = 0$. We discuss the question: When are homeostasis singularities invariants of the system when viewed as a network?

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MS20

Optimized Networks Have Cusp-like Dependence on Structural Parameters

Using synchronization stability as a prototypical example, we demonstrate a general phenomenon observed in complex networks of coupled dynamical units: the optimization of collective dynamics leads to cusp-like dependence on network-structural parameters, such as the number of nodes/links and the magnitude of structural perturbations. We show that this phenomenon is observed in a wide range of systems, including Turing instability in activator-inhibitor systems and the dynamics of generators in power grids.

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MS20

Symmetries, Cluster Synchronization, and Isolated Desynchronization in Complex Networks

Many networks are observed to produce patterns of synchronized clusters, but their prediction in general is difficult. We use computational group theory to find network symmetry and cluster synchronization. The number of symmetries can be astronomically large. We show this experimentally using an electro-optic network. We observe a surprising phenomenon (isolated desynchronization) in which some clusters lose synchrony while leaving others connected to them synchronized. This is explained by a subgroup decomposition of the group.

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MS20

Symmetry Breaking and Synchronization Patterns in Networks of Coupled Oscillators

In a recent paper [1] we considered the dynamics of a collection of oscillators coupled to form a network and we showed that the analysis of the network symmetries can be used to predict the emergence of cluster synchronization patterns. In particular, we focused on a specific solution corresponding to the partition of the network nodes in clusters, characterized by the 'maximal symmetry'. In general, given a network, there are other cluster synchronous solutions that may emerge, which correspond to symmetry breakings of the maximal symmetry solution. While in [1], we presented a method to characterize this one solution and its stability, we will try to extend this approach to the 'lower symmetry' solutions. In particular, we will outline a procedure to exhaustively study the existence and stability of all these solutions. [1] L. M. Pecora, F. Sorrentino, A. M. Hagerstrom, T. E. Murphy, R. Roy, "Cluster Synchronization and Isolated Desynchronization in Complex Networks with Symmetries", Nature Communications, 5, 4079 (2014)

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MS21

A Multi Agent Control Strategy for Sampling Uncertain Spatio-Temporally Varying Flow Fields

Uncertainties are a key factor when measuring geophysical flows to determine optimal positions for mobile sensors. To include uncertainties with a physical model of the environment, a model-based observer framework is used, which integrates measurements from sensors and propagates the estimated field by computational fluid dynamics. Spatiotemporal flow, concentration and uncertainty layers of this observer are combined with importance and collision avoidance maps to generate optimal paths for a team of underactuated autonomous sampling vehicles.

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MS21

Bayesian Nonlinear Assimilation for Eulerian Fields and Lagrangian Trajectories

We consider the Bayesian nonlinear assimilation of Eulerian and Lagrangian flow data, exploiting nonlinear governing equations and mutual information structures inherent to coastal ocean dynamical systems and optimally inferring the corresponding multiscale fields and transports. Our Bayesian nonlinear smoothing combines reduced-order Dynamically-Orthogonal equations with Gaussian Mixture Models, extending linearized backward pass updates to a Bayesian nonlinear setting. This mutual information transfer, both forward and backward in time, is linked to Lagrangian concepts, coherent structures and optimal sampling. Examples are provided with a focus on transports in fluid flows. This is joint work with Tapovan Lolla, Patrick Haley, Jing Lin, Deepak Subramani and our MSEAS group at MIT.

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MS21

Optimal Control in Lagrangian Data Assimilation

Inferring the state of an ocean flow is an integral part of environmental monitoring. Autonomous vehicles with a limited capacity for locomotion are increasingly being used for data assimilation of various quantities of interest in the ocean, including the underlying time-independent velocity field. We assess the efficacy of optimal control techniques to guide Lagrangian data assimilation in 2-dimensional flows, focusing on assimilation of the velocity field itself.

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MS21

A Hybrid Particle-Ensemble Kalman Filter for High Dimensional Lagrangian Data Assimilation

We apply the recently proposed hybrid particle-ensemble Kalman filter to assimilate Lagrangian data into a nonlinear, high dimensional quasi-geostrophic ocean model. Effectively the hybrid filter applies a particle filter to the highly nonlinear, low-dimensional Lagrangian instrument variables while applying an ensemble Kalman type update to the high-dimensional Eulerian flow field. We will present some initial results and discuss both challenges and opportunities that this strategy provides.

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MS22

The Geometry of the Toda Lattice Map

In this talk we consider some of the geometry behind the Flaschka coordinates for the Toda lattice equations. We show in particular that the Flaschka mapping is a momentum map and indicate how it can be generalized to study related systems such as rigid body flows on lower triangular matrices. This is joint work with Francois Gay-Balmaz and Tudor Ratiu.

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MS22

Geodesic Finite Elements on Symmetric Spaces and Their Applications to Multisymplectic Variational Integrators

To obtain multisymplectic discretizations of Hamiltonian PDEs with symmetries, we introduce group-equivariant geodesic finite-element spaces that take values in symmetric spaces. This is achieved by endowing symmetric spaces, and in particular, the space of positive-definite matrices, Lorentzian matrices, and symplectic matrices, with a Riemannian metric structure that is induced by a metric on the general linear group. This allows us to apply the Riemannian center of mass construction to obtain manifold-valued shape functions.

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MS22

Dynamics and Optimal Control of Flexible Solar Updraft Towers

The use of solar chimneys for energy production has been suggested more than 100 years ago but was hampered in large part due to the high cost of erecting tall towers. Recently, alternative technique of flexible towers built of inflatable toroidal bladders was suggested. We develop a geometric theory of motion and control of such towers, and report on the results of experiments demonstrating the remarkable stability of the tower in real-life conditions.

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MS22

Hamel's Formalism for Infinite-Dimensional Mechanical Systems

Hamel's formalism is a form of Lagrangian mechanics that generalizes both Euler-Lagrange and Euler-Poincare equations. This is accomplished by unlinking the configuration and velocity measurements. The use of this formalism often leads to a simpler representation of dynamics. This talk will introduce Hamel's formalism for infinite-dimensional mechanical systems and demonstrate its utility in constrained dynamics.

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MS23

Self-Oscillations Via Two-Relay Controller: Design, Analysis, and Applications

Limit cycles induced by relay feedback systems and its application to underactuated mechanical systems will be addressed. Particularly, a two-relay controller (TRC) is proposed for generation of Self-Oscillations (SO) in dynamic systems. The design procedures are proposed using three methodologies: the one based on DF, on Poincaré maps, and on Locus of Perturbed Relay System method. The results are illustrated by experiments on SO generation in a wheel pendulum, Furuta pendulum, and a 3-DOF helicopter.

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MS23

Periodic Solutions in Dynamical Systems with Relay: Existence, Stability, Bifurcations

We consider a system of ordinary differential equations with hysteresis of a relay type. In particular, such a system describes diffusion equations with hysteretic control on the boundary. We analyze existence, stability, and bifurcations of periodic solutions. Furthermore, we show that additional time-delay terms can favorably change the stability of periodic solutions. The first part of our talk is based on a joint work with Sergey Tikhomirov and the second part with Eyal Ron.

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MS23

Population Dynamics with the Preisach Operator

We consider population dynamics models where species (individuals) can switch between two modes of behavior in response to exogenous stimuli. The switching rule of each individual is modeled by a two-threshold non-ideal relay; the averaged state of the individuals feeds back into the system. We consider the SIR and predator-prey type models extended by these switching dynamics and discuss continuous sets of equilibria, robust homoclinic trajectories and other dynamics.

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MS23

Reaction-Diffusion Equations with Discontinuous Relay Nonlinearity

We consider reaction-diffusion equations involving a relay discontinuity in the source term, which is defined at each spatial point. In particular, such problems describe chemical reactions and biological processes in which diffusive and nondiffusive substances interact according to hysteresis law. We show that behaviour of such systems essentially depends on the initial data. For the so-called transverse initial data we show that solutions of the problem can be described by a certain free boundary problem. In the case of non-transverse initial data values of the relay form a spatially periodic or spatially quasyperiodic pattern that originates at a point and propagates outwards.

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MS24

Influence of Finite Larmor Radius on Critical Parameters for Invariant Curves Break Up in Area Preserving Maps Models of ExB Chaotic Transport

We consider 2-dimensional area preserving maps describing chaotic transport in magnetized plasmas with zonal flows perturbed by electrostatic drift waves. We include finite Larmor radius effects by gyro-averaging the corresponding Hamiltonians of the nontwist maps. Dynamical systems methods based on recurrence time statistics are used to quantify the dependence on the Larmor radius of the threshold for the destruction of shearless transport barriers.

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MS24

Breakup of Tori in Multiharmonic Nontwist Standard Maps

Invariant circles play a prominent role in the dynamics of area-preserving maps. Unfortunately, much of the theory developed to study these circles in twist maps does not apply to nontwist systems. In this talk we will employ a quasi-Newton, Fourier-based method to compute the conjugacies of the circles. We will then demonstrate how the near-critical conjugacies provide insight into the mechanics of the breakup of the circles and the topology of the invariant sets afterwards.

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MS24

Nontwist Worm Map

In this work we propose a nontwist discrete map to investigate how the confinement of chaotic regions affects the topology of phase space. We choose to modify the Hamiltonian that generates the standard nontwist map, in order to create two linear barriers on the y-axis. As the perturbation is increased, we observe an onset of avoided regions not visited by chaotic orbits initiated inside the range formed by the introduced barriers. On the other hand, unstable manifolds from two hyperbolic fixed points, located outside the chosen region, can pass through these barriers, filling the avoided regions generated by the confinement proposed. The effect that allows the diffusion of chaotic orbits in only certain directions is known as the ratchet effect, which has been extensively studied in dissipative and Hamiltonian systems, due to its relevance in biology and nanotechnology. The possible observation of the ratchet effect in our map motivates our analyses.

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MS24

Breakup of Shearless Tori and Reconnection in the Piecewise-Linear Standard Nontwist Map

A piecewise-linear version of the area-preserving standard nontwist map is considered as a simple model of a piecewise-smooth map which also violates the twist condition. Using symmetry lines and involutions, I compute periodic orbits to analyze periodic orbit collisions and separatrix reconnection. The transition to chaos due to the destruction of the shearless curve with rotation number equal to the inverse golden mean is studied using Greene s residue criterion.

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MS25

The Role of Voltage-Dependent Electrical Coupling in the Control of Oscillations

We focus on the role of voltage-dependent electrical coupling in determining existence, stability and qualitative properties of solutions in the crab gastric mill rhythm. The network consists of a mutually inhibitory pair of neurons that receive electrical input from a particular projection neuron together with the synaptic input from a pacemaker neuron. Using singular perturbation techniques and phase-plane space analysis, we derive and analyze a low-dimensional map that encodes the effects of these distinct inputs.

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MS25

The Essential Role of Phase Delayed Inhibition in Decoding Synchronized Oscillations

The widespread presence of synchronized neuronal oscillations in the brain suggests the existence of a mechanism that can decode such activity. Candidate mechanisms include: high-spike threshold detection (HTD) and phase-delayed inhibition (PDI). Despite being more complex, PDI has been observed in multiple systems, suggesting an inherent advantage over the alternative. We show that PDI is capable of detecting synchrony far more robustly than HTD, making the motif essential in any system with noisy encoders.

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MS25

Neural Mechanisms of Limb Coordination in Crustacean Swimming

Long-tailed crustaceans swim by rhythmically moving limbs called swimmerets. Over the entire biological range of animal size and paddling frequency, movements of adjacent swimmerets maintain an approximate quarter-period phase difference with the more posterior limbs leading the cycle. Recently we have demonstrated that this frequency-invariant stroke pattern is the most effective and mechanically efficient paddling rhythm across the full range of biologically relevant Reynolds numbers in crustacean swimming. Here, we argue that the organization of the neural circuit underlying swimmeret coordination provides a robust mechanism for generating this stroke pattern.

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MS25

Understanding and Distinguishing Multiple Time Scale Oscillations

CPGs may exhibit behavior, including bursting, involving multiple distinct time scales. Our goal is to understand bursting dynamics in multiple-time-scale systems, motivated by a model of respiratory CPG neuron. We apply geometric singular perturbation theory to explain the mechanisms underlying some interesting forms of bursting dynamics involving multiple forms of activity within each cycle. We consider how many time scales are involved, obtaining some non-intuitive results, and identify solution properties that truly require three time scales.

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MS26

How Small a Thought: Design of Mixing and Separation Processes with Dynamical Systems

We use dynamical systems to design manufacturing processes. Two examples are: (1) The Rotated Arc Mixer, an embodiment of the KAM theorem, increases manufacturing productivity 25% and decreases mixing energy 95%. (2) The dynamical system for inertial particles in a laminar flow has both attracting and repelling regions, the interplay of which localizes particles when the Reynolds number exceeds a critical value with applications in solid-liquid separations. The predicted instability boundary agrees well with data.

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MS26

3D Chaotic Advection in Langmuir Cells

We investigate Lagrangian transport processes in a row of horizontally aligned, vertically sheared, alternating cylindrical vortices: a simple model of ocean Langmuir circulations. We map out the chaotic regions and barriers that result when the system is subject to three-dimensional steady and unsteady disturbances. Chaotic advection occurs in resonant layers within each Langmuir cell, and exchange between the cells via three-dimensional turnstile lobes also occurs.

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MS26

Chaotic Mixing and Transport Barriers

We present experiments on chaotic transport in two- and three-dimensional flows. The 2D flows are oscillating vortex chains with a wind that produces Lévy flights and superdiffusive transport. We consider two 3D flows: (a) a nested vortex chain flow, which gives rise to chaotic mixing even if the flow is time-independent; and (b) a vortex chain with Ekman pumping for which all transport barriers can be destroyed even for arbitrarily small time-dependent perturbations.

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MS26

Experimental Investigation of Fundamental Lagrangian Transport Phenomena

Principal goal is experimental validation of the predicted response of a prototypical 3D unsteady flow with spheroidal (as opposed to toroidal) invariant surfaces to weak perturbations. Investigated are fundamental features as symmetries and periodic lines in the unperturbed state and the formation of tubular structures upon weak perturbation. The latter promote global transport and, ultimately, 3D chaos. Moreover, the experiments validate the essential independence of this response upon the particular nature of the perturbation.

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MS27

Dynamics of Asynchronous Networks

Systems that have the structure of a network of interconnected nodes are abundant in nature and technology. Many mathematical models of such networks are given as ordinary differential equations defined by smooth vector fields. These traditional or "synchronous' network models, however, fail to incorporate features seen in real world; for example, individual components of a network cannot stop and restart in finite time. Asynchronous networks are an attempt to set up a mathematical framework to study systems that exhibit stopping of nodes and their bifurcations. We compare our framework to traditional approaches of differential equations with discontinuous vector fields and show equivalence under certain assumptions. We also explore deadlocks as specific dynamical states in which all nodes stop and never restart. These states cannot occur in a synchronous setup but are a natural feature of asynchronous settings.

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MS27

Pulse Bifurcations in Stochastic Neural Fields

We study the effects of additive noise on traveling waves in spatially extended neural fields. Neural fields equations have an integral term, characterizing synaptic interactions between neurons at different spatial locations of the network. Traveling pulse solutions emerge when considering the effects of local negative feedback, generating a drift instability. Near this criticality, we derive a stochastic amplitude equation describing the pulse dynamics when the noise and the deterministic instability are of comparable magnitude.

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MS27

Classifying Bifurcations in Coupled Cell Networks

Stewart and Golubitsky observed that robust synchrony in coupled cell networks is determined by quotient networks. This result was recently generalized by DeVille and Lerman, who noted that any so-called 'graph fibration' induces a conjugacy between the dynamics of a network and its quotients. Starting from the simple observation that any 'self-fibration' hence induces a symmetry, we present a theory of center manifold reduction that is specifically suited for coupled cell networks.

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MS27

Dynamics of Heterogeneous Networks: Reductions and Coherent Behaviour

Recent experiments show that networks exhibit multiple levels of coherent dynamics depending on the connectivity level of the network. Striking examples are found in the brain. Indeed, synchronisation between highly connected neurons coordinate and shape development in hippocampal networks. We provide a probabilistic approach for random networks with chaotic dynamics. We develop a reduction technique to describe the dynamics of the highly connected network layers in terms of the network's microscopic details.

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MS28

Oscillatory Dynamics of the Candelator

We describe the dynamics of the popular "candle see-saw" experiment in which a candle lit at both ends undergoes vertical oscillations as liquid wax drips from either end. We compare existing theory for small oscillations ($\theta < 30^\circ$) and numerical simulations for large oscillations to experimental data.

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MS28

Period Doubling in the Saline Oscillator

We provide today a simple, nonlinear system that captures many aspects of cardiac dynamics. The saline oscillator is a two chambered plastic box with one orifice connecting the two chambers. There is a jet of fluid flowing through the orifice. Along with this jet is a local voltage that parallels the flow of the jet. The voltage from the saline oscillator highly resembles an action potential and can produce period one and period two cycles.

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MS28

Synchronization Patterns in Simple Networks of Optoelectronic Oscillators

Simple motifs are important constituents of complex networks; insight into the patterns of synchrony for different connection topologies is relevant to understanding how they perform different dynamical functions. Global synchrony, the formation of clusters and desynchronized behavior are all aspects of operation that are observed in the experiments we describe on coupled optoelectronic oscillators. We explore the dependence of these patterns of synchrony and their stability in relationship to the symmetries of the network motifs.

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MS28

Noise-Induced Transitions in Bistable Tunnel Diode Circuits

We measure first-passage time distributions of electrical current switching in a bistable tunnel diode circuit driven with adjustable noise intensity. Near a saddle-node bifurcation, the logarithm of mean switching time scales *linearly* with distance to the bifurcation point and inversely with noise intensity. This suggests a noise-induced switching process that is mediated by nucleation to a distinct state of current flow, with nucleation occurring either at the edge or interior of the diode.

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MS29

Population Models Applied to Model the Pregnancy to Labor Transition

In human pregnancy the steroid hormone progesterone acts via two receptors designated PR-A and PR-B. At term PR-A interferes with PR-B's anti-inflammatory function to initiate labor. We present a model of PR-B's interactions with inflammation and use the dimensionless model to predict the onset of labor in two human transcriptome datasets. Solving the dimensionless model allows us to plot the trajectory of a womans pregnancy in time and study the dynamics of the PR-A/PR-B interaction.

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MS29

Stochastic Fluctuations in Suspensions of Swimming Microorganisms

Mean field theories have had a good deal of success in explaining many features regarding the remarkable dynamics of suspensions of swimming microorganisms, including the onset of patterned motion in certain parameter regimes. We describe an extension of these mean field theories to include stochastic fluctuations in the density of the swimming microorganisms, and some computational issues in simulating the resulting stochastic partial differential equations.

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MS29

A Model for Riot Dynamics: Shocks, Diffusion and Thresholds

In this talk I will introduce variants of a system of differential equations that model social outbursts, such as riots. The systems involves coupling of an explicit variable representing the intensity of rioting activity and an underlying (implicit) field of social tension. Our models include the effects of exogenous and endogenous factors as well as various propagation mechanisms. I will discuss various properties of this system, including the existence of traveling wave solutions whose speed experiences a transition based on a critical threshold for the social tension.

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MS29

Crowd Modeling: How Can People Respond to Fear

We present a model for crowd dynamics where the motion of individuals is assumed to depend on their level of excitement (or fear) and thus the mechanism by which the emotion spreads play an important role. We start with an agent based Cucker-Smale-like model for which we derive the continuity equation from the mean field limit and analyze their asymptotic behavior. Then we explore numerically how variations, in both the effects of the emotion and its mechanism of propagation, affects the dynamics of the crowd.

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MS30

A Self-Organising Distributed Strategy for Optimal Synchronisation of Networked Mechanical Systems

We consider the problem of adapting a weighted graph in a distributed fashion to maximise a desired cost function, as for instance the algebraic connectivity of the graph subject to constraints such as maximum weighted degree at each node and non-negativity of edge weights. The proposed method adapts edge weights in continuous time and is robust to topological changes in the network. We apply the strategy to solve the problem of optimising synchronisation in a network of coupled mechanical systems.

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MS30

Synchronization in Dynamical Networks of Noisy Nonlinear Oscillators, Or Collective Behavior of Zebrafish

Zebrafish is a popular laboratory animal species for the investigation of several functional and dysfunctional biological processes. Their burst-and-coast swimming style is well described through a stochastic mean reverting jump diffusion model. Here, we analyze zebrafish schooling by modeling their social interactions through a noisy vectorial network model, in which each fish is assimilated to a network node whose neighbors are randomly and uniformly selected from the group. Through numerical simulations and closed-form results, we assess the role of the network size, number of neighbors, and noise features on the stochastic synchronization.

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MS30

Synchronization of a Nonlinear Beam Coupled with Deformable Substrates

The nonlinear dynamics of a distributed mechanical system comprised of a beam mechanically coupled with a deformable substrate is considered. A mathematical model of the coupled system is constructed with the inclusion of beam's geometric nonlinearities and the combined effect of strain and strain rate in the material response of the substrate. Synchronization between the beam and the substrate is formally investigated through the evolution of the governing system on nonlinear partial differential equations. It is shown how locomotion of the beam can be achieved by synchronization with motions of the substrate, and how material and geometric properties of the substrate can be inferred by synchronization with imposed motions of the beam.

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MS30

Synchronization Control of Electrochemical Oscillator Assemblies by External Inputs

We consider the manipulation of a collection of heterogeneous nonlinear oscillators, which have unobservable state and receive a common input, to form dynamical synchronization structures. Examining the conditions for entrainment of an oscillator to a periodic input yields insight into a non-traditional control methodology. Phase coordinate transformation, ergodic averaging, and novel waveform design algorithms are used to produce inputs that establish structures in the systems' oscillation phases. The complexity of realizable designs is limited by the nonlinearity and heterogeneity of oscillators in the ensemble. The technique is applied successfully in experiments involving assemblies of electrochemical oscillators.

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MS31

Extreme Events on Small-World Networks of Excitable Units

We investigate small-world networks of excitable units that exhibit different types of collective dynamics, which include extreme events. The transitions between the different types of dynamics are irregular and self-generated. We discuss the mechanisms behind these transitions as well as the impact of the coupling topology on the observed phenomena.

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MS31

Extreme Events in Nature: Harmful Algal Blooms

Harmful algal blooms (HABs) are rare events in the ocean characterized by a sudden large abundance of toxic phytolankton species. We study the mechanism behind the emergence of HABs by modeling the population dynamics as an excitable system involving the competition between different activators, toxic and non-toxic species, as well the preference of the inhibitor, the grazing zooplankton, for certain activators. We show how toxin production, hydrodynamics and variable nutrient input influence the trigger mechanism.

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MS31

Forecasting and Controlling Dragon-King Events in Coupled Dynamical Systems

It is often believed that extreme events in dynamical system follow a scale-free, power-law probability distribution and hence these events are unpredictable. We study extreme events in coupled chaotic oscillators and find that the largest events deviate from the power law distribution (so-called dragon-kings). We show that it is possible to forecast in real time an impending dragon-king and that they can be suppressed by applying tiny perturbations to the system.

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MS31

Extreme Events in Stochastic Multistable Systems

Pulses with extremely large amplitude appear in a system with coexisting attractors subject to stochastic processes. We demonstrate the emergence of such pulses in fiber and semiconductor lasers close to saddle-node bifurcations, and show how their probability depends on noise and laser parameters.

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MS32

Convergent Heat Conduction in One-Dimensional Lattices with Dissociation

The paper considers highly debated problem of convergence of heat conductivity in one-dimensional chains. We conjecture that the convergence may be promoted due to possibility of the chain to dissociate. To clarify this point, we study the simplest model of this sort – a chain of linearly elastic rods with finite size. Formation of gaps between the rods is the only possible mechanism for scattering of the elastic waves. Heat conduction in this system turns out to be convergent. Moreover, an asymptotic behavior of the heat conduction coefficient for the case of large densities and relatively low temperatures obeys simple Arrhenius-type law.

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MS32

Bistable Nonlinear Energy Sink Coupled System for Energy Absorption and Harvesting

The nonlinear dynamics of a two-degree-of-freedom system consisting of a linear oscillator (LO) coupled to a bistable light attachment (NES) is investigated. The parameters of the bistable NES are optimized in order to make it functioning as a linear TMD for low-amplitude, in-well, oscillations. The energy transfer mechanisms between the LO and the NES are discussed in order to assess the potential of this configuration for absorption and harvesting purposes.

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MS32

Stochastic Closure Schemes for Bi-stable Energy Harvesters Excited by Colored Noise

The goal of this work is the development of a closure methodology that can overcome the limitations of traditional statistical linearization/Gaussian closure schemes and can approximate the steady state statistical structure of bistable systems. Our approach is based on the minimization of a cost functional that expresses i) second-order moment information for the dynamics and ii) pdf representation constraints for bi-stable systems. Our results compare favorably with direct Monte-Carlo simulations.

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MS32

Acceleration of Charged Particles in the Presence of Fluctuations

We consider resonances-driven acceleration and energy transport of charged particles in the earth magnetotail in the presence of high-frequency fluctuations of the background magnetic field. We show that fluctuations significantly affect both capture into resonance, by forcing particles to escape from the surfatron resonance and thus altering the resulting energy spectrum of particles; and scattering by resonance, by changing the structure of beamlets, which are regular islands in chaotic sea.

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MS33

Models of Large Deviations and Rare Events for Optical Pulses

In optical systems, amplified spontaneous emission noise leads to errors if noise-induced fluctuations are large. We discuss methods for modeling large deviations in such sys-

tems. In particular, we show how the problem of finding large deviations can be formulated as a constrained optimization problem that combines the pulse evolution equation and, in some cases, a detector model. The results of the combined optimization are then used to guide importance-sampled Monte-Carlo simulations to compute error probabilities.

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MS33

Influence of Periodic Modulation in Extreme Optical Pulses

Semiconductor lasers with optical injection display a rich variety of behaviours, including extreme pulses, which have been identified as rogue waves (RWs). We have shown that RWs can be completely suppressed via direct current modulation, with appropriated modulation amplitude and frequency. Here we show that, when RWs are not suppressed, their probability depends on the modulation phase. There are “safe’ windows where no RWs occur. The most extreme RWs occur at the window boundary.

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MS33

Rare Events in Stochastic Dynamical Systems with Delay: From Random Switching to Extinctions

We consider delayed multi-attractor noise-induced switching, and extinction in populations systems with delay near bifurcation points. For weak noise, the rates of inter-attractor switching and extinction are exponentially small. Finding these rates is formulated as a set of acausal variational problems, which in turn give the most probable paths followed in switching or extinction. Explicit general theoretical results obtained show the analytical results agree well with the numerical simulations for both switching and extinction rates.

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MS33

Rare Event Extinction on Stochastic Networks

We consider stochastic extinction of an epidemic on a network. We use a pair-based proxy model for nodes and links for a susceptible-infected-susceptible (SIS) epidemic on a random network. Extending the theory of large deviations to random networks, we predict extinction times and find the most probable path to extinction. Predictions are shown to agree well with Monte Carlo simulations of the network.

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MS34

A Mathematical Model of Cancer Stem Cell Lineage Population Dynamics with Mutation Accumulation and Telomere Length Hierarchies

Cancer develops when cells acquire a sequence of mutations, which determines a hierarchy among the cells, based on how many more mutations they need to accumulate in order to become cancerous. Telomere loss and differentiation define another cell hierarchy, on top of which is the stem cell. This mutation-generation model combines the mutation-accumulation hierarchy with the differentiation hierarchy of the cells, allowing us to take a step further in examining cancer acquisition and growth.

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MS34

How Much and How Often? Mathematical Models of Cancer Vaccine Delivery

Cancer immunotherapy was heralded as the Breakthrough of the Year 2013 by Science magazine due to innovations in strategies to harness the immune system to fight cancer. Yet many questions remain unanswered: What is the correct mixture of therapies to give, in what order should they be given, and according to what schedule? In this talk I will present mathematical models that can be used to suggest answers to these questions.

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MS34

A Cell Population Model Structured by Cell Age

Incorporating Cell-cell Adhesion

An analysis is given of a continuum model of a proliferating cell population, which incorporates cell movement in space and cell progression through the cell cycle. The model consists of a nonlinear partial differential equation for the cell density in the spatial position and the cell age coordinates. The equation contains a diffusion term corresponding to random cell movement, a nonlocal dispersion term corresponding to cell-cell adhesion, a cell age dependent boundary condition corresponding to cell division, and a nonlinear logistic term corresponding to constrained population growth. Basic properties of the solutions are proved, including existence, uniqueness, positivity, and long-term behavior dependent on parametric input. The model is illustrated by simulations applicable to in vitro wound closure experiments, which are widely used for experimental testing of cancer therapies.

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MS34

Mathematical Models of the Treatment of Chronic Lymphocytic Leukemia with Ibrutinib and the Development of Drug Resistance

Chronic lymphocytic leukemia (CLL) is the most common leukemia in the western world. A recently developed targeted kinase inhibitor, ibrutinib, has shown very promising results in clinical trials and has now been approved for the treatment of the disease. I will discuss mathematical models that have been used to analyze the dynamics of CLL cells during drug therapy, and show how this model can be used to estimate parameters and obtain important insights into the mechanisms of action of the drug. Further, I will discuss mathematical models that seek to predict the duration for which ibrutinib can maintain control of the disease, and when drug resistance causes relapse of the disease.

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MS35

Inertia Effects in the Dynamics of Spherical and Non-Spherical Objects at Low Reynolds Number

Particles moving in a fluid at low but finite Reynolds numbers experience hydrodynamic forces that may be significantly affected by fluid inertia. As a result the particle dynamics (both translational and rotational) may be strongly altered. This presentation aims at presenting theoretical tools, essentially based on matched asymptotic expansions, which allow to take these effects into account in certain situations.

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MS35

Influence of the History Force on Inertial Particle Advection: Gravitational Effects and Horizontal Diffusion

We study the advection dynamics of inertial particles in order to understand the sedimentation of marine snow. In this work we analyze the effect of the Basset force, an integral over the particle's history, on the advection of slowly moving, dense or nearly neutral particles in the presence of gravity. We highlight the parameters and select case studies where memory changes the vertical and horizontal transport.

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MS35

Effect of Fluid and Particle Inertia on the Dynamics and Scaling of Ellipsoidal Particles in Shear Flow

Simulations of the rotational behaviour of ellipsoidal particles in linear shear flow are made by the Lattice Boltzmann Method. As fluid and/or particle inertia is increased, a number of rotational states are observed and the bifurcation sequence is detected and analysed. The behaviour of triaxial particles will be presented in some detail. It is observed that the drift to chaotic rotation observed in creeping flow seems to be less significant with fluid inertia present.

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MS35

The Effect of Particle and Fluid Inertia on the Dynamics of Particles in Flows

The dynamics of a very small particle suspended in a fluid flow is simple: the centre-of-mass is advected by the fluid velocity, and the orientational dynamics is determined by

the sequence of fluid-velocity gradients that the particle experiences. For larger particles inertial effects may become important. Particle inertia is relatively straightforward to treat and there has recently been substantial progress in understanding its effect upon the dynamics of particles in flows. The effect of fluid inertia, by contrast, is more difficult to describe. In this talk I will review what is known about the effect of fluid inertia upon the translational and orientational motion of particles in flows.

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MS36

How Nonsmooth Are the Earth Sciences?

Geological folding of sedimentary rock layers is often thought of as being a smooth process, leading to regular sinusoidal folds. In fact, a look at actual rocks will show you that they often fold in a different non-smooth manner, with sharp corners. Such folding patterns include kink bands and (zig-zag) chevron folds. Non-smooth features are often linked to the presence of (possibly precious) minerals deep underground. In this talk I will develop a theory for such non-smooth behaviour which accounts for the friction and compression between rock layers. This theory gives a consistent description of the non-smooth folding patterns in terms of novel homoclinic bifurcations.

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MS36

Analysis of an Arctic Sea Ice Model in a Nonsmooth Limit

We analyze an energy balance model for the Arctic, which takes the form of a low-dimensional, periodically forced dynamical system that captures key feedbacks, in the limit of discontinuous ice-albedo feedback. This mathematical simplification enables detailed analysis and provides intuition for the role that the discontinuity boundary in phase space plays in the bifurcation structure of the model. We explore how this analysis provides an alternative perspective on previous numerical studies of this model.

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MS36

Mathematical Quantifications of Resilience

Roughly speaking, resilience refers to the capacity of a system to absorb disturbance and still retain its structure and function. This ecologically and socially relevant definition of resilience is used in ecology, medicine, and climate science, and by policy makers in community, government and conservation efforts. Despite this fast growing interest in resilience across the sciences and social sciences, there is little work done to describe resilience in quantifiable mathematical terms. The Resilience Focus Group of the Mathematics and Climate Research Network is working on quantifiable definitions of resilience. A continuous dynamical system is used to model the undisturbed ecological or biological system, but what kind of perturbations best model disturbance to the system? How is resilience different from Lyaponov stability of the system? What metrics could we use to understand this difference?

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MS36

The Search for Glacial Cycles: A Quasiperiodically Forced Nonsmooth System in a Conceptual Climate Model

The glacial-interglacial cycle provides mesmerizing dynamical system and modeling topics. We present a novel energy balance model with glacial mass balance adjustment. The model is a non-smooth dynamical system with nonautonomous orbital forcing, exhibiting a similar sawtooth result typical of glacial and interglacial cycles. Some future dynamical challenges will be outlined.

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MS37

Probabilistic Approach to Deployment Strategy in Lagrangian Data Assimilation

A sequence of position observations by Lagrangian instruments, such as drifters and floats, contains time-integrated information of local flow velocity along the trajectories. Direct assimilation of these Lagrangian observations is effective in estimating time-evolving, underlying flow. Along a trajectory, each observation has a limited region of influence where dynamic correlation to the observation location is significant. Because trajectories are governed by the Lagrangian geometry of the underlying flow, design of the deployment strategy should take into account the detection of the Lagrangian geometry. However, even when the underlying flow is perfectly known, detection of the Lagrangian geometry is challenging. In this talk, we present a probabilistic approach to Lagrangian data assimilation that incorporates the detection of the Lagrangian geometry while estimating the underlying flow and design the deployment strategy accordingly.

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MS37

A Quantitative Measure of Observability for Data Assimilations

For complicated systems found in numerical weather prediction, we introduce a characterization of observability to quantify the quality of information provided by sensors and prior knowledge. Optimal sensor positions can be found by maximizing the observability. To evaluate the performance of this method we consider the assimilation sensitivity of the optimized sensors as well as the performance in Monte Carlo experiments against test cases. Lastly we discuss the application of the method to mobile sensors.

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MS37

Multivehicle Motion Planning in the Presence of Ocean Eddies

We present a path-planning paradigm for a team of autonomous sampling platforms in the presence of coherent ocean eddies. Vehicle paths near eddies are planned by utilizing Hamiltonian dynamics with added dissipation to generate control vector fields for vehicle guidance. The path-planning framework is based on the concept of an active singularity whose strength is a tunable control input. The active singularities are associated with individual vehicles and the Hamiltonian structure of their dynamics enables a principled method for motion planning.

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MS37

Bayesian Nonlinear Smoothing and Mutual Information for Adaptive Sampling

New schemes are presented for optimal Bayesian nonlinear state estimation and adaptive sampling of nonlinear fluid and ocean dynamical systems, both forward and backward in time. The Bayesian nonlinear smoothing combines reduced-order Dynamically-Orthogonal (DO) equations with Gaussian Mixture Models (GMMs), extending linearized backward pass updates to a Bayesian nonlinear setting. Bayesian nonlinear adaptive sampling schemes are then derived to predict the observations to be collected that maximize the mutual information about variables of interest. Examples are provided for fluid and ocean flows. This is joint work with our MSEAS group at MIT.

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MS38

A 3D Model of Cell Signal Transduction

We consider a 3D model of cell signal transduction in which the enzymes promoting the various stages in the signal are in fixed positions within the cell. We use the method of matched asymptotic expansions to reduce the partial differential equation modeling the signal transduction process to a system of ordinary differential equations. We consider various bifurcations and the addition of delay to the system.

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MS38

Organization of Metabolic Reactions for Improved Efficiency: Carbon Fixation and Bioengineering Applications

Recent advances in the experimental understanding of cellular organization motivate the need for novel spatial modeling of reactions in cells. Cells organize biochemical reactions to optimize growth, prevent toxic side-reactions, and direct metabolic flux. We review recent experimental work, traditional methods for modeling metabolic networks, and open problems. We present an example model of how the organization of carbon fixation reactions in photosynthetic bacteria improves reaction efficiency reducing the energy needed for growth of cells.

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MS38

An Spatial Model of Anti-Cancer Drug Resistance: the Role of the Micro-Environment

Although resistance to chemotherapeutic agents seems to be bound to appear, it is difficult to determine whether it arises prior to, or as a result of, cancer therapy. We developed a hybrid discrete-continuous mathematical model to explore anti-cancer drug resistance development. We describe cells through a particle-spring approach responding to changing levels of oxygen and drug concentrations, using partial differential equations. We consider two kinds of resistance (namely pre-existing and acquired) and explore the role of microenvironmental niches of drug and oxygen in tumor cell survival and tumor expansion.

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MS38

Synthetic Genetic Circuits for Spatial Patterning

One promise of synthetic biology is the creation of genetic circuitry that enables the execution of logical programming in living cells. Our lab has previously engineered intracellular and multicellular oscillators that give robust dynamic behavior and observed them at the single cell and colony level using time-lapse microscopy. We have recently turned to the task of creating a circuit giving robust spatial oscillations of gene expression in a population – stripes. The key to robust oscillations in temporal genetic oscillators was positive feedback coupled to delayed negative feedback. In the spatial case, time delay corresponds to spatial offset, suggesting that stripe formation will require local positive feedback coupled to long-range negative feedback. This is essentially the model of pattern formation first described by Turing and expanded on by Gierer and Meinhardt. These models as originally formulated require two signals diffusing at very different rates, but similar patterning mechanisms can function even if the two signals diffuse at the same rate. Signals that do not crosstalk are required for these patterning mechanisms, but orthogonal signals for synthetic genetic circuits have proved elusive. Recently we have developed a system that permits two signals to be used in the same cell and her we describe efforts to construct self-organizing genetic circuits using this new tool.

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MS39

Reduced Models for Granular and Ecological Dynamics

The potency of reduced dynamical models is illustrated with two examples: First, by a sequence of reductions from infinite-dimensional to discrete dynamical models of granular flows. The effectiveness of these models for predicting granular dynamics is demonstrated, as are some innovative integrability results they have inspired. Secondly, effective reduced discrete dynamical models for ecological dynamics are described and analyzed, and some associated serendipitous insights on the identification and analysis of strange attractors are outlined.

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MS39

Collective Coordinates as Model Reduction for Nonlinear Wave Interactions

The linear superposition of two traveling wave solutions of a PDE offers a quantitative description of nonlinear wave interactions, provided certain parameters, usually termed "collective coordinates", of the shapes (e.g., the trajectories of the centers) are considered unknown a priori. For PDEs with Hamiltonian structure, substituting such an ansatz into the Lagrangian leads to a reduced-order dynamical model (a "coarse-grain" description) in the form of (a few) coupled nonlinear ODEs. To demonstrate the versatility of this variational technique, the sine–Gordon wave and the $K^*(l,p)$ evolution equations are considered.

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MS39

On the Calogero Type Integrable Discretization of Nonlinear Dynamical Systems

The Calogero type matrix discretization scheme is applied to constructing Lax type integrable discretizations of nonlinear dynamical systems. The Lie-algebraic integrability properties of co-adjoint flows on the related Markov type Lie algebras are discussed.

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MS39

A Scheme for Modeling and Analyzing the Dynamics of Logical Circuits

It is shown how logical circuits can be modeled by discrete dynamical systems. While continuous dynamical systems provide quite accurate mechanistic models, they tend to be computationally expensive to simulate. In contrast, simulating a discrete dynamical system is relatively inexpensive. A model for the RS flip-flop circuit is constructed using chaotic NOR gates. Next, a systematic - algorithmic - first principles approach is developed and shown to be useful in obtaining models of more complicated logical circuits.

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MS40

Predator-Swarm Interactions

We propose a minimal model of predator-swarm interactions which captures many of the essential dynamics observed in nature. Different outcomes are observed depending on the predator strength. For a weak predator, the swarm is able to escape the predator completely. As the strength is increased, the predator is able to catch up with the swarm as a whole, but the individual prey is able to escape by confusing the predator: the prey forms a ring with the predator at the centre. For higher predator strength, complex chasing dynamics are observed which can become chaotic, and eventually leading to successful prey capture. Our model is simple enough to be amenable to a full mathematical analysis, which is used to predict the shape of the swarm as well as the resulting predatorprey dynamics as a function of model parameters. The complex shape of the swarm in our model during the chasing dynamics is similar to the shape of a flock of sheep avoiding a shepherd.

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MS40

Non-Standard Travelling Waves in Traffic and Pedestrian Flow Models

Non-standard waves for particle models of car traffic and pedestrian flow are presented and analyzed both analytically and numerically. The car traffic model is an extended optimal velocity model with velocity dependent driver strategies which shows traveling multi-pulse traffic jams and modulated waves. The pedestrian model is based on a social force model with asymmetric couplings (pedestrians in front have bigger influence on the pedestrian behaviour) and shows transitions to multi-lane waves and peristaltic motion.

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MS40

Topological Data Analysis of Biological Aggregation Models

We apply tools from topological data analysis to two mathematical models inspired by biological aggregations such as bird flocks, fish schools, and insect swarms. Our data consists of numerical simulation output from the models of Vicsek, *et al.* and D'Orsogna, *et al.*. These models are dynamical systems describing the movement of agents who interact via alignment, attraction, and/or repulsion. Each simulation time frame is a point cloud in position-velocity space. We analyze the topological structure of these point clouds, interpreting the persistent homology by calculating the first few Betti numbers. These Betti numbers count connected components, topological circles, and trapped volumes present in the data. To interpret our results, we introduce a visualization that displays Betti numbers over simulation time and topological persistence scale. We compare our topological results to order parameters typically used to quantify the global behavior of aggregations, such as polarization and angular momentum. The topological calculations reveal events and structure not captured by the order parameters.

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MS40

Modeling Stripe Formation in Zebrafish

Zebrafish is a small fish with distinctive black and yellow stripes that form due to the interaction of different pigment cells. We present a comprehensive agent-based model for stripe formation in zebrafish that describes the full spectrum of biological data: development from a larval pre-pattern, ablation experiments, and mutations. We find that fish growth shortens the necessary scale for long-range interactions and that iridophores, a third type of pigment cell, maintain stripe boundary integrity.

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MS41

Stability of Power Grid: Dynamical Systems Perspective

Power grids can be conveniently represented as dynamical systems. Their normal operations depend on two kinds of stability: steady state and transient stability. An overview of the techniques for estimation of both types of stability will be given. An approach for improving the stability based on using electrical vehicles plugged to the grid will be presented. Influence of the delays on the stabilization will be also shown.

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MS41

Analysis of Systems in Buildings Using Koopman Operator Methods

Commercial buildings consume 20% of U.S. energy half of which is due to Heating, Ventilation, & Air Conditioning. Due to the multiple time-scales and spatial configurations of HVAC sub-systems, energy efficiency is difficult to achieve. By projecting building time-series data onto eigenmodes of the Koopman operator, interactions between sub-systems become identifiable leading to improved building performance. Technique is illustrated on model simulated predictions and actual sensor data.

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MS41

Time Series Prediction for Renewable Energy Resources

The prediction of renewable energy outputs is almost equivalent to weather forecasting, although the time resolutions often required are different between these two: the prediction of renewable energy often needs the finer resolution that can go down to the orders of seconds and minutes. The prediction of renewable energy outputs of such a finer resolution can be realized by employing time series prediction with empirical observations rather than refining outputs of global circulation models.

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MS41

Hierarchical Subsystem Clustering for Distributed Control of Networked Systems

We examine hierarchical subsystem clustering for networked systems in the framework of hierarchical distributed control proposed by the authors. More specifically, for various existing clustering methods such as the K-means method, we numerically examine stability as well as control performance of the whole control system with resultant subsystem clusters. This study is expected to be a first step towards development of hierarchical distributed control theory with systematic determination of subsystem clustering.

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MS42

On the Relationship Between Koopman Mode Decomposition and Dynamic Mode Decomposition

We present an explicit relationship between Koopman Mode Decomposition (KMD) of dynamical systems and companion-matrix version of Dynamic Mode Decomposition (DMD). We use this relationship to explain some of the differences in the variants of DMD algorithm. We also discuss some applications of DMD as a tool to extract Koopman modes from experimental and computational data.

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MS42

Extracting Spatial-Temporal Coherent Patterns in Large-Scale Neural Recordings Using Dynamic Mode Decomposition

There is a broad need in the neuroscience community to understand and visualize large-scale recordings of neural activity, big data acquired by tens or hundreds of electrodes simultaneously recording dynamic brain activity over minutes to hours. Such dynamic datasets are characterized by coherent patterns across both space and time, yet existing computational methods are typically restricted to analysis either in space or in time separately. Here we report the adaptation of dynamic mode decomposition (DMD), an algorithm originally developed for the study of fluid physics, to large-scale neuronal recordings. We validated the DMD approach on sub-dural electrode array recordings from human subjects performing a known motor activation task. Next, we leveraged DMD in combination with machine learning to develop a novel method to extract sleep spindle networks from the same subjects. We suggest that DMD is generally applicable as a powerful method in the analysis and understanding of large-scale recordings of neural activity.

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MS42

Dynamic Mode Decomposition with Control with a Special Focus on Epidemiological Applications

Here, we present a new method called Dynamic Mode Decomposition with control (DMDc) which, similar to Dynamic Mode Decomposition (DMD), finds low-order models from high-dimensional, complex systems, but now incorporates the effect of external control. In contrast to DMD, DMDc is capable of producing an accurate input-output model recovering the dynamics and modes without being corrupted by external forcing. We focus on a set of epidemiological applications which have both dynamics and interventions (control).

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MS42

A Rigorous Definition and Theory of Dynamic Mode Decomposition

Dynamic mode decomposition (DMD) is often described algorithmically, rather than through a set of defining mathematical properties, as other decompositions are. In this talk, we present a formal definition of DMD that agrees with the familiar algorithmic descriptions. This establishes a foundation from which new theory and algorithms can be developed. For instance, it allows for non-sequential datasets and elucidates the connections between DMD, Koopman operator theory, the eigensystem realization algorithm, and linear inverse modeling.

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MS43

Methods for Implementing Exactly Solvable Chaos in Electronic Circuits

Exactly solvable chaos may lend many advantages to applications in radar, communications, computing and security. In order for these technologies to benefit from the use of exactly solvable chaos, these governing equations must be first implemented using various electronic circuit design techniques. This work outlines various methodologies for realizing exactly solvable chaos using mixed-signal electronic circuits, while considering many crucial component design limitations such as frequency response, bandwidth, noise, linearity and parasitics.

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MS43

A Pseudo-Matched Filter for Solvable Chaos

In the work of Corron *et al.* [Chaos **20**, 023123 (2010)], a matched filter is derived for the chaotic waveforms produced by a piecewise-linear dynamical system. Motivated by these results, we systematically investigate the matched filters properties in order to design a pseudo-matched filter, which captures important features of the matched filter and is realized using first order filters. Using numerical simulations and statistical analyses, we compare the performances of the matched and pseudo-matched filters.

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MS43

Communication Waveforms and Exactly Solvable Chaos

We show that, under practical constraints, an optimal communication waveform is chaotic. That is, we assume a simple matched filter and derive the corresponding basis function that maximizes the receiver signal-to-noise performance. We then consider a communication waveform using this basis function, and surprisingly we find a waveform return map that is conjugate to a chaotic shift map. We also show a relationship of the optimal waveform to an exactly solvable hybrid chaotic oscillator that has been previously reported.

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MS43

Exactly Solvable Chaos in An Electromechanical Oscillator

A novel electromechanical chaotic oscillator is described that admits an exact analytic solution. The oscillator is a hybrid dynamical system with governing equations that include a linear second order ordinary differential equation with negative damping and a discrete switching condition that controls the oscillatory fixed point. The system produces provably chaotic oscillations with a topological structure similar to either the Lorenz butterfly or Rössler's folded-band oscillator depending on the configuration. Exact solutions are written as a linear convolution of a fixed basis pulse and a sequence of discrete symbols. We find close agreement between the exact analytical solutions and the physical oscillations. Waveform return maps for both configurations show equivalence to either a shift map or tent map, proving the chaotic nature of the oscillations.

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MS44

A Measurable Perspective on Finite Time Coherence

The concept of coherent structures in a flow refers to notions of subsets of the flow which preserve some measurable quantity, despite the generally nonlinear flow: something simple embedded in the complexity. Our own perspective of shape coherent sets is defined in terms of flow that is locally as rigid body motions, and uncovered by investigating boundary curvature evolution. Key for unifying to other concepts of coherence is choice of measure interpreted across domains .

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MS44

Rigorous Numerical Approximation of Invariant Measures – History and Recent Progress

Interest in rigorous schemes to approximate invariant measures in ergodic theory dates back at least to Ulam's celebrated 1960 conjecture about their approximation via finite-dimensional Markov chains. We review this history from the modern perspective of spectral perturbation. Recently, with R. Murray, convex optimization techniques have been proposed; we compare and contrast these with Ulam's scheme. Finally, we place all of these approaches into a unified setting of regularized least-squares optimization for solution of the (ill-posed) Perron-Frobenius fixed point problem.

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MS44

Non-Autonomous Dynamical Systems, Multiplicative Ergodic Theorems and Applications

Non-autonomous dynamical systems yield very flexible models for the study of time-dependent systems, with driving mechanisms ranging from deterministic forcing to stationary noise. Multiplicative ergodic theorems (METs) encompass fundamental information for the study of transport phenomena in such systems, including Lyapunov exponents, invariant measures and coherent structures. In this talk, we will discuss recent developments on METs, motivated by questions coming from oceanic and atmospheric dynamics.

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MS44

On Triangularization of Matrix Cocycles in the Multiplicative Ergodic Theorem

The Multiplicative Ergodic Theorem shows that a real matrix cocycle is block diagonalizable over the real numbers, given mild hypotheses; that is, the cocycle is cohomologous to one in which the matrices are supported on blocks corresponding to the Lyapunov exponents. We shall talk about block *triangularizing* cocycles, and investigate when this may occur; namely, not all cocycles may be triangularized, even over the complex numbers.

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MS45

Vibration Energy Harvesting Based on Nonlinear Targeted Energy Transfer

We investigate the use of targeted energy transfer via essential (nonlinearizable) stiffness nonlinearity to promote efficient energy harvesting. The system of interest consists of two oscillators, a linear primary and strongly nonlinear secondary, coupled electromechanically. The primary is a grounded linear oscillator; the secondary, the harvester, is a lightweight oscillating mass attached to the primary mass through a permanent magnet, inductance coil, and untensioned steel wire positioned normal to the direction of the oscillation, which provides the purely cubic essential nonlinearity. Impulsive excitation of the primary at a sufficiently high level results in transient resonance capture with the secondary, resulting in a large-amplitude high-frequency component in the harvester response. Energy generated is harvested in a circuit via the magnet and coil. Performance is demonstrated through both simulation and experiment.

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MS45

Nonlinear Energy Harvesting in Granular Media

In this talk, we explore the possibility of using granular crystals for the purpose of vibration energy harvesting. In particular, we focus on time-periodic structures of such systems and how the interplay of spatial heterogeneity, discreteness and nonlinearity can lead to desirable localization properties. We approach the problem with computational, analytical and experimental tools.

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MS45

2D Energy Channeling in the Locally Resonant Acoustic Metamaterials

Dynamics of locally resonant, acoustic meta-materials is a subject of intense study of the past few years. As of today there is a lack of a substantial theoretical understanding of the dynamics of locally resonant, 1D, 2D non-linear lattices. In the present talk I'll present the recent results of the theoretical study of controlled, unidirectional energy transport, wave redirection and nonlinear energy channeling in the locally resonant, 2D metamaterials, incorporating internal rotators.

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MS45

Non-Linearizable Wave Equation: Nonlinear Sonic Vacuum

We consider low-energy oscillations of a finite spring-mass chain in the plane, with geometric nonlinearity generating a smooth nonlinear sonic vacuum with zero speed of sound, and strongly non-local nonlinear terms despite only next-neighbor physical interactions between particles. The nonlinear normal modes of this system are identical to those of a simple linear spring-mass chain. Asymptotic analysis reveals a rich structure of resonance manifolds, mixed standing/traveling waves, and strong nonlinear energy exchanges between modes.

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MS46

The Effect of Extrinsic Noise on Gene Regulation

Stochastic gene expression is influenced both by intrinsic noise (IN) arising from intracellular variability and extrinsic noise (EN) arising from intercellular variability. While IN is well understood, a rigorous understanding of how EN influences the function of genetic networks is still lacking. Here we study the IN/EN interplay in simple network motifs, focusing of how EN characteristics affect the overall statistics. Our analytical predictions are compared with Monte-Carlo simulations efficiently accounting for fluctuating reaction rates.

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MS46

Fundamental Limits to the Precision of Multicellular Sensing

Single cells sense their environment with remarkable precision. At the same time, cells communicate. How are sensing and communication related? I will describe a system in which epithelial cells, by communicating, can detect shallower chemical gradients than single cells can alone. A minimal stochastic model provides fundamental limits on the precision of communication-aided sensing, which we validate in the experimental system. Our results demonstrate that known sensory limits are altered when communication is accounted for.

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MS46

Inferring Predictive Signal-Activated Gene Regulation Models from Noisy Single-Cell Data

Spatial, temporal and stochastic fluctuations can cause genetically identical cells to exhibit wildly different behaviors. At first glance, fluctuations seem to compromise cellular responses, complicate modeling, and disrupt predictive understanding and control. Under closer examination, cellular fluctuations actually become exceptionally useful. I will discuss how integrating single-cell experiments with precise spatiotemporal stochastic analyses can reveal new insight, enable quantitatively predictive models, and improve the controllability of heterogeneous gene regulation in bacteria, yeast and mammalian systems.

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MS46

Coarse-Graining Biochemical Networks

We consider a generic stochastic model either for ion transport through a single channel with arbitrary internal structure or arbitrary enzyme kinetics. We show that measurements of statistics of transition times through specific states of such a system contain only restricted information about parameters of the model. This observation allows one to identify the most relevant variables that can be quickly estimated if statistical measurements are performed on a biochemical process at a single molecule level. For example, we show that the Poisson indicator in enzyme kinetics depends only on three parameters in addition to the parameters of the Michaelis-Menten curve that characterizes average enzyme turnover rate in a very broad class of enzyme models. Nevertheless, measurement of Poisson indicator or Fano factor for such renewal processes can discriminate reactions with multiple intermediate steps as well as provide valuable information about the internal kinetic rates.

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MS47

Computation of the Koopman Eigenfunctions Is a Systematic Method for Global Stability Analysis

The Koopman operator framework provides a novel approach to global stability analysis of dynamical systems, which can be seen as an extension of classic stablility analysis of linear systems. We show that the existence of specific eigenfunctions of the operator is a necessary and sufficient condition for global stability of the attractor. Moreover, the computation of the eigenfunctions in a polynomial basis yields systematic methods for stability analysis and estimation of the basin of attraction.

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MS47

Koopman Mode Expansion in Theory and Practice

We discuss current theory and practice of applications of Koopman operator methods in dynamical systems and its relationship with computational methods. The approach has recently been extended to associate geometrical objects such as isochrons and isostables with level sets of Koopman eigenfunctions. We will also discuss the relationship between numerical methods such as Dynamic Mode Decomposition and Koopman Mode Decomposition, and extensions of theory to stability of nonlinear systems and control.

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MS47

Generalized Laplace Analysis and Spaces of Observables for the Koopman Operator

We extend Koopman spectral analysis to spectral operators of scalar type having non-unimodular spectrum and give conditions on the spectrum so that spectral projections can be computed using Laplace averages. This naturally extends the theory existing for dynamical systems restricted to an attractor, where spectral projections are computed using Fourier averages, to dissipative systems. For dynamical systems with dissipation, we construct a natural space of observables for which the associated Koopman operator is spectral.

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MS47

What Can the Koopman Operator Do for Dynamical Systems?

We report on "Operator Theoretic Aspects of Ergodic Theory" as developed in the new monograph with the same name (Springer 2015, coauthored by Tanja Eisner, Balint Farkas, Markus Haase and R.N.) and their applications to nonlinear dynamical systems.

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MS48

An Observational Basis for Sudden Stratospheric Warmings As Bifurcations in Planetary Wave Amplitude

Sudden stratospheric warmings (SSWs) are midwinter events in which the polar cap temperature and circulation undergo large and abrupt changes. Currently two competing theories contend to explain the explosive stratospheric wave amplitude growth that triggers a SSW: anomalously large planetary wave forcing, or nonlinear resonance. In this work we utilize 35 years of atmospheric data to show that SSWs are most likely triggered by a wave amplitude bifurcation due to nonlinear resonance.

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MS48

Tropical-Extratropical Wave Interactions in the Atmosphere

The coupling between moist convective processes and large-scale circulation is at the core of tropical-extratropical atmospheric interactions. Observational evidence of this type of phenomena will be presented and a reduced model will be proposed to understand the physical processes underlying this type of multi-scale interactions. In particular, the model will be used to interpret the relative roles of tropical versus extratropical wave sources of moist convection modulations at low latitudes.

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MS48

The Use of Green Functions of the Shallow Water Model for Understanding Climate Anomalies

Climate anomalies are frequently connected the intensity and positioning of anomalous tropical heat sources. Green Functions of simplified atmospheric models constitute a simple tool for identifying the origin of major climate anomalies. Examples will be shown for the 2014 climate anomalies such as the North American extreme cold period, the flooding in western Europe and the warm conditions in eastern Europe, and the extreme drought in Southeastern South America that caused severe water shortage.

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MS48

The Role of Noise in Bifurcations in Fluids and the Atmosphere

Triggering the strongest disturbances to the wintertime stratospheric polar vortex sudden stratospheric warming (SSWs) is to first order governed by the strength of forcing due to planetary-scale atmospheric waves and the vortexs waveguide. Using a model of SSWs, stochastic Kida vortex equations, we show that the basin of attraction is not only more complex than previously believed, but can be significantly altered by additive noise. Resulting soft bifurcation caused by the random basin is the possible mechanism leading to a SSW.

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MS49

Dangerous Border Collision Bifurcation in Piecewise Smooth Maps

A dangerous bifurcation has been defined as a situation where a stable period-1 orbit occurs before and after the bifurcation, and yet the basin of attraction shrinks to zero size at the bifurcation point. It is known that this phenomenon can occur is non-smooth systems. In this paper we generalize the definition to one in which any attracting orbit may exist before and after the bifurcation, and their basins of attraction shrink to zero size at the bifurcation point, resulting in divergence of orbits starting from all initial conditions. Using the normal form of a 2D piecewise smooth map, we develop the conditions and show the parameter space regions where this phenomenon occurs.

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MS49

Generalized Hopf Bifurcation in a Nonsmooth Climte Model

Low dimensional ocean circulation box models have been used by many scientists to model large scale behavior in ocean dynamics. The convection box model we will discuss in this talk exhibits oscillitory behavior, and so was influential to the field at its time of publication. The model depends on abrupt transitions between two different mixing states, and has a natural nonsmooth limit. In this talk we discuss the Hopf bifurcation in the smooth model, and its continuation to the nonsmooth limit. We will also discuss general forms for this type of nonsmooth Hopf bifurcation.

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MS49

Canard Phenomena in Nonsmooth Systems

This presentation will present new results on canard phenomena in planar nonsmooth systems. Canard explosion in piecewise-smooth, continuous, planar systems will be discussed, including the super-explosion phenomenon. Additionally, the talk will touch on canard trajectories in discontinuous systems. It will be shown that it is possible for a discontinuous system to undergo a canard explosion, where part of the stable canard cycle is a Filippov sliding solution.

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MS50

Intrinsic Mechanisms for Pattern Generation in Three-Node Networks

Bursting patterns can be qualified and modeled using low-dimensional models. We show that, depending on intrinsic mechanisms of release, escape, and post-inhibitory rebound, reciprocally inhibitory Fitzhugh-Nagumo type networks can produce a range of phase-locked states such as anti-phase bursting, propagating waves, and peristaltic patterns with recurrently phase-varying lags. Phase-lag return maps identify phase states with rhythm switching and attractor robustness revealed using external inhibition.

Our qualification promotes the use of simplified modeling for CPG circuitries.

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MS50

From Andronov-Hopf to Z_3 Heteroclinic Bifurcations in Cpgs

We study the formation of some rhythmic states in various 3-cell network motifs of a multifunctional central pattern generator (CPG) via several computational tools. The study is complemented with a detailed analysis of a single leech heart neuron, including bifurcations, spike-counting techniques and Lyapunov exponents, that gives a "roadmap" for the basic neuron. We locate a complete route of Andronov-Hopf and heteroclynic cycle connections in the 3-cell leech heart neurons and we illustrate the use of advanced GPU computing technologies and suitable numerical algorithms.

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MS50

Key Bifurcations of Bursting Polyrhythms in 3-Cell Central Pattern Generators

We identify and describe the key qualitative rhythmic states in various 3-cell network motifs of a multifunctional central pattern generator (CPG). Such CPGs are neural microcircuits of cells whose synergetic interactions produce multiple states with distinct phase-locked patterns of bursting activity. To study biologically plausible CPG models, we develop a suite of computational tools that reduce the problem of stability and existence of rhythmic patterns in networks to the bifurcation analysis of fixed points and invariant curves of a Poincare return maps for phase lags between cells. We explore different functional possibilities for motifs involving symmetry breaking and heterogeneity. This is achieved by varying coupling properties of the synapses between the cells and studying the qualitative changes in the structure of the corresponding return maps. Our findings provide a systematic basis for understanding plausible biophysical mechanisms for the regulation of rhythmic patterns generated by various CPGs in the context of motor control such as gait-switching in locomotion. Our analysis does not require knowledge of the equations modeling the system and provides a powerful qualitative approach to studying detailed models of rhythmic behavior. Thus, our approach is applicable to a wide range of biological phenomena beyond motor control.

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MS51

Impact of Single-Neuron Dynamics on Transfer of Correlations from Common Input

One source of spike train correlations in the nervous system is common input, a consequence of the ubiquity of coding by populations. The details of how input correlations map onto output spike correlations is surprisingly complex, depending on single-neuron dynamics in subtle ways. Much progress has been made in untangling this relationship in Type I and Type II excitable neurons, in both simplified phase oscillator and conductance-based models. In this talk, we apply these techniques to novel patterns of excitability that arise in the presence of calcium currents.

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MS51
Integrate-and-Fire Model of Insect Olfaction

When a locust detects an odor, the stimulus triggers a series of synchronous oscillations of the neurons in the antennal lobe, followed by slow dynamical modulation of the firing rates. I model this behavior using an Integrate-and-Fire neuronal network with excitatory and inhibitory neurons, each with a fast and slow inhibitory conductance response. I derived a coarse-grained model for each (excitatory and inhibitory) neuronal population, which allows for more detailed analysis of the olfaction mechanisms.

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MS51
A Network of Excitatory and Inhibitory Neurons with Gap Junctions

Brain networks are known to give rise to global oscillations that are linked to synchronized neuronal activity. How these oscillations arise is not yet completely understood. Researchers believe that electric coupling through sites called gap junctions may facilitate their emergence, and determine some of their properties. Following data from experimental papers, we construct a detailed model with synaptic and electric coupling for excitatory and inhibitory neurons using a modified version of the Hodgkin Huxley equations.

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MS51
Phase Delayed Inhibition and the Representation of Whisker Deflection Velocity in the Rodent Barrel Cortex

The primary sensory feature represented within the rodent barrel cortex is the velocity with which a whisker has been deflected. Whisker deflection velocity is encoded within the thalamus via population synchrony (higher deflection velocities entail greater thalamic synchrony). Thalamic (TC) cells project to regular spiking (RS) cells within the barrel cortex, as well as to inhibitory cortical fast-spiking (FS) neurons, which in turn project to RS cells. Thus, TC spikes result in EPSPs followed, with a small time lag, by IPSPs within an RS cell; i.e., the RS cell decodes TC population synchrony by employing a phase-delayed inhibition synchrony detection scheme. In this work, we construct a biophysical model of a basic 'building block' of barrel cortex (the feedforward circuit consisting of TC cells, FS cells, and a single RS cell) and we examine the role of the purely feedforward circuit, and of the phase-delayed inhibition network architecture, in explaining the experimental data.

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MS52
Extending the Zero Derivative Principle

The Zero Derivative Principle determines an approximate invariant manifold in a singular perturbation systems of ODEs by repeated differentiation of the slow components of the vector field. We show that even if the slow components are not identified correctly, an approximate invariant manifold still results from the algorithm, a most useful feature for systems with no explicit time scale separation. We show results for the Templator, a simple model for a self-replicating biological system.

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MS52
Idealized Models for Vortex Shedding and Fluid-Body Interactions

The dynamics of free solid bodies in fluids can be influenced significantly by vortex shedding. Although this phenomenon depends fundamentally on fluid viscosity, reduced-order models for vortex shedding can be realized in some cases by imposing velocity constraints on systems involving inviscid fluids. Models obtained in this way can be framed naturally in the context of geometric mechanics and can simplify problems of analysis and control design pertaining to the locomotion of biologically inspired aquatic robots.

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MS52

Visualization of Reduced Granular Dynamics

Reduced dynamical models often lend themselves to straightforward plots of the correspond dynamics. Yet, the intricate geometry and topology of the resulting phase portrait can prove challenging to convey in a picture. In this talk, some recent and ongoing work on the visualization of low-dimensional dynamical systems will be discussed. In particular, results obtained for a reduced model of granular dynamics will be considered. Joint work with D. Blackmore and A. Rosato.

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MS52

A Novel Semidiscete Scheme for a Reduced Continuum Flow Model

We focus on numerical methods for solving the BSR equations - a reduced dynamical model for granular and other flows. Using a reliable numerical scheme for the BSR model, we study the dynamics of a vertically tapped column of particles. A novel semi-discrete numerical scheme has been derived to demonstrate the value of BSR models for predicting the evolution of granular and other flows. Simulation results are compared with experiments and DEM results.

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MS53

Initiation of Rain and Inertial Particles

Abstract not available.

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MS53

Aggregate Growth in Optimizing Steel Production

Abstract not available.

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MS53

Ostwald Ripening and Nanoparticle Growth

Abstract not available.

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MS53

Episodic Precipitaton

Abstract not available.

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MS54

Model Free Tuning of Wind Farms for Maximizing Power Production

In this minisymposium, we introduce our recent result on the model-free approach for maximizing power production of wind farms. In particular, by exploiting the special structure of the wind farm about turbines location and wind direction, we show our multi-resolution SPSA based method that can achieve fast model-free controller tuning. Simulation results illustrate that the proposed method yields the maximum total power production with faster convergence compared with other existing model-free methods.

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MS54

Basin Stability for Evaluating Large Perturbations in Power Grids

The human brain, power grids etc. are all characterized by multistability. We claim that the traditional linearization-based approach to stability is often too local to adequately assess how stable a state is. Instead, we quantify it in terms of basin stability, a new measure related to the volume of the basin of attraction which is non-local and easily applicable, even to high-dimensional systems and apply it to the Northern European power system.

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MS54

Predicting Critical Links in Complex Supply Networks

Link failures repeatedly induce large-scale outages in power grids and other complex supply networks. Yet, which links are particularly sensitive to inducing such outages is still not fully understood. Here we propose two criteria to predict critical links on the basis of the topology of the undamaged network and its load distribution *prior to* link failure. These criteria outperform critical link prediction based on pure loads or flows more than six-fold.

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MS55

Compressive Sensing and Dynamic Mode Decomposition

This work explores compression and compressive sensing strategies for computing the dynamic mode decomposition (DMD) from heavily subsampled or output-projected data. We demonstrate this architecture on three model systems. First, we construct a spatial signal from a sparse vector of Fourier coefficients driven by a linear dynamical system. Next, we consider the double gyre flow field, which is a model for chaotic mixing in the ocean. Finally, we explore the 2D cylinder at Re=100.

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MS55

Improving the Accuracy of Dynamic Mode Decomposition in the Presence of Noise

The usefulness of dynamic mode decomposition (DMD) relies on its ability to extract accurate dynamic features from imperfect, noisy data. By deriving the statistical properties of the DMD algorithm, we demonstrate that sensor noise biases the results of DMD in a predictable manner. We introduce a number of modifications to the DMD algorithm that give improved robustness to noisy data, which are validated on a range of synthetic, numerical and experimental data sets.

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MS55

Parallel Qr Algorithm for Data-Driven Decompositions, in Particular Dynamic Mode Decomposition

Many fluid flows of engineering applications, although very complex in appearance, can be approximated by lower-order models governed by a few modes, able to capture the dominant behavior (dynamics) of the system. Recently, different techniques have been developed, designed to extract the most dominant coherent structures from the flow. Some of the more general techniques are based on data-driven decompositions, most of which rely on performing a singular value decomposition (SVD) on a formulated snapshot matrix. As the number of degrees of freedom of a simulation increases, the resulting data-matrix becomes longer, otherwise referred to as a tall-and-skinny (TS) matrix. Ultimately, the SVD of a TS data-matrix can no longer be handled on a single processor. To overcome this limitation, the present study employs the parallel TSQR algorithm of Demmel *et al.* (2012), which is further used as a basis of the underlying parallel SVD. This algorithm is shown to scale well on machines with a large number of processors and, therefore, allows the decomposition of very large data-sets.

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MS55

Using Dynamic Mode Decomposition to Extract Linear Global Modes from Nonlinear Fluid Flow Solvers

We present a dynamic mode decomposition (DMD) based technique to capture the dominant linear global modes and eigenvalues using snapshots from a nonlinear flow solver. This approach relies on tracking the growth of perturbation from the base state with a nonlinear solver. The guidelines for the DMD-based analysis to predict stability properties of the flow are discussed. Validations are performed against the global stability analysis based on the linearized flow solver and full eigenvalue problem.

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MS56

Morse Homology on Spaces of Braids

A Morse Homological theory is constructed on spaces of braids, allowing us to consider simultaneously distinct periodic solutions of gradient-like scalar ODEs of the form

$$u_s = u_{tt} - u + V(t, u, u_t)$$

with possibly different periods simultaneously. This gives information on existence of certain solutions but also makes it possible to do computation on Floer Homology by linking the (very) infinite dimensional Floer Homology and the finite dimensional Conley Index of a discretised dynamical system.

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MS56

Computing Conley-Morse Databases

Abstract not available.

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MS56

Rigorous Computing in Strongly Indefinite Problems

Floer homology was originally developed in the late 80s by A. Floer to solve the Arnold Conjecture which states that the number of periodic solutions of a periodic Hamiltonian system is bounded from below by the topological invariants of the manifold on which the Hamiltonian system is defined. In this setting the periodic orbits are the solutions of the Euler-Lagrange equations, i.e. critical points of a strongly indefinite action functional. Being an infinite dimensional version of Morse theory, Floer homology is defined in terms of (1) the critical points; (2) their relative indices; and (3) the connecting orbits between critical points with relative index one. While Floer homology is a powerful and celebrated theory, there remains an outstanding issue: how computable is it? Recent years have witnessed the development of exciting rigorous computational methods to make Conley-Morse homology computable and applicable to a broad class of dynamical systems. Now the question is: can we do the same with Floer-Morse homology? In this talk, we introduce some preliminary results about rigorous computing in Floer homology, i.e. we present a rigorous computational technique to compute critical points of strongly indefinite functional as well as their relative indices.

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MS56

Reconstructing Functions from Dense Samples

Abstract not available.

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MS57

Global Invariant Manifolds Unravelling Shilnikov Chaos

We analyse the role of two-dimensional global invariant manifolds in the transition through a chaotic Shilnikov homoclinic bifurcation in a 3D model for an optically injected laser. We compute the respective two-dimensional global manifolds, and their intersection curves with a suitable sphere, as families of orbit segments with a two-point boundary-value-problem setup. This allows us to determine how the arrangement of global manifolds changes through the bifurcation and how this influences the topological organisation of phase space. In this way, we find that the stable manifold of the associated saddle-focus is an accessible set of the stable manifold of a chaotic saddle (the Shilnikov chaotic set) that contains countably many periodic orbits of saddle type. In intersection with a suitably chosen sphere we find that this stable manifold is an indecomposable continuum consisting of infinitely many closed curves that are locally a Cantor bundle of arcs.

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MS57

The Lorenz System Near the Loss of the Foliation Condition

We consider the onset of hooks in the Poincaré return map of the famous Lorenz system, when the one-dimensional Lorenz map ceases to accurately represent the dynamics. We employ a two-point boundary value problem set-up to calculate a point of tangency of the two-dimensional unstable manifold $W^u(\Gamma)$ of a periodic orbit Γ with the stable foliation. This allows us to continue this boundary curve in any of the system parameters.

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MS57

Analytic Proof of Lorenz Attractors in Flows and Maps

In this talk I will give an overview of the recent results regarding the theoretical proof of the birth of strange Lorenz attractors in various models. This includes the criteria of the birth of Lorenz attractors from global bifurcations of flows (double homoclinic loop), which were also applied to prove analytically (without a computer assistance) that such an attractor is present in the Lorenz model (the 14th Smale's problem). This result allows to obtain conditions of the birth of Lorenz attractors in local bifurcations of flows as well as local and global bifurcations of diffeomorphisms.

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MS57

The Many Facets of Chaos

There are many ways that a person can encounter chaos, such as through a time series from a lab experiment, a basin of attraction with fractal boundaries, a map with a crossing of stable and unstable manifolds, a fractal attractor, or in a system for which uncertainty doubles after some time period. These encounters appear so diverse, but the chaos is the same in all of the underlying systems; it is just observed in different ways. We describe these different types of chaos. We will give two conjectures about the types of dynamical behavior that is observable if one randomly picks out a dynamical system without searching for a specific property. In particular, we conjecture that from picking a system at random, one observes (1) only three types of basic invariant sets: periodic orbits, quasiperiodic orbits, and chaotic sets; and (2) that all the definitions of chaos are in agreement.

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MS58

The Quantification of the Nonergodic Property Via Snapshot Attractors: An Application to a Conceptual Climate Model

The natural measure of a snapshot attractor can be approximated only with the use of an ensemble of trajectories. We quantitatively describe the limitations for extracting estimates on the relevant probabilities from the time evolution of a single trajectory. For instance, temporal averages over finite time intervals taken along a single trajectory are found to typically differ from the corresponding ensemble averages. This can be regarded as a measure of the nonergodic property. In addition, we introduce further, probabilistic measures for nonergodicity. We show that even in stationary systems ergodic behavior sets in for asymtotically long times, no characteristic time exists for the convergence. Ergodicity is typically broken down even for asymtotically long times in nonautonomous systems with a permanent shift of their parameters. We illustrate via a conceptual climate model that this nonergodic snapshot framework might be useful in Earth System dynamics.

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MS58

Random Attractors and How They Help Understand Climate Change and Variability

Until recently, there were two basic approaches to apprehend the complexity of climate change: deterministically nonlinear and stochastically linear, or the Lorenz and the Hasselmann approach. The theory of random dynamical systems provides a framework for unifying these two approaches. We apply this theory to study the random attractors of nonlinear, stochastically perturbed climate models, and define climate sensitivity via Wasserstein distances between such attractors. Numerical results are presented for a highly simplified ENSO model.

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MS58

Snapshot Attractors and the Transition to Extensive Chaos in Large Systems of Mean-Field Coupled Oscillators

We consider systems of many (N) mean-field coupled oscillators with two types of dynamics: low dimensional attractors (in which the oscillator states all clump into just a few values), and extensively chaotic states (in which the attractor dimension scales linearly with N). We use the concept of snapshot attractors to analyze extensively chaotic states focusing on the associated fractal dimension. We also study dynamical transitions from low dimensional attractors to extensive chaos and vice verse.

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MS58

SRB Measures for Time-Dependent and Random

Attractors

For autonomous systems of ODEs with chaotic attractors, large-time orbit distributions are described by SRB measures. This theory carries over very well to random dynamical systems, for which the picture is in fact simpler due to the averaging effects of random noise. Some of the ideas extend even to time-dependent attractors without any notion of stationary. I will review known ideas and report on new results.

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MS59

Chimeras in Networks of Identically Coupled Mechanical Oscillators

Synchronization has been vastly observed in nature as well as in man-made systems. Synchronous states are possible when two or more oscillators are interacting with each other. In particular, arrays of identical oscillators can exhibit a fascinating spatiotemporal pattern, termed chimera state, in which synchronous domains coexist with incoherent ones. Previous studies have addressed this phenomenon theoretically and experimentally. However, the spontaneous emergence of chimeras in translationally invariant networks remains an experimental challenge. Here, we use a one-dimensional network of identically coupled identical mechanical oscillators, to implement an experimental demonstration yielding this unique phenomenon. Our findings, supported by a mathematical model, bring new insights into the search for chimeras in nature.

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MS59

Synchronization Properties Related to Neighborhood Similarity in a Complex Network of Non-Identical Oscillators

We explore in this article complex networks of non-identical interacting oscillators. More specif- ically, the impact of Similar or Dissimilar neighborhoods over the emergence of synchronization is studied. These scenarios are defined based on a vertex weighted graph measure, the Total Dissonance, which comprises the sum of the dissonances between all neighbor oscillators in the network. Our numerical simulations show that the more homogeneous is a network, the higher tend to be both the coupling strength required to phase-lock and the associated final phase configuration spread over the circle. On the other hand, the initial spread of partial synchronization occurs faster for Similar neighborhoods in comparison to Dissimilar ones.

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MS59

Chimera States in Networks with Symmetry-Breaking Coupling

In a network of Stuart-Landau oscillators with nonlocal topology and symmetry-breaking coupling we establish novel partially coherent inhomogeneous spatial patterns, which combine the features of chimera states (coexisting incongruous coherent and incoherent domains) and oscillation death (oscillation suppression), which we call chimera death. Moreover, we find chimera states with respect to amplitude dynamics rather than the phase (amplitude chimeras). Additionally, we show that two distinct scenarios from oscillatory behavior to a stationary state regime are possible: a transition from an amplitude chimera to chimera death via in-phase synchronized oscillations, and a direct abrupt transition for larger coupling strength. We believe our results are of particular importance for the life sciences. For instance, these peculiar hybrid states may account for the observation of partial synchrony in neural activity, like unihemispheric sleep etc. A. Zakharova, M. Kapeller, E. Schöll, Chimera Death: Symmetry Breaking in Dynamical Networks, Phys. Rev. Lett. 112, 154101 (2014)

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MS59

Dynamics of Clustering in Networks with Repulsive Interaction

In dynamics of simple coupled systems attracting interaction usually leads to synchronization. In contrast, repulsive interaction is able to split the ensemble into clusters, to create multistability and, as we will show, in certain cases even generate continuous families of oscillatory states.

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MS60

Dynamic Mode Decomposition for Multi-

Resolution Analysis

The dynamic mode decomposition (DMD) is an ideal method for decomposing complex systems into spatio-temporal modes with prescribed temporal signatures. The frequency and duration of the data collection process can be adapted, much as in wavelet theory, to sift out information at different temporal scales. Indeed, an iterative refinement of progressively shorter snapshot sampling windows and recursive extraction of DMD modes from slow-to increasingly-fast time scales allows for a multi-resolution DMD analysis that allows for improved analytics. Moreover, it also allows for improved analytic predictions of the short-time future state of the system which is of critical importance for control protocols.

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MS60

Approximating the Koopman Operator Using Extended Dynamic Mode Decomposition

It has recently been observed that eigenvalues and modes of the Koopman operator may be approximated using a data-driven algorithm called Dynamic Mode Decomposition (DMD). We first provide a new definition of DMD that is equivalent to the original, but is more amenable to analysis. We then describe an Extended DMD method which approximates the Koopman operator directly, using a user-specified set of basis functions, and allows one to compute Koopman eigenvalues, modes, and eigenfunctions.

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MS60

Koopman Operator Techniques in Power Grid Analysis

Spectral properties of the so-called Koopman operator provide an alternative framework for dynamical systems analysis. This enables a new technique of nonlinear modal decomposition, which is referred to as the Koopman Mode Decomposition (KMD). In this presentation, we will outline our recent efforts on applications of KMD to analysis of power grid dynamic performances such as stability analysis and network partitioning. This will lead to a data-driven framework of analysis and operation of the future power grid that can handle high penetration of renewable energy resources.

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MS60

Machine Learning and the Koopman Operator: Algorithms and Applications

We present two extensions of Extended Dynamic Mode Decomposition (EDMD), which is a data-driven method that approximates the eigenvalues, eigenfunctions, and modes of the Koopman operator. The first is algorithmic: we show that EDMD can be rewritten as a kernel method, which enables Koopman-based computation in large systems to be performed. The second is an application: the Koopman eigenfunctions are used as a set of intrinsic coordinates that enable data-fusion/state-reconstruction tasks to be accomplished.

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MS61

What Is the Right Functional for Variational Data Assimilation?

Variational data assimilation refers to matching model trajectories with observations. This is usually accomplished by minimising a quadratic error functional which, in discrete time with gaussian perturbations, can be interpreted as the likelihood of a trajectory. Different ways to solve this problem though can lead to different solutions in the limit of $\Delta t \to 0$. This corresponds to the fact that in continuous time, there are several contenders for the likelihood of a trajectory.

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MS61

Time Delay Methods for Variational Data Assimilation

We investigate an extension to variational data assimilation by modifying the minimized cost function. A penalty to the cost function is added if the state vector at a given time is inconsistent with the measurements at a later time. The idea is to inform the choice of unmeasured state variables by looking at how they affect the observed dynamics over a window of time, rather than comparing the optimum path only at adjacent times.

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MS61

Filtering Unstable Quadratic Dissipative Systems

The long-time behavior of filters for partially observed quadratic dissipative dynamical systems is considered. It is proven that for both discrete-time and continuous-time observations the 3DVAR filter can recover the signal within a neighborhood defined by the size of the observational noise, as long as a sufficiently large proportion of the state vector is observed; an explicit form for a sufficient constant observation operator is given. Three models of interest fit into this class – Lorenz '63, Lorenz '96, and 2D Navier-Stokes on a torus. Furthermore, in the case of Lorenz '96, non-constant adaptive observation operators are studied numerically, with data incorporated by use of both the

3DVAR and the extended Kalman filter. It is shown that for carefully chosen adaptive observations, the proportion of state coordinates necessary to accurately track the signal is significantly smaller than the proportion proved to be sufficient for constant observation operator. Indeed it is shown that the necessary number of observations may even be significantly smaller than the total number of positive Lyapunov exponents of the underlying system.

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MS61

Observability of Chaotic Lorenz-96 Systems

In 1996 E. Lorenz proposed a ring of one-dimensional ODEs for describing some meteorological quantity at equidistant locations along a latitude circle. Since then this systems became a frequently used hyperchaotic model for exploring new concepts in dynamical systems theory. In our contribution we shall use it as a prototypical example for illustrating, testing, and comparing methods for observability analysis, and state and parameter estimation.

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MS62

Control of Complex Diffusion in Networks of NEMS

Recent advances in NEMS enable us to explore nonlinear phenomena on networks in unprecedented ways. We apply methods from control of complex diffusion to the oscillators' complex envelopes as coupled via a linear diffusion term. We focus on network synchronization and our ability to guide the system to synchronized states by controlling a small number of oscillators' natural linear frequencies. Additionally, we investigate control of other limit cycles in small systems with simple network structure.

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MS62

Intrinsic Computation in NEMS

The ways in which nanoscale systems generate, store, and process information and dissipate energy yield insights into their behavior, potential technological functions, and fundamental physics of computation. Nanoelectromechanical systems (NEMS) are nonlinear and subject to thermal fluctuations, making them an ideal experimental platform to probe the trade-offs between intrinsic computation and energy use. I will present results quantifying intrinsic computation in the dynamics of the theoretical counterpart of many NEMS devices, the noisy Duffing oscillator.

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MS62

Phase Synchronization Between Nanoelectromechanical Oscillators

Synchronization, the mutual entrainment of limit cycle oscillators, is a ubiquitous phenomenon both in the physical and biological sciences. There exist many observation studies of this phenomenon; however, controlled experiments in this field are scant. In this talk, I will describe an experiment in synchronization based on NanoElectroMechanical (NEMS) oscillators. In addition to the ability to measure the amplitude and phase dynamics of individual nodes, the experiment demonstrates a large degree of control over the parameters of the system. Both the coherent and stochastic dynamics will be discussed.

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MS63

Ensemble Inflation by Shadowing Techniques

The artificial inflation of ensembles is a technique common to ensemble data assimilation whereby the ensemble variance is increased in order to prevent deviation of the ensemble from the truth. Various techniques for inflating ensembles exist in the literature. This talk will discuss ensemble shadowing and our implementation of shadowing techniques as a method of ensemble inflation. We will also present results from a low order chaotic system that support using shadowing inflation.

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MS63

Ionospheric Weather Forecasting Using the Letkf Scheme

We assimilate satellite observations to forecast ionospheric electron density using the Local Ensemble Transform Kalman Filter(LETKF). This assimilation scheme generates forecasts from an ensemble of initial conditions and forms its analysis by computing a unique linear combination of the forecast ensembles at each grid point using nearby observations. The ionosphere model used is the TIEGCM. Assessments of the LETKF include validation against independent data sources as well as skill in estimating ionospheric drivers, forecast ensemble uncertainty, and spatially sharp electron density gradients.

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MS63

Predicting Flow Reversals in a Cfd Simulated Thermosyphon Using Data Assimilation

A thermal convection loop is a circular chamber filled with water, heated on the bottom half and cooled on the top half. With sufficiently large forcing of heat, the direction of fluid flow in the loop oscillates chaotically, forming an analog to the Earths weather. As is the case for state-of-the-art weather models, we only observe the statistics over a small region of state space, making prediction difficult. To overcome this challenge, data as- similation methods, and specifically ensemble methods, use the computational model itself to estimate the uncertainty of the model to optimally combine these observations into an initial condition for predicting the future state. First, we build and verify four distinct DA methods. Then, a computational fluid dynamics simulation of the loop and a reduced order model are both used by these DA methods to predict flow reversals. The results contribute to a testbed for algorithm development.

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MS63

An Application of Lagrangian Data Assimilation to Katama Bay, Ma

Lagrangian data assimilation (LaDA) methods directly use observations of passive drifters in a flow in order to estimate the underlying currents. We apply the ensemble Kalman filter in this context to a model of Katama Bay in Martha's Vineyard, using real drifter observations. We compare the augmented-vector method of LaDA to so-called pseudo-Lagrangian methods. Finally, we judge the method‘s performance using Eulerian data of the bay from the same time.

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MS64

A Mechanism of Spiral Wave Unpinning and Its Implications for the Treatment of Cardiac Arrhythmias with Periodic Far-Field Pacing

Spiral waves pinned to inexcitable regions of tissue pose a particular challenge in the effort to control cardiac arrhythmias without a strong defibrillating electrical shock. We investigate one particular unpinning mechanism due to far-field pulses in a two-dimensional model of excitable media and determine its potential benefits over alternative low-energy strategies such as anti-tachycardia pacing. Furthermore, we explore how a simple map-based model can predict success rates for more realistic scenarios involving periodic stimuli.

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MS64

The Effects of Cardiac Fibroblasts on Wave Propagation in Ventricular Tissue: Insights from Numerical Studies of Mathematical Models

We study spiral-wave turbulence in partial-differential-equation models for human cardiac tissue, with both myocytes and fibroblasts. We obtain results for cells, with one myocyte coupled to several fibroblasts, and for tissue. We study (a) regularly and (b) randomly arranged fibroblasts, systematize their role in modifying the cardiac action potential and the propagation of activation waves, and investigate a low-amplitude control scheme for the suppression of spiral-wave turbulence.

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MS64

How to Control Spiral Waves Using Weak Signals: A Few Suggestions

In this talk I will describe a few recently developed methods to control dynamics of spiral waves and spatiotemporal chaos in excitable media. Control is achieved by the application of small amplitude external signals in a fashion designed to exploit nonlinear properties of excitable systems. Payoffs for the experimental realisation of such robust methods to control spiral dynamics is enormous and could have several practical applications, potentially including a device for safe cardiac defibrillation.

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MS64

Controlling Spiral Wave Dynamics in Cardiac Monolayers Using Far Field Pulses

Waves in two-dimensional excitable media forms patterns such as target waves and spiral waves. Spiral waves tend to attach to the heterogeneities in the medium and form very stable structures. We study controlling such waves using far field electric pulses in two-dimensional layers of cultured cardiac cells. We will discuss resetting and terminating spiral waves using periodic far field pulses.

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MS65

Anatomy Induced Drift of Reentrant Waves in Human Atrium

In biophysically and anatomically realistic model of human atrium, we demonstrate functional effects of atrial anatomical structures on reentrant waves spontaneous drift. Spiral waves drift from thicker to thinner regions, along ridge-like structures of pectinate muscules (PM) and cristae terminalis, anchor to PM-atrial wall junctions or to some locations with no obvious anatomical features. The insight can be used to improve low-voltage defibrillation protocols, and predict atrial arrhythmia evolution given a patient specific atrial anatomy.

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MS65

Stabilized Wave Segments in An Excitable Medium with a Phase Wave at the Wave Back

We determine analytically the propagation velocity and the shape of stationary propagating wave segments in excitable media supporting excitation waves with trigger fronts and phase backs. Relationship between the medium excitability and the wave segment parameters is described using the free boundary approach. This leads to two universal limits, restricting the region of existence of stabilized wave segments. Comparison of the analytical results with numerical simulations of the Kessler-Levine model demonstrates their good quantitative agreement.

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MS65

Use of Delay-Differential Equations in Cardiac Models

Period-2 behavior of cardiac electrical responses, referred to as alternans, often leads to more complicated arrhythmias. To date, alternans has been generated mathematically from the loss of stability of the period-1 solution in coupled nonlinear ODE/PDE systems. We build on the fact that delays arise naturally in non-instantaneous cellular processes and present an alternative approach using delay-differential equations (DDEs), which are known to promote complex dynamics. We analyze the dynamical behaviors of our DDE system and discuss the implications of our findings.

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MS65

Spiral Wave Activity in a Mixture of Resting and Oscillating Cardiomyocytes: Limitations on Biopacemaker Development

Self-organization of interconnected elements is important for development of biopacemakers. Monolayers of pluripotent cell-derived cardiomyocytes exhibit spontaneous activation and consist of a heterogeneous network of cells. A simple stochastic model of cell distributions combined with a Fitzhugh-Nagumo type model highlights the importance of spatial granularity of spontaneous cells on biopacemaker activity. Interestingly, spiral wave activity and the desired simultaneous activation of the biopacemaker are found in

opposite spectrum of oscillating cell spatial patterns.

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MS66

Traveling Waves in a Laminar Neural Field Model of Visual Cortex

One of the challenges in the mathematical and computational modeling of primary visual cortex (V1) is developing recurrent networks models that keep track of neural activity with respect to both retinotopic and feature-based degrees of freedom such as orientation selectivity. This is further complicated by the fact that different cortical layers have different response properties. In this talk we present a laminar neural field model consisting of a superficial layer of orientation-selective cells interacting vertically with a deep layer of non-orientation selective cells. We use the model to analyze the propagation of orientation selectivity across cortex.

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MS66

A Computational Model of the Influence of Depolarization Block on Initiation of Seizure-like Activity

Seizure-like activity can be triggered in a network of excitatory and inhibitory neurons when excessive excitation is not suppressed by matching inhibition. Recent experimental studies report that inhibitory neurons, receiving strong excitatory drive, were functionally impaired due to depolarization block prior to propagation of ictal discharges. In this talk, we will discuss different types of dynamics emerging from a network of excitatory and inhibitory neurons when inhibitory neurons are prone to depolarization block. We find that the network may reach the pathological state via saddle-node bifurcation or homoclinic bifurcation. Oscillatory activity present in the network allows us to produce tonic to clonic phase transition observed in epileptic brain slices and human patients. We also discuss the effects of network motifs on promoting pathological dynamics. The convergent motifs from excitatory neurons onto inhibitory neurons, which may be observed in mossy fiber sprouting, facilitates depolarization block in inhibitory neurons so that the network can enter the pathological state more easily. The mean field equation accounting for the network structure allows us to make predictions about the effects of different type of network motifs. The predictions from the mean field model are verified by simulating a network of conductance-based neurons.

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MS66

Finite Size Effects in Networks of Theta Neurons

The dynamics of a large but finite number of coupled spiking neurons is not well understood. We analyze finite size effects in a network of synaptically coupled theta neurons. We show how the system can be characterized by a functional integral from which finite size effects are calculated perturbatively. We consider how finite size effects affect the stability of the asynchronous state of a uniformly coupled network. We then discuss the implications for bump attractors.

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MS66

Optimal Decision-Making in a Changing Environment

We derive a continuous stochastic differential equation describing the optimal accumulation of evidence in a changing environment. Our results apply to two choice decision making wherein the underlying truth switches stochastically. Sequential analysis is used to determine the prior probabilities of finding the truth in one of two states. Passing to the continuum limit and non-dimensionalizing, we find the evidence accumulation process depends on a single parameter, information received per mean switch time.

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MS67

Costs and Benefits of Mutational Robustness in Rna Viruses

The accumulation of mutations in RNA viruses is thought to facilitate rapid adaptation to changes in the environment. However, most mutations have deleterious effects, especially for viruses. Thus, tolerance to mutations should determine the nature and extent of genetic diversity in the population. I will present a combination of population genetics theory, computer simulation, and experimental evolution to examine the advantages and disadvantages of tolerance to mutations, also known as mutational robustness.

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MS67

Evolutionary Dynamics of Mutator Phenotypes in Changing Environments

Stochastic switching is an example of phenotypic bet-hedging, where offspring can express a phenotype different from that of their parents. Even though phenotypic switching is well documented in viruses, yeast, and bacteria, there has been little exploration of the evolution of these mutator phenotypes under spatially and temporally fluctuating selection pressures. In this talk, I will use a population genetic model to explore the interaction of temporal and spatial variation in determining the evolutionary dynamics of phenotypic switching. Although the formulation of the model is in terms of non-genetic switching, the same framework can be used to study the evolution of genetic mutation rates under volatility in selection. This study offers new insights into how the interplay of spatial and temporal environmental variability can influence the evolution of phenotypic switching rates, mutation rates, or other sources of phenotypic variation.

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MS67

The Acceleration of Evolutionary Spread by Long-Range Dispersal

The spreading of evolutionary novelties across populations is the central element of adaptation. Unless population are well-mixed (like bacteria in a shaken test tube), the spreading dynamics not only depends on fitness differences but also on the dispersal be- havior of the species. Spreading at a constant speed is gener- ally predicted when dispersal is sufficiently short-ranged, specifically when the dispersal kernel falls-off exponentially or faster. However, the case of long-range dispersal is unresolved: While it is clear that even rare long-range jumps can lead to a drastic speedup as air-trafficmediated epidemics show it has been difficult to quantify the ensuing stochastic dynamical pro- cess. Yet, such knowledge is indispensable for a predictive understanding of many spreading processes in natural populations. I present a simple iterative scaling approximation supported by simulations that accurately predicts evo- lutionary spread which is determined by a tradeoff between frequency and potential effectiveness of long-distance jumps. In contrast to the exponential laws predicted by deterministic mean- field approximations, we show that the asymptotic spatial growth is either according to a power-law or a stretched exponential, depending on the tails of the dispersal kernel. More importantly, we provide a full time-dependent description of the convergence to the asymptotic behavior which can be anomalously slow and is relevant even for long times. I will discuss to what extend our results might be used to improve the inference of the evolutionary spread based on genealogical trees, which is however a largely open problem.

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MS67

Thermodynamics and Statistical Mechanics of Viral Evolution

We analyze a simplified model of viral infection and evolution using the grand canonical ensemble and formalisms from statistical mechanics and thermodynamics to calculate the behavior of a macroscopic number of viruses, and to derive thermodynamic variables for the system. We model the infection process as a series of energy barriers determined by the genetic states of the virus and host as a function of immune response and system temperature. We find a phase transition between a positive temperature regime of normal replication and a negative temperature disordered phase of the virus. These phases define different regimes in which different genetic strategies are favored. Perhaps most importantly, it demonstrates that the system has a real thermodynamic temperature. For normal replication, this temperature is linearly related to effective temperature. For all temperatures and immunities studied, we find a universal curve relating the order parameter to viral evolvability. Real viruses have finite length RNA segments that encode for proteins which determine their fitness; hence the methods put forth here could be refined to apply to real biological systems; perhaps providing insight into immune escape, the emergence of novel pathogens and other results of viral evolution.

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MS68

Characterizing the Structure of Multilayer Networks

The development of Complex Network's Theory is providing radical new ways of understanding many different processes from physical, social, engineering, information and biological sciences. Several notions, such as networks of networks, multidimensional networks, multilevel networks, multiplex networks, interacting networks, interdependent networks, and many others have been introduced, and even different mathematical approaches, based on tensor representation have been proposed. In this talk we will discuss a general framework for multilayer networks that includes the great majority of the different approaches addressed so far in the literature and review some of attempts to extend the notions, measures and models from single layer to multilayer networks.

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MS68

Synchronization and the problem of Targeting in

Multilayer Networks

We concentrate on the case involving a two-layer master-slave network to steer a desired collective behavior, not necessarily synchronous. The problem is here tackled through a Master Stability Function approach, assessing the stability of the aimed dynamics, and through a selection of nodes to be targeted. We show that the degree of a node is a crucial element in this selection process, and that the targeting mechanism is most effective in heterogeneous scale-free architectures.

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MS68

Game and Diffusion Dynamics in Multilayer Networks

Besides the structure of interactions within networks, also the interactions between networks are of the outmost importance. We therefore study the outcome of the evolutionary games on multilayer networks that are connected by means of a utility function, which determines how payoffs on networks jointly influence the success of players in each individual network.. To reach this aim, we consider the symmetric, asymmetric utility function and find the symmetric breaking phenomenon and the spontaneous emergence of multilayer network reciprocity. Along this line, the role of partially correlation is investigated and the optimal condition for cooperation is found. Finally, we consider the co-evolution mechanisms of evolutionary games on multilayer networks and find that the optimal cooperation can be attributed to individual self-organization trait.

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MS68

Synchronization in Time Varying Networks: the Non Commutative Case

We provide a rigorous solution to the problem of constructing a structural evolution for a network of identical coupled dynamical units switching between topologies without structural constraints. Our method guarantees that the coupling matrices eigenvectors change smoothly in time. This allows to extend the Master Stability Function formalism, and to use it to assess the stability of a synchronized state when the network topology evolution is fully general, and not necessarily restricted to commuting structures.

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MS69

The Response of Statistical Averages to Small Stochastic Forcing

We present a response theory for statistical averages of deterministic dynamical systems perturbed by a small stochastic forcing. We derive the response formula explicitly in terms long-time averages of the tangent map of the unperturbed system, and show that the response is the second-order effect with respect to the magnitude of perturbation. We also demonstrate that for a finite response time the response is consistent with the prediction of the classical response theory for stochastic systems with smooth invariant distribution density perturbed by a small stochastic forcing.

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MS69

Is Our Sensing Compressed?

Considering many natural stimuli are sparse, can a sensory system evolve to take advantage of sparsity? We show significant downstream reductions in the numbers of neurons transmitting stimuli in early sensory pathways might be a consequence of sparsity. Our work points to a potential mechanism for transmitting stimuli related to compressed-sensing (CS) data acquisition. Through simulation, we examine the characteristics of networks that optimally encode sparsity and the role of receptive fields in stimulus sampling.

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MS69

A Multiscale Method for Optical Responses of Nano Structures

We introduce a new framework for the multiphysical modeling and multiscale compu- tation of nano-optical responses. The semi-classical theory treats the evolution of the electromagnetic field and the motion of the charged particles self-consistently by coupling Maxwell equations with Quantum Mechanics. To overcome the numerical challenge of solving high dimensional many body Schrödinger equations involved, we adopt the Time Dependent Current Density Functional Theory (TD-CDFT). In the regime of linear responses, this leads to a linear system of equations determining the electromagnetic field as well as current and electron densities simultaneously. A self-consistent multiscale method is proposed to deal with the well separated space scales. Numerical examples are presented to illustrate the resonant condition.

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MS69

Parareal Methods for Highly Oscillatory Dynamical Systems

We introduce a multiscale parareal method that efficiently numerically integrates highly oscillatory ordinary differential equations. The algorithm computes a low-cost approximation of all slow variables in the system. Then, fast phase-like variables are ob- tained using the parareal iterative methodology and an alignment algorithm. The method may be used either to enhance the accuracy and range of applicability of the multiscale method in approximating only the slow variables, or to resolve all the state variables. The numerical scheme does not require that the system is split into slow and fast coordinates. Moreover, the dynamics may involve hidden slow variables, for example, due to resonances. Convergence of the parareal iterations is proved and demonstrated in numerical examples.

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MS70

Invariant Manifolds of Multi Interior Spike States for the Cahn-Hilliard Equation

We construct invariant manifolds of interior multi-spike states for the nonlinear Cahn-Hilliard equation and then investigate the dynamics on it. An equation for the motion of the spikes is derived. It turns out that the dynamics of interior spikes has a global character and each spike interacts with all the others and with the boundary. Moreover, we show that the speed of the interior spikes is super slow, which indicates the long time existence of dynamical multi-spike solutions in both positive and negative time. This result is obtained through the application of a companion abstract result concerning the existence of truly invariant manifolds with boundary when one has only approximately invariant manifolds.

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MS70

Oscillatory Pulses in FitzHugh-Nagumo

It is well known that the FitzHugh-Nagumo system exhibits stable, spatially monotone traveling pulses. Also, there is numerical evidence for the existence of spatially oscillatory pulses, which would allow for the construction of multi-pulses. Here we show the existence of oscillatory pulses rigorously, using geometric blow-up techniques and singular perturbation theory.

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MS70

Slow-Fast Factorization of the Evans Function Via the Riccati Transformation in the Semi-Strong Regime

The complexity of singularly perturbed linear stability problems can be reduced by factorizing the Evans function in accordance with the scale separation. The factorization has always been established by geometric arguments, customized for the specific equations and solutions under consideration. We present an alternative method, that formalizes and generalizes the factorization procedure. This analytic method is based on the Riccati transformation. We employ our techniques to study the spectral stability of semi-localized periodic pulse patterns.

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MS70

Travelling Waves for Fully Discretized Bistable Reaction-Diffusion Problems

We study various temporal and spatial discretization methods for bistable reaction-diffusion problems. The main focus is on the functional differential operators that arise after linearizing around travelling waves in the spatially discrete problem and studying how the subsequent discretization of time affects the spectral properties of these operators. This represents a highly singular perturbation that we attempt to understand via a weak-limit method based on the pioneering work of Bates, Chen and Chmaj (2003). Once this perturbation is understood, one can study the existence and (non)-uniqueness of waves in the fully discretized reaction-diffusion system.

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MS71

Nonlocal Aggregation Models: A Primer of Swarm Equilibria

Biological aggregations (swarms) exhibit morphologies governed by social interactions and responses to environment. Starting from a particle model we derive a nonlocal PDE describing evolving population density. We study equilibria and their stability via the calculus of variations which yields analytical solutions. These solutions include features such as spatial localization with compact support, mass concentrations, and discontinuous density jumps that are also observed numerically. We apply our methods to a model of locust swarms.

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MS71

Fire Ants Build, Morph, and Repair to Survive Floods

Fire ants are model organisms for studying active self-healing materials. By linking their legs together, they build highly interconnected networks that can quickly rearrange themselves in response to applied stress. In this talk, we present experiments and modeling that elucidate their construction. Spherical rafts of ants morph into pancakes within minutes; towers are constructed to provide an equal compressive load on each ant. We also use plate-on-plate rheology to show ants modify their elastic and viscous moduli by rearrangement of their bodies. Particular consideration is given to showing how structural shape and material properties arise from movement and interactions between ants.

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MS71

Quantifying Collective Cell Migration During Cancer Progression

During cancer progression, tumor cells migrate throughout the body, forming clinically dangerous secondary tumors. This metastatic process begins when cells leave the primary tumor, either as individual cells or collectively migrating groups. Using quantitative image analysis techniques, we are able to extract motion information from time-lapse images of epithelial sheets with varying malignancy. Adapting metrics originally used to study fluid flows we characterize the dynamics of these cell lines and compare to collective dynamics models.

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MS71

Aggregate Behaviors of Heterogeneous, Delay-Coupled Agents

Emerging collective motions of swarms of interacting agents are a subject of great interest with a wide range of applications. We show, using mean-field analysis, how collective motion patterns and segregation of populations of agents with different dynamic properties emerge naturally in a model based on self-propulsion and attractive pairwise interactions between delay-coupled agents. We show persistence of behaviors with non-global coupling and reduced swarm populations, and verify these results through simulation and experiments.

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MS72

Clustering, Malleability and Synchronization of Hodgkin-Huxley-Type Neurons

In this work we consider a "network of network" of bursting neurons described by the Huber-Braun model. Each network is coupled internally in a small word scheme while each network is coupled to all other networks using the connectivity matrix of the cat cerebral cortex. Three dynamical behavior are analyzed: network clustering generation, characterized by the coherence of a group of network; malleability of the entire network face small changes in the intra coupling (internal to a network) and inter coupling (between networks) parameters; and the synchronization of the entire network. In particular we pay attention in the complex interplay between inter and intra coupling that makes the network to be very adaptive to small variations on the coupling parameters.

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MS72

Nontrivial Collective Dynamics in Networks of Pulse Coupled Oscillators

A wealth of complex phenomena arise in coupled phase oscillators – typically associated to various forms of synchronization – but the collective (macroscopic) dynamics itself is usually regular (either consisting in a fixed point or in a limit cycle for the macroscopic variables). This is somehow surprising, as the collective dynamics follows from the evolution of functional, i.e. infinite dimensional, equations. We discuss a few examples, where the collective motion is chaotic and possibly even high-dimensional. Disorder in the form of diversity among the oscillator frequencies (such as in the standard Kuramoto model) appears to be a basic ingredient, accompanied by the selection of suitable phase response curves. The possible extension to phase-oscillators setups will be also discussed.

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MS72

Synchronization in a Cortical Multilayered Computational Model: A Simulation Study

We performed a simulation study on the emergence of synchronous states in a cortical network model. The model consists of excitatory and inhibitory neurons arranged in four layers representing local cortical circuit. Neurons are described by Izhikevich model with parameters that reproduce firing behavior of different excitatory and inhibitory neuronal types. We studied versions of the model without synaptic plasticity and with synaptic plasticity modeled by an asymmetric spike-timing-dependent plasticity (STDP) rule. The version without synaptic plasticity displayed asynchronous irregular spontaneous activity while the version with STDP displayed synchronous activity with properties dependent on the neuronal types comprising the network.

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MS72

Effects of Reciprocal Inhibitory Coupling in Synchronous Neurons

The influences of chemical and electrical synapses are investigated here using Hodgkin-Huxley model neurons. We study the dynamics displayed by a pair of neurons coupled by either (*i*) only chemical inhibition or by (*ii*) electrical coupling first and then chemical inhibition. In both scenarios the neuron with the lower firing rate stops spiking for strong enough inhibition, while the faster neuron remains active. However, in scenario (*ii*) the originally slower neuron stops spiking earlier, suggesting that synchronization introduces an element of instability into the two-neuron network.

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MS73

Crossover Collisions of Scroll Waves

The interaction of a pair of scroll waves is studied in a chemical system by optical tomography. When the two locally counter-rotating filaments approach each other closer than radius of the spiral core, they may collide. These crossover collisions lead to a rupture and a subsequent reconnection of the filaments. Each reconnected filament consisted of parts that originated from both of the original filaments. The conditions for rupture and reconnection of filaments will be discussed.

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MS73

Role of Small Sized Heterogeneities in the Onset and Perpetuation of Arrhythmias

We investigate, in silico, the dynamics of rotors in 2D and in an anatomical model of human ventricles. We study the effect of small size ionic heterogeneities, similar to those measured experimentally. We show that they can anchor and also attract rotors rotating at a substantial distance from the heterogeneity. It depends on the extent of the heterogeneities and can be as large as 5-6 cm. We discuss possible mechanism of the observed phenomena.

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MS73

Effects of Substrate Geometry on Spiral Wave Chi-

rality

We introduced inexcitable obstacles into 1-cm-diameter cardiac monolayers, leading to the initiation of clockwise-rotating, counterclockwise-rotating, and pairs of spiral waves. Simulations demonstrated that the location of the obstacle and the side pacemaker frequency controlled spiral wave chirality. Instabilities observed in action potential duration restitution curves computed at different spatial locations predicted sites of propagation failure, and, thus, spiral wave chirality.

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MS73

Scroll Waves in Viscous Systems with Stokes Flow: Writing Filaments and Other New Tricks

Excitable and oscillatory reaction-diffusion systems can self-organize vortex states that rotate around one-dimensional phase singularities. We have studied the dynamics of these scroll waves and filaments in the Belousov-Zhabotinsky reaction with a particular emphasis on the interaction of filaments with internal heterogeneities and the system boundaries. For a highly viscous system, scroll waves can be pinned to moving glass rods and repositioned at will. If the glass rod extends only along a fraction of the filament, the free filament gets stretched out along the rod trajectory and the trailing end moves with a speed that depends on the local curvature. We also performed experiments on scroll wave drift along step-shaped height changes. Our experimental results are complemented by simulations of which some explicitly consider the Stokes flow generated by the slowly moving heterogeneities.

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MS74

Dynamics of Networks with Partially Symmetric Connectivity Matrices

According to the long-standing Hebbian hypothesis, external stimuli are stored in long-term memory thanks to modifications of synaptic connectivity in neural circuits that are activated by such stimuli. However, the details of synaptic 'learning rules', as well as the impact of synaptic plasticity on network dynamics, are still unclear. In this talk, I will describe two complementary directions whose goal is to improve our understanding of these questions. The first consists in investigating the effects of realistic 'learning rules' that have been used to fit in vitro data on network dynamics. The second consists in inferring synaptic 'learning rules' from the changes in neuronal activity upon repeated presentations of initially novel stimuli.

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MS74

Oscillations in Neuronal Networks

Neurons in the visual cortex exhibit heterogeneity in feature selectivity and the tendency to generate action potentials synchronously with other nearby neurons. Visual responses from cat visual cortex during gamma oscillations reveal a postive correlation between strength of oscillations, propensity towards synchronization, and sharpness of orientation tuning. We present a model that can account for the correlations between these three properties and could apply more generally to any brain region with analogous neuron types.

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MS74

On a Kinetic Fitzhugh-Nagumo Equation

We consider the dynamics of the electric activity of a neuron within a large network, described at a mesoscopic scale incorporating intrinsic stochastic dynamics and disordered interactions. We are concerned with showing (i) existence and linear stability of steady states, as well as (ii) nonlinear exponential stability in the weak connectivity regime. We illustrate these results analyzing the electrically coupled Fitzhugh-Nagumo kinetic equation.

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MS74

Assembling Collective Activity in Neural Circuits

Experimental breakthroughs are yielding an unprecedented view of the brain's connectivity and of its coherent dynamics. But how does the former lead to the latter? We use graphical and point process methods to reveal the contribution of successively more-complex network features to coherent spiking.

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MS75

Entropy, Dissipation and Information Processing in Models of Complex Systems

Recent advances in the study of (biological) complex systems have shown an intimate connection between dissipation and computation. Information theory provides a universal framework to formalize these notions. In this talk, I review complex systems as information-processing devices, which compute patterns at the expense of information written to hidden degrees of freedom. As an example, I review how such a picture yields a direct connection between the notions of dissipation used in the major modelling paradigms of complex systems: Markovian stochastic dynamics (stochastic thermodynamics, Monte-Carlo simulations) and thermostatted equations of motion (molecular dynamics simulations).

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MS75

Degrees of Information Processing in Chaotic Dynamical Systems

It is well known that chaotic dynamical systems generate information. This is typically captured by the Kolmogorov-Sinai entropy, the supremum of Shannon entropy rates over all possible partitions of the system. We have recently shown that this is a rather crude measure, and can in fact be dissected in to two pieces: a part that is remembered by being correlated with future behavior, and a part which is forgotten and plays no role in the temporal evolution of the system. Here, we show that although the entropy rate is invariant for both Markov and generating partitions of the system, its decomposition is not. We compare these values for the tent map, and comment on what this means for study of such chaotic systems as information generators or processors.

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MS75

Time-Dependent Chaotic Attractors Shape Information Content in Neural Networks

Large networks of sparsely coupled, excitatory and inhibitory cells occur throughout the brain. They are responsible for ongoing and complex computations, the exact mechanisms of which are poorly understood. Groups of connected neurons form very high-dimensional Dynamical Systems that are often responding to rich, temporally fluctuating signals from various afferents. For many models of these networks, a striking feature is that their dynamics are chaotic and thus, are sensitive to small perturbations. How does this chaos manifest in the neural code? Understanding how the dynamics of large driven networks shape their capacity to encode and process information presents a sizeable challenge. Inspired by this question, I will discuss the use of Random Dynamical Systems Theory as a framework to study information processing in high-dimensional, non-autonomous systems. Using a neural network model, I will present recent results linking random strange attractors to noise entropy and input discrimination of dynamical observables.

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MS75

Deconstructing Maxwells Demon

The thermodynamic role of information processing has become an active topic of research because of its relevance to a wide range of problems, from bacterial sensing and feedback control of microscopic systems to single-photon cooling of atoms. This is most dramatically captured in the gedanken experiment of Maxwells demon, where a neat-fingered intelligent being can violate the second law of thermodynamics by extracting work from a single heat source. With an exactly solvable model, we discuss a possible working mechanism of the demon. We draw a nonequilibrium phase diagram and show that, depending on the location on the diagram, the model can act either as an engine, converting into work the extracted heat from the single heat source, or as a Landauer eraser, erasing information and consuming external work in the process.

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MS76

Microfluidic Networks of Belousov-Zhabotinsky Drops

Several microfluidic based experimental systems of networks of non-linear chemical oscillators are presented. 2D planar arrays of oscillators with nearest neighbor coupling involving both inhibitory and excitatory species are developed. We explore phenomena such as synchronization, oscillator death and assess the number of attractors, as well as their basin of attraction, as a function of the topology of the network and the heterogeneity of the oscillators and their coupling strength.

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MS76

Synchronization and Network Topology of Electrochemical Micro-Oscillators in On-Chip Integrated Flow Cells

We present that oscillatory reactions taking place on electrode arrays in single or branched flow channels inherently form a network, whose characteristics can be tuned with the position of the electrodes. The network structure is decoded from experimental measurements and the structure is interpreted with a theory. The unusual, spatially dependent network topology induces a unique dynamical response in the form of a spatial gradient in the extent of synchronization with large set of electrodes.

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MS76

Synchronization in Networks of Coupled Chemical Oscillators

We have studied heterogeneous populations of chemical oscillators to characterize different types of synchronization behavior. The formation of phase clusters in stirred suspensions of Belousov-Zhabotinsky oscillators is described, where the (global) coupling occurs through the medium. We then describe the formation of phase clusters and chimera states in populations of photosensitive oscillators. The nonlocal coupling occurs via illumination intensity that is dependent on the state of each oscillator. The behavior of oscillators in ring configurations as a function of the number of oscillators is described, including traveling cluster states. References: A. F. Taylor et al., Angewandte Chemie Int. Ed. 50, 10161 (2011); M. R. Tinsley et al., Nature Physics 8, 662 (2012); S. Nkomo et al., Phys. Rev. Lett. 110, 244102 (2013).

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MS76

Long Transients to Synchronization in Random Networks of Electrochemical Oscillators

In sparse, connected, random networks of attractively coupled oscillators one can expect a range of dynamical equilibria, such as complete synchronization, phase synchronization, partial synchronization or incoherence [Toenjes et al., Chaos 20, 033108 (2010)]. Here we report on experiments studying the transitions to and from a regime of phase synchronized electrochemical oscillators forming complex wave patterns on a small ring network with a few random non-local connections.

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MS77

Travelling Waves and Canards in a Model of Wound Healing Angiogenesis

We discuss the existence of travelling waves in a singularly perturbed model of wound healing angiogenesis. We use geometric singular perturbation theory, supplemented with canard theory due to a fold in the critical manifold where normal hyperbolicity is lost. Along this fold, canard points may exist that allow solution trajectories to pass through the fold. These so-called canard solutions are crucial to establishing the existence of travelling waves, in particular, that contain shocks.

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MS77

Singularities in Front Bifurcations with Scale Separation

A paradigm for the occurrence of fronts are phase separation phenomena and Allen-Cahn type equations provide the simplest model class. The coupling to further equations with scale-separation leads to a surprisingly rich class of singularly perturbed problems that is amenable to analysis. Over the past decades several methods have been developped to obtain rigorous existence and stability results also for more complicated patterns than single fronts. In this talk we showcase an analysis of a three-component model with two linear equations coupled to an Allen-Cahn equation with scale separation. We show the front dynamics is organized by a butterfly catastrophe that leads to accelerating and direction reversing slow fronts. In addition, a more general result concerning the imbedding of arbitrary singularities in such front bifurcations is shown. This is joint work with Martina Chirilus-Bruckner, Peter van Heijster and Arjen Doelman.

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MS77

Pinning and Unpinning in Nonlocal Equations

We investigate pinning regions and unpinning asymptotics in nonlocal equations. We show that phenomena are related to but different from pinning in discrete and inhomogeneous media. We establish unpinning asymptotics using geometric singular perturbation theory in several examples. We also present numerical evidence for the dependence of unpinning asymptotics on regularity of the nonlocal convolution kernel.

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MS77

Canard Supersonique

Looking at the gas dynamics of stars under the assumption of spherical symmetry, I will show that transonic events in such systems are canard phenomena – peculiar solution structures identified in geometric singular perturbation problems. Consequently, stellar winds are carried by

supersonic ducks, and canard theory provides a mathematical framework for this astrophysical phenomenon. So, whenever you have the chance to watch an *aurora*, remember the superheros behind that scene – transonic canards!

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MS78

Control of Moreau's Sweeping Process: Some Results and Open Problems

While the existence theory is a very active area of research since the '70s, the understanding of the dynamics and of the control of the sweeping process is an entirely new subject. The talk will focus on some models and open problems, together with recent results, obtained in collaboration with other authors (including Nguyen D. Hoang, B. Mordukhovich, R. Henrion), on necessary conditions for various cases of optimal control for the sweeping process. In particular, the case where the moving set depends on control parameters will be considered and the obtained necessary conditions will be illustrated through examples. If time permits also a minimum time problem will be addressed.

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MS78

On the Response of Sweeping Processes to Perturbation

If x_0 is an equilibrium of an autonomous differential equation $\dot{x} = f(x)$ and $\det \|f'(x_0)\| \neq 0$, then x_0 persists under autonomous perturbations and x_0 transforms into a T-periodic solution under non-autonomous T-periodic perturbations. In this paper we discover an analogues structural stability for Moreau sweeping processes of the form $-\dot{u} \in N_B(u) + f_0(u)$, $u \in R^2$, i. e. we consider the simplest case where the derivate is taken with respect to the Lebesgue measure and where the convex set B of the reduced system is an immovable unit ball of R^2. We show that an equilibrium $\|u_0\| = 1$ persists under periodic perturbations, if the projection $\overline{f} : \partial B \to R^2$ of f_0 on the tangent to the boundary ∂B is nonsingular at u_0. Supported by RFBR grants 14-01-00867, 14-01-92004, 13-01-00347.

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MS78

Dynamics of Sweeping Processes with Jumps in the Driving Term

For discontinuous driving terms, sweeping processes were originally formulated first for step multifunctions and then extended to BV moving convex sets. Another natural procedure consists in extending the classical continuous process from absolutely continuous to BV driving terms through a continuity method [V. Recupero, *A continuity method for sweeping processes*, J. Differential Equations, 2011]. We show that this method leads to a new of notion of sweeping process and we compare the two different dynamics.

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MS78

Estimation and Control Problems in Systems with Moreau's Sweeping Process

This talk will address control-theoretic design problems for dynamical systems modeled as variants of Moreau's sweeping process. As a first case, we consider physical systems which comprise a time-varying Lipschitz vector field and the set-valued mapping resulting from a first-oder convex sweeping process. A well-posedness result on existence and uniqueness of solutions for such systems is presented. The result is used for designing controllers, and state estimators in the context of output regulation problem. An extension of these techniques is used to derive Lyapunov stability conditions and design state estimators for systems involving sweeping processes with proximally regular set-valued mappings. We next consider second order sweeping processes which are useful in modeling mechanical systems with unilateral constraints. The problem of velocity estimation is considered using only the position measurements, which becomes nontrivial due to discontinuities in the velocity caused by the impacts. A state estimator is proposed which has the form of a measure differential inclusion. It is shown that there exists a unique solution to the proposed differential inclusion and that solution converges to the actual velocity of the system.

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MS79

The Dynamics of Vortices and Masses over Surfaces of Revolution

One of the today's challenges is the formulation of the N-body and N-vortex dynamics on Riemann surfaces. In this talk we show how the two problems are strongly related one another from the point of view of the intrinsic geometry of the surface where thedynamics takes place. Given a surface M of metric g and the distribution of matter S on M, we deduce the dynamics of the masses and some of its properties.

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MS79

Eulerian Geometric Integration of Fluids for Computer Graphics

We present two geometric numerical methods for fluid simulation in computer animation. One is built to enforce Kelvin's theorem in a semi-Lagragian manner, while the other is derived from first principles using a finite dimensional approximation of the group of volume-preserving diffeomorphisms. The two resulting time integrators are shown to exhibit much improved numerical behavior. Time permitting, we will also discuss extensions to magnetohydrodynamics and geophysical flows.

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MS79

Poincare-Birkhoff Normal Forms for Hamiltonian Relative Equilibria

Consider a cotangent bundle Hamiltonian system with a free, proper and compact Lie symmetry. We present an iterative algorithm suitable for the application of the Poincare-Birkhoff normal forms method near a relative equilibrium on a fixed momentum level set.

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MS79

Studies on Dynamics of Vortices on a Flat Torus

In this talk I will present a complete description of the dynamics of two vortices on flat tori. The dynamics is determined by a Hamiltonian equation for the evolution of the center of vorticity with a Hamiltonian function defined in terms of Jacobi theta functions. We describe the bifurcation curves obtained under variations of the module parameter of the torus. The analysis of the stability for some special solutions are in progress.

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MS80

Spiral Pinballs

Spiral waves in excitable media possess both wave-like and particle-like properties. When resonantly forced, spiral cores drift like particles along straight trajectories. These trajectories may reflect from medium boundaries or from obstacles within the medium. Interestingly, such reflections are almost always non-specular (that is, they have english), and this results in interesting ricochet paths within the medium. Paths may be further complicated if the medium itself undergoes motion.

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MS80

Drift of Scroll Waves in Thin Layers Caused by Thickness Features

A scroll wave in a thin layer of excitable medium is similar to a spiral wave, but may drift depending on layer geometry. Effects of sharp thickness variations are distinct from filament tension and curvature-induced drifts described earlier. We describe these effects asymptotically, with the layer thickness and its relative variation as small parameters. Asymptotic predictions agree with numerical simulations for drift of scrolls along thickness steps, ridges, ditches, and disk-shaped thickness variations.

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MS80

Tidal Forces Act on Cardiac Filaments

During cardiac arrhythmias, scroll waves of electrical activation rotate around a filament curve. By treating the anisotropy of cardiac tissue as a curved space, I derive the laws of motion for filaments in anisotropic reaction-diffusion systems. In addition to the familiar filament twist and curvature terms, intrinsic curvature (Riemann curvature terms) also act as tidal forces on the filament.

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MS80

Computation of Unstable Solutions of Cardiac Models on Static and Evolving Domains

Although typical cardiac models respect global Euclidean symmetries, these symmetries are generally broken by chaotic solutions. A generalized amplitude-phase representation allows "decomposition' of such chaotic multi-spiral solutions into tiles, each of which contains a single spiral described by an unstable periodic or relative periodic solution that respects translational and rotational symmetries locally. We present a method for computing such solutions on irregular domains with stationary or moving boundaries and discuss their properties.

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MS81

First-Passage Times of Random Walks in Confined Geometries

Abstract not available.

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MS81

Asymptotic Analysis of Narrow Escape Problems in Non-Spherical 3D Domains

Narrow escape problems for non-spherical 3D domains with $N \geq 1$ boundary traps are considered. We compute an asymptotic expression for the average mean first passage time (AMFPT) for three-dimensional domains bounded by a level surface of an orthogonal coordinate system. A two-term asymptotic expansion for the AMFPT is derived for an arbitrary N; it is compared with COMSOL numerical solutions. Steps are taken towards the derivation of higher-order asymptotics and a position-dependent MFPT formula.

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MS81

First Passage Times in Biological Self-Assembly

Nucleation and self-assembly in biology usually involve a fixed number of constituents aggregating into clusters of a finite maximal size. Motivated by this scenario, we derive the corresponding backward Kolmogorov equation for the cluster probability distribution and study the distribution of times it takes for a single maximal cluster to be completed, starting from any initial particle configuration. Surprisingly, we find, both analytically and numerically, that faster detachment can lead to a shorter mean time to first completion of a maximum-sized cluster. This result is due to the redistribution of trajectory weights upon increasing the detachment rate so that paths that take a shorter time to complete a cluster become more likely.

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MS81

Signal Focusing Through Active Transport

The precision of cellular signaling and novel diagnostic devices is limited by the counting noise imposed by the thermal diffusion of molecules. Many macromolecules and organelles bind to molecular motors and are actively transported. We will show that a random albeit directed delivery of molecules to within a typical diffusion distance to the receptor reduces the noise correlation time, thereby improving sensing precision. The conditions for improved sensing are compatible with observations in living cells.

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MS82

Control of Multiscale Dynamical Systems

New applications in materials, medicine, and computers

are being discovered where the control of events at the molecular and nanoscopic scales is critical to product quality, although the primary manipulation of these events during processing occurs at macroscopic length scales. These systems motivate the creation of tools for the control of multiscale systems that have length scales ranging from the atomistic to the macroscopic. This talk describes a systematic approach that consists of stochastic parameter sensitivity analysis, Bayesian parameter estimation applied to ab initio computational chemistry calculations and experimental data, model-based experimental design, hypothesis mechanism selection, and multistep optimization. The application of control theory to the analysis and design of multiscale simulation codes is also discussed.

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MS82

Some Results on the Backward Stability of Singular Perturbation Approximations of Linear and Nonlinear Stochastic Control Systems

An important aspect of model reduction of large-scale control systems is the estimation of the approximation error as a function of the control input. A different question is whether feedback controls computed from a reduced model are a reasonable approximation of the optimal control for the original model, the computation of which is often infeasible. In this talk we present recent results on the backward stability of singular perturbation approximations of a certain class of stochastic control systems and discuss various applications.

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MS82

Variational Integrators for Multiscale Dynamics

In this talk variational integrators are developed for the structure-preserving integration of systems with dynamics on multiple time scales. The construction is based on a derivation in closed form via a discrete variational principle on a time grid consisting of macro and micro time nodes. The structure preserving properties as well as the convergence behavior of the multirate integrator are analyzed and its performance is demonstrated by numerical examples.

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MS82

Control of Oscillators, Temporal Homogenization, and Energy Harvest by Super-Parametric Resonance

We show how to control an oscillator by periodically perturbing its stiffness, such that its amplitude follows an arbitrary positive smooth function. This also motivates the design of circuits that harvest energies contained in infinitesimal oscillations of ambient electromagnetic fields. To overcome a key obstacle, which is to compensate the dissipative effects due to finite resistances, we propose a theory that quantifies how small/fast periodic perturbations affect multidimensional systems. This results in the discovery of a mechanism that reduces the resistance threshold needed for energy extraction, based on coupling a large number of RLC circuits.

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MS83

Nonlinear Waves in Microsphere-Based Metamaterials

Locally-resonant metamaterials and granular media are both highly dispersive and known to drastically affect acoustic wave propagation. In this work, we consider the nonlinear dynamics of a system at the intersection of these two types of media: a locally-resonant metamaterial composed of microscale spheres adhesively coupled to an elastic substrate, where the spheres act as nonlinear local resonators. Dynamical simulations of a discrete element model representing the metamaterial are compared with photoacoustic experimental measurements.

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MS83

Multiscale Analysis of Strongly Localized Waves

Abstract not available.

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MS83

Standing Waves on Tadpole Graphs

We develop a detailed rigorous analysis of edge bifurcations of standing waves in the nonlinear Schrodinger (NLS) equation on a tadpole graph (a ring attached to a semi-infinite line subject to the Kirchhoff boundary conditions at the junction). It is shown in the recent work of C. Cacciapuoti, D. Finco, and D. Noja by using explicit Jacobi elliptic functions that the cubic NLS equation on a tadpole graph admits a rich structure of standing waves. Among these, there are different branches of localized states bifurcating from the edge of essential spectrum of an associated Schrodinger operator. In this work, joint with D. Noja (Milan), we show by using the Lyapunov-Schmidt reduction that the bifurcation phenomenon is general for other power nonlinearities and moreover, the local properties of bifurcating standing waves can be characterized in full details. We distinguish a primary branch of never vanishing standing waves bifurcating from the trivial solution and an infinite sequence of higher branches with oscillating behavior in the ring. The higher branches are not small at threshold and bifurcate

from the branches of degenerate standing waves with vanishing tail outside the ring. Each higher nontrivial branch breaks the symmetry of the degenerate branch. Moreover, we analyze stability of bifurcating standing waves. Namely, we show that the primary branch is composed by orbitally stable standing waves, while the nontrivial higher branches are linearly unstable near the bifurcation point. The stability character of the degenerate branches remains inconclusive at the analytical level, whereas heuristic arguments and numerical approximations support the conjecture of their linear instability at least near the bifurcation point.

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MS83

Granular Acoustic Switches and Logic Elements

We present analytical, numerical, and experimental demonstration of an acoustic switch, analogous to its electric/optical counterpart, based on a 1D chain of granular crystals. This system controls the propagation of primary output stress waves by applying secondary control waves, exploiting the nonlinear dynamic effects of the granular chain. We also realize OR and AND acoustic logic gates using multiple control signals.

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MS84

Modulating Synaptic Plasticity Within In Vitro Hippocampal Networks

Synaptic plasticity, in the form of long-term potentiation (LTP) and long-term depression (LTD), is thought to underlie learning and memory. Both must be highly regulated for proper memory storage to take place. We chemically induce LTP and LTD within networks of hippocampal neurons and quantify the changes in action potential firing within the purview of network dynamics.

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MS84

Traveling Patterns in Lateral Inhibition Neural Networks

We investigate the necessary condition- asymmetry in the coupling function, for traveling pulses to exist in a neural network coupled with lateral inhibition. We then compute the traveling pulses using a system of equivalent delayed differential equations derived from the neural field model. We further study the dynamical dependency of traveling pulses on the gain and coupling parameters, and demonstrate how to determine the stability of given traveling pulses.

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MS84

Homogenization Theory for Neural Field Models

This talk is divided into two parts. In the first part we review the derivation of the homogenized one - population Amari equation by means of two - scale convergence technique in the case of periodic microvariation in the connectivity function. In the second part we discuss the existence and stability of single and multibump solutions of the homogenized model.

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MS84

Asymmetric Stationary Bumps in Neural Field Models

For 1D neural field models, we show that the symmetry of the connectivity function causes a degeneracy, permitting the existence of asymmetric bump solutions. When the governing nonlinear integral equation is transformed into a higher-order ODE, the degeneracy leads to a conserved quantity. With this, we construct a horseshoe map and obtain infinitely many asymmetric/symmetric bump solutions. We then discuss the persistence of these solutions under perturbations of the connectivity function and the nonlinear gain.

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MS85

Contact Network Models for Immunizing Infections

Many infectious agents spread via close contact between infected and susceptible individuals. The nature and structure of interactions among individuals is thus of fundamental importance to the spread of infectious disease. Heterogeneities among host interactions can be modeled with contact networks, and analyzed using tools of percolation theory. Thus far, the field of contact network epidemiology has largely been focused on the impact of network structure on the progression of disease epidemics. In this talk, we introduce network models which incorporate feedback of the disease spread on network structure, and explore how this feedback limits the potential for future outbreaks. This has implications for seasonal diseases such as influenza, and supports the need for more adaptive public health policies in response to disease dynamics.

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MS85

Mathematical Models of the Spatial and Evolutionary Dynamics of Influenza A

The research areas of population biology and dynamical systems already have a fruitful shared history. Within this, disease modelling has been particularly lively for both its rich dynamics and its practical importance. In this talk, we will have a brief tour of some of the types of models that are in use for both the spatial and evolutionary aspects of the spread of influenza at the population level, and some of the future mathematical challenges.

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MS85

A Multi-Scale Model of Multiple Exposures to a Pathogen

Dose size and incubation period length are related for many infectious diseases. We explore a dose-dependent latent period of infection (a component of incubation period) following multiple exposures to a pathogen, and study its effect on disease transmission in a population. The immuno-epidemiological model is developed using a threshold-type delay, which is transformed in a biologically natural way, to a system of differential equations with state-dependent delay. Bistability results, which has implications in infection control.

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MS85

Evaluation of Combined Strategies for Controlling Dengue Fever

Dengue is the most significant mosquito-borne viral infection of humans, causing 50-100 million infections annually. The main line of attack against dengue has been traditional mosquito control measures, such as insecticides. The coming years will see the broadening of our anti-dengue arsenal to include genetically-modified mosquitoes, biocontrol methods—such as Wolbachia—and vaccines. In this talk, I will discuss mathematical modeling that is being used to help design dengue control efforts using one, or a combination, of these methods.

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MS86

Experimental Studies of Burning Invariant Manifolds as Barriers to Reaction Fronts

We study Belousov-Zhabotinsky reaction fronts in the following flows: (a) a single vortex flow; (b) a chain of oscillating vortices; and (c) extended vortex array or spatially disordered flows. In these flows, front propagation is impeded and sometimes pinned by burning invariant manifolds (BIMs) which act as one-way barriers. Experimental measurements of barriers are compared with BIMs that are predicted numerically. We consider the limits of validity of the BIM approach to more complicated flows.

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MS86

Front Pinning in Single Vortex Flows

We study fronts propagating in 2D fluid flows and show that there exist stable invariant front configurations for fairly generic flows. Here we examine the simple flow which combines a single vortex with an overall wind. Existence of the stable front is related to the underlying fluid bifurcation. This elementary structure has application in chemical reactor beds and laminar combustion in well-mixed fluids.

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MS86

Propagation of An Autocatalytic Reaction Front in Heterogeneous Porous Media

We investigate experimentally and numerically the coupling of the propagation of an auto-catalytic reaction and the flow in porous media. We will investigate the different propagation modes depending on the flow direction, its amplitude and the disorder of the medium. More particularly, we will demonstrate that heterogeneity of the medium induces a rich variety of front dynamic and morphology.

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MS86

Front Propagation in Cellular Flows for Fast Reaction and Small Diffusivity

We investigate the influence of cellular flows on the propagation of Fisher-Kolmogorov-Petrovsky-Piskunov chemical fronts in the limit of small molecular diffusivity and fast reaction i.e., large Péclet (Pe) and Damköhler (Da) numbers. We develop an asymptotic theory that describes the front speed in terms of a periodic path – an instanton – that minimizes a certain functional and yields closed-form results for $(\log Pe)^{-1} \ll Da \ll Pe$ and $Da \gg Pe$. Our theoretical predictions are compared with (i) numerical solutions of an eigenvalue problem and (ii) simulations of the advection–diffusion–reaction equation.

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MS87

Geometric Optics and Piecewise Linear Systems

Light through a chessboard material with two different refractive indices (for black and white squares) is refracted and reflected in complicated ways. I will describe the derivation of a return map for a geometric ray obeying Snell's Law and use this to derive properties of the rays.

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MS87

Analysis of Traveling Pulses and Fronts in a Nonsmooth Neural Mass Model

We study the activity of coupled populations of excitatory and inhibitory neurons in a neural firing rate model that includes 1D nonlocal, spatial coupling. To facilitate analysis of spatio-temporal patterns, we approximate the (typically smooth) nonlinear firing rate function with the Heaviside step function. We study the corresponding nonsmooth differential system in traveling wave coordinates, with a particular interest in how the system transitions from traveling front to pulse as the time-constant of inhibition increases.

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MS87

Are Plankton Discontinuous, Smooth Or Slow-Fast (and Furious)?

In this talk, we first discuss a piecewise-smooth dynamical system constructed for one predator feeding on two different types of prey and inspired by plankton observations. The piecewise-smooth model has a discontinuity between the two vector fields. Thus, we then construct and discuss different smooth reformulations of the model and compare model predictions with data on freshwater plankton.

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MS87

Infinitely Many Coexisting Attractors in the Border-Collision Normal Form

The nature of piecewise-linear maps (such as the tent map) facilitates exact calculations, yet such maps can display extremely complicated dynamics (including chaos). This talk looks at two mechanisms by which two-dimensional piecewise-linear continuous maps can exhibit infinitely many stable, or asymptotically stable, periodic solutions at special points of parameter space. Scaling laws indicate the rate at which the number of coexisting attractors decreases with the distance from these points.

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MS88

Swarming of Self-propelled Particles in Fluids

Self propulsion, a distinction between active swarmers and passive interacting particles, often invokes speed regulation strategies that can be essential for a swarm to develop and maintain a certain flocking formation. However, speed regulation depends on the ability of a swarmer to sense its own speed relative to its perceived surroundings. Here we study a swarming system in low-Reynolds number flows, examining the effects of hampered speed regulation by the disturbance flow on flock formations.

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MS88

Origin and Structure of Dynamic Social Networks Based on Cooperative Actions

Societies are built on social interactions. A novel theoretical framework to model dynamic social networks focusses on individual actions instead of interactions between individuals and thereby eliminates the traditional dichotomy between the strategy of individuals and the structure of the population. As a consequence, altruists, egoists and fair types are naturally determined by the local social structures, while globally egalitarian networks or stratified structures arise. Cooperative actions drive the emergence and shape the structure of social networks.

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MS88
Hotspots in a Non-Local Crime Model

We extend the Short et al. burglary hotspot model to allow for a larger class of criminal movement. Specifically, we allow criminals to travel according to a Lévy flight rather than Brownian motion. This leads to a non-local system of differential equations. The stability of the homogeneous state is studied both numerically and through a Turing-type analysis. The hotspot profiles are then constructed to leading order in a singular regime.

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MS88
Co-Dimension One Self Assembly

Self assembly refers to emergent behavior that occurs in systems with a large number of interacting molecules or nanoparticles. These systems produce ordered, supramolecular structures solely due to the interactions between their constituent molecules or particles. My talk will focus on mathematical models for physical processes, such as the assembly of inorganic polyoxometalate (POM) macroions into hollow spherical structures or the assembly of surfactant molecules into micelles and vesicles, where the supramolecular structure has co-dimension one characteristics. I will discuss both the mathematical theory that characterizes when such structures can arise, as well as applications of these insights to physical models of these assemblies.

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MS89
Network Reliability As a Tool for Using Dynamics to Probe Network Structure

We apply the Moore-Shannon network reliability polynomial to infectious disease epidemiology on large social networks. Special cases of the polynomial represent the probability of cascading failures or epidemic outbreaks in complex networks. Although its exact evaluation is NP-hard, efficient, scalable Monte-Carlo estimation is practical. A physical interpretation supports analytical understanding of how local structures interact with dynamics to produce global function.

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MS89
Dynamical Macro-Prudential Stress Testing Using Network Theory

We present a dynamic model to reveal the systemic structure of a banking system, to analyze its sensitivity to external shocks and to evaluate the presence of contagious underlying features of the system. As a case study, we make use of the Venezuelan banking system in the period of 1998–2013. The introduced model was able to capture, in a dynamic way, changes in the structure of the system and the sensitivity of banks portfolio to external shocks. Results suggest the fruitfulness of this kind of approach to policy makers and supervision agencies to address macro-prudential dynamical stress testing and regulation.

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MS89
Role of Netwok Topology in Collective Opinion Formation

To investigate the role of network structures on the phenomena of collective opinion formation, we investigate several modifications to the voter model on co-evolving networks. For example we modify the rewiring step by a path-length-based preference for rewiring that reinforces local clustering and show that reinforcement of clustering in a voter model can have significant ramifications. Furthermore, we will be employing this voter model dynamics to analyze the structures of various empirical social network data sets.

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MS89

Linear Dynamics on Brain Networks: A Tool for Understanding Cognition

Human cognitive function is a complex phenomenon that occurs via intricate neuronal dynamics evolving over a sculpted anatomical network architecture housed within the skull. Yet, fundamental structural drivers of these functions remain poorly understood. Drawing inspiration from network control theory, here we utilize a simple linear model of brain dynamics on experimentally measured anatomical networks to predict the role of brain areas (network nodes) in moving the brain into (i) easily reachable states, (ii) difficult-to-reach states, and (iii) states that require interactions between network communities, which traditionally map to cognitive systems including audition, vision, and motor systems. Our predictions map well to known functions of brain areas, suggesting that structural network architecture forms a fundamental constraint on observed cognitive processes underlying human thought. More broadly, our study illustrates the utility of dynamic models on networks to uncover critical drivers of system function.

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MS90

The Dynamics of Alopecia Areata

Alopecia areata is an autoimmune disease causing distinct patterns of hair loss. Little is known regarding the causes or treatment of the disease. We develop an ODE model for alopecia areata dynamics which incorporates one of the current hypotheses that explains a range of experimental observations and suggests several avenues for treatment. Sensitivity analysis is used to determine which inputs have the greatest influence helping focus the study on avenues with the highest potential impact.

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MS90

Epistemic Uncertainty Quantification Using Fuzzy Set Theory

Epistemic uncertainty due to lack of knowledge is inevitable in modeling and simulation. The existing stochastic tools do not readily apply to epistemic uncertainty quantification since probability distributions may not be available. In this paper, we propose a general three-step procedure based on fuzzy set theory to deal with epistemic uncertainty and extend it for mixed epistemic and aleatory uncertainty quantification. The convergence rate of obtained numerical solutions is analyzed and demonstrated with examples.

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MS90

Using Sensitivity Analysis to Understand *S. aureus* Infections

The immune system is a complex network of interactions that challenges the technology and skills of biologists and mathematicians who study it. We present results from global sensitivity analysis techniques (PRCC and Sobol') for two different models, one ODE and one PDE, and discuss the usefulness of these results for: model reduction, understanding immune system interactions, focusing data assimilation techniques on parameters of interest, and motivating biological experiments in the context of *S. aureus* infections.

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MS90

Computational Aspects of Stochastic Collocation with Multi-Fidelity Models

We shall discuss a numerical approach for the stochastic collocation method with multifidelity simulation models. The method combines the computational efficiency of low-fidelity models with the high accuracy of high-fidelity models. We shall illustrate the advantages of the method via a set of more comprehensive benchmark examples including several two-dimensional stochastic PDEs with high-dimensional random parameters. Finally, We suggest that tri-fidelity simulations with a low-fidelity, a medium-fidelity, and a high-fidelity model would be sufficient for most practical problems.

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MS91

Moreau Sweeping Processes on Banach Spaces

The sweeping process or Moreau's process in a Hilbert space H (introduced and studied by J.J. Moreau in J.D.E. in 1977) is an interesting problem in both Analysis and Mechanics

$$-\dot{y}(t) \in N(C(t); y(t)) \text{ a.e. in } [0,T], y(0) = y_0 \in C(0)$$

where $C(t)$ is a closed convex moving set depending on the time $t \in [0,T]$ and $y : [0,T] \to H$ is a BV mapping. There are a plethora of variants in this problem in Hilbert spaces.

In this talk I will present my last recent results on the existence of solutions for several extensions to Banach spaces of Moreau sweeping processes and its variants. The main problems that will be presented are: For a given reflexive smooth Banach space X,

$(P1)$ Find $y : [0,T] \to X^*$ such that

$$\begin{cases} -\frac{d}{dt}(y(t)) \in N(C(t); J^*(y(t))) + F(t; J^*(y(t))) \text{ a.e. in } [0,T] \text{ and} \\ J^*(y(t)) \in C(t), \forall t \in [0,T], \text{ and } J^*(y(0)) \in C(0). \end{cases}$$

$(P2)$ Find $y : [0,T] \to X^*$ such that

$$\begin{cases} -y(t) \in N(C(t); J^*(\frac{d}{dt}(y(t)))) + F(t; J^*(y(t))) \text{ a.e. in } [0,T] \text{ and} \\ J^*(\frac{d}{dt}(y(t))) \in C(t), \text{ a.e. on } [0,T], \text{ and } J^*(y(0)) \in C(0), J^*(\frac{d}{dt}y(0)) \in C(0). \end{cases}$$

$(P3)$ Find $y : [0,T] \to X^*$ such that

$$\begin{cases} -\frac{d}{dt}(y(t)) \in N(C(t, J^*(y(t))); J^*(y(t))) \text{ a.e. in } [0,T] \text{ and} \\ J^*(y(t)) \in C(t, J^*(y(t))), \forall t \in [0,T], \text{ and } J^*(y(0)) \in C(0, J^*(y(0))). \end{cases}$$

Here J^* is the normalized duality mapping in X^* defined from X^* to X by

$$J^*(x^*) = \{j^*(x^*) \in X : \langle x^*, j^*(x^*)\rangle = \|j^*(x^*)\|\|x^*\| = \|x^*\|^2 = \|j^*(x^*)\|^2\}.$$

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MS91

Periodic Solutions of Moreau Sweeping Processes and Applications

The concept of equilibrium has been introduced by O. Makarenkov in recent studies of the following autonomus Moreau sweeping process:

$$-u'(t) \in N_B(u(t)) + f(u(t)).$$

In the case of periodically perturbed f there exists a solution in the neighbourhood of the equilibrium. By using contraction mapping theory it is possible to prove stability of closed orbit for a prototypic sweeping process in a Hilbert space.

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MS91

Evolution Equations Governed by Sweeping Processes and Applications in Heat Equations with Controlled Obstacles

In this talk, we provide results on existence, stability and optimality conditions for the following class of evolution equations

$$-\dot{x}(t) \in \partial\Phi(x(t)) + N(x(t); C(t, u(t))) \quad \text{a.e. } t \in [0,T]; \quad x(0) = x_0.$$

We then apply these results for heat equations with controlled obstacles. This talk bases on joint work with Juan Peypouquet and Luis M. Briceño-Arias.

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MS91

Sweeping Process and Congestion Models for Crowd Motion

We propose a mathematical model of crowd motion in emergency evacuation. This microscopic model takes into account the local interactions between pedestrians. The underlying evolution problem takes the form of a first order differential inclusion.and its well-posedness can be proved with the help of recent results concerning sweeping process by uniformly prox-regular sets. Furthermore, we propose a numerical scheme (adapted from Moreau's catching-up algorithm) and prove its convergence.

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MS92

Braid Dynamics, Self-organized Criticality, and Solar Coronal Heating

Magnetic field lines in the atmosphere of the sun are anchored at the surface, and exist in a highly conducting environment. Hence their topological structure can only change gradually via surface motions, or violently via flaring events. We present models for the evolution of the braid structure to a self-organized state. The discrete nature of the flux distribution at the surface enhances the resulting energy dissipation.

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MS92

Characterizing Complexity of Aperiodic Braids of Trajectories

A braid of trajectories is an algebraic model of the sequence of interchanges of particles advected by a flow. Insights based on braid-theoretic arguments typically require periodicity of analyzed trajectories. This talk explores

what can be deduced from generic, non-periodic trajectories sampled from a flow. We define an aperiodic quantifier of braid complexity and present its dependence on flow parameters, on number of trajectories analyzed, and discuss connections to topological entropy.

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MS92

Topological Shocks in Burgers Turbulence

We shall discuss statistical properties of global solutions to the random forced Burgers equation. The problem is closely related to analysis of minimizers for random time-dependent Lagrangian systems. We show that for such systems on compact manifolds there exists a unique global minimizer. We also discuss dynamical properties of shocks and show that their global structure is quite rigid and reflects the topology of the configuration manifold

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MS92

Topology of Vortex Trajectories in Wake-Like Flows

Complex vortex patterns can emerge downstream of bluff bodies as the result of fluid-structure interaction. As in many fluid systems, the vortex cores define regions that remain coherent for relatively long times. Using a reduced-order model of the dynamics, the topological complexity of the flow is examined through braiding of the vortex trajectories. This wake-like model provides an example of how topological chaos may occur naturally through the dynamics of coherent structures.

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MS93

On the Generation of Spiral and Scroll Waves by Periodic Stimulation of Excitable Media in the Presence of Obstacles of Minimum Size

In this work we consider the periodic stimulation of two and three dimensional excitable media in the presence of obstacles. We focus our attention in the understanding of the minimum size obstacles that allow generation of spiral and scroll waves, and describe different mechanisms that lead to the formation of such waves. The present studies might be helpful in understanding and controlling the appearance of spiral and scroll waves in the medium.

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MS93

Interaction of Electric Field Stimuli with Scroll Waves in Three Dimensions

An applied electric field interacts differently with an action potential scroll wave depending on its orientation with the scroll wave's filament. In particular, defibrillation characteristics of the electric field are often more favorable when oriented parallel to the filament, particularly in the case of a thin medium. Theory and computer simulations will be presented illustrating the dynamics of the scroll-wave-electric-field interaction and its dependence on wall thickness and field orientation.

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MS93

Describing Scroll Wave Ring Interactions Via Interacting Potentials

We study the dynamics of scroll rings using a simplified model of cardiac action potential (the Karma model) that produces scroll waves with circular core at high excitability (positive tension regime). We calculate the trajectories of symmetric scroll rings as a function of core radius and distance to a bottom boundary and derive a potential function that can then be used to characterize and predict the dynamics without the need for integrating the whole system.

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MS93

Unusually Simple Way to Create Spiral Wave in An Excitable Medium

Our analytical and numerical results indicate that a sufficiently strong jump in the diffusion coefficient can result in a unidirectional propagation block in a nonuniform excitable medium. This phenomenon can be used to create spiral wave in a two-dimensional medium with a specific size and geometry of the inhomogeneity. Following this way the spiral wave can be created simply after a single excitation stimulus while others known methods need at

least two stimuli.

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MS94

Narrow Escape to Traps with Absorbing and Reflecting Portions

We study the Narrow Escape Problem to a small trap with a mixed configuration of absorbing and reflecting sections. In the limit of small trap radius, we derive a high order expansion for the mean survival time which incorporates the asymmetry of the trap through an orientation term. The orientation of the trap is found to significantly influence capture time, particularly in the scenario where the trap is undergoing prescribed motion.

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MS94

Sampling First-Passage Events When Drift Is Included in the First-Passage Kinetic Monte Carlo Method

We have developed a method for simulating stochastic reaction-drift-diffusion systems, where the drift arises from potential fields. The method combines elements of the First-Passage Kinetic Monte Carlo (FPKMC) method for reaction-diffusion systems and the Wang-Peskin-Elston lattice discretization of drift-diffusion. The original FPKMC uses analytic solutions of the diffusion equation and therefore cannot include nonlinear drift. In our method (Dynamic Lattice FPKMC), each molecule undergoes a continuous-time random walk on its own adaptive lattice.

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MS94

Uniform Asymptotic Approximation of Diffusion to a Small Target

The problem of the time required for a diffusing molecule within a large bounded domain to first locate a small target is prevalent in biological modeling. I consider this problem for a small spherical target. Uniform in time asymptotic expansions in the target radius of the solution to the corresponding diffusion equation is developed. The approach is based on combining short-time expansions using pseudo-potential approximations with long-time expansions based on first eigenvalue and eigenfunction approximations. These expansions allow the calculation of corresponding expansions of the first passage time density for the diffusing molecule to find the target.

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MS94

Drunken Robber, Tipsy Cop: First Passage Times, Mobile Traps, and Hopf Bifurcations

For a random walk on a confined one-dimensional domain, we consider mean first passage times in the following two scenarios: a randomly moving trap and an oscillating trap. In both cases, we find that a stationary trap actually performs better than a very slowly moving trap; however, a trap moving sufficiently fast performs better than a stationary trap. Also, we will show the connection between MFPT and Hopf-bifurcation in Gray-Scott model.

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MS95

A Dynamical Switching of Reactive and Nonreactive Modes at High Energies

In Hamiltonian systems, the reaction coordinate, the degree of freedom along which reaction proceeds, has been considered to be unchanged independent of the total energy of the system. I will present our recent finding that, for more than two degrees of freedom Hamiltonian systems, the identity of reaction coordinate can change, in general, as a function of the total energy of the system through the breakdown of normally hyperbolic invariant manifold located around the saddle.

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MS95

Control of a Model of DNA Opening Dynamics via Resonance with a Terahertz Field

We study the internal resonance, energy transfer, and control of DNA opening dynamics via parametric resonance. The model is a chain of pendula in Morse potential that takes into account helicity, inhomogeneity, and environ-

mental effects. While the model is robust to noise, we demonstrate the possibility of triggering its opening dynamics by targeting certain internal modes with specific terahertz fields. This may suggests that DNA natural dynamics can be significantly affected by terahertz radiation exposures.

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MS95

Obtaining Coarse-Grained Models from Multiscale Data

In many applications it is desirable to infer stochastic coarse-grained models from observational data of a multiscale process. Estimators such as the maximum likelihood estimator can, however, be strongly biased in this setting. In this talk we discuss a novel inference methodology that does not suffer from this drawback. Moreover, we exemplify through a real-world data set how these data-driven coarse-graining techniques can be used to study the statistical properties of a given temporal process.

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MS95

Mode-Specific Effects in Structural Transitions of Atomic Clusters with Multiple Channels

We present the dynamical origin of mode-specific effects in structural transitions of atomic clusters with multiple channels. We employ the hyperspherical coordinates to identify reactive modes and driving modes for the respective channels of structural transitions. It is shown that the branching ratios among different channels depend significantly on the modes that are initially activated. Such mode-specific branching ratios are explained in terms of the dynamical coupling and energy transfer between reactive modes and driving modes.

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MS96

Discrete Breathers in Vibro-Impact Lattice Models

Vibro-impact models offer a unique opportunity for obtaining exact analytic solutions for discrete breathers in one-dimensional and two-dimensional systems (with trivial possibility of generalization for 3D case). The solutions are obtained both for Hamiltonian models and for their forced/damped counterparts. Moreover, a formalism based on saltation matrices allows efficient analysis of global stability patterns for such breather solutions.

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MS96

Stable Two-Dimensional Solitons in Free Space: Gross-Pitaevskii Equations with the Spin-Orbit Coupling

Abstract not available.

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MS96

Nonlinear Dynamics of Non-Stretched Membrane

We present the analytical study of resonance non-stationary dynamics in the discrete initially non-stretched membrane. The model consists of the weightless string with n attached masses which are supported in turn by n orthogonal weightless strings. It is shown that the intense energy exchange(nonlinear beats) in such discrete membrane can be realized between different parts of the system (effective particles). Its analytical description is obtained in terms of limiting phase trajectories (LPT) with using the non-smooth transformations. The LPT bounds the domain of ordered motion in the phase space of the system. Increase of the excitation energy leads to two dynamical transitions caused by instability of one of nonlinear normal modes and LPT, respectively. As a result of the second transition the non-stationary energy localization arises. The obtained analytical solutions are confirmed by numerical simulations.

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MS96

Mixed Solitary Shear Waves in a Granular Network

We study primary pulse transmission in two-dimensional granular networks and predict a new type of mixed nonlinear solitary pulses shear waves, and pulse equi-partition between the chains of the network. An analytical model is asymptotically studied, based on the one-dimensional nonlinear mapping technique of Starosvetsky. To confirm the theoretical predictions we experimentally tested a series of two-dimensional granular networks, and validated the occurrence of strong energy exchanges and equi-partition for sufficiently large number of beads.

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MS97

Cyclic Drug Delivery Devices and Monotone Dynamical Systems

In the case of a gel membrane geometry, we show existence of oscillatory solutions corresponding to the system oscillating between the collapsed and the swollen phases, as the ionic concentration reaches a critical threshold. We apply the theory to the design of a cyclic drug delivery device activated by a chemical reaction that releases the positively charged ions that trigger the volume transition.

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MS97

Evaluation of the Diffusion Coefficient of Nanoparticles Using Mathematical Simulation

We developed a novel, non-expensive nanoparticle (NP) drug-carrying system produced by self-assembly. A major objective was to evaluate the NP diffusion properties. To characterize their drug-release properties drug-loaded particles were placed in the donor of a double-compartment diffusion cell and the drug concentration in the receiver was sampled periodically. In this study we show a mechanistic model and mathematical simulation that, coupled with the experimental results, was used to evaluate the nanoparticle diffusion coefficient.

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MS97

Viscoelastic Effects in Drug Delivery

Classical models of Hookean solid and Newtonian liquid may be insufficient for description of biological fluids and materials used in controlled drug delivery. Instead, different viscoelastic models may be appropriate. We present a number of examples where viscoelasticity effects are significant. Among them are: (i) non-Fickian drug release from a swelling polymer particle; (ii) dynamics of a pore in a lipid membrane; (iii) drug delivery through a mucus layer in pulmonary airways. The support of the US-Israel Binational Science Foundation (grant No. 2008122) is acknowledged.

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MS97

Fluid Flow and Drug Delivery in a Brain Tumor

We consider the problem of steady/unsteady fluid flow and drug delivery in a growing brain tumor. Objective is to understand the physiology of fluid flow and examine the effect of concurrent application of two anti-cancer drugs in a brain tumor. Therapeutic Index, which is a measure of efficiency of drug delivery in the tumor, is determined for different values of the parameters and discussed in the absence or presence of drugs' interactions.

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MS98

HIV Viral Rebound Times Following Suspension of Art: Stochastic Model Predictions

Suspension of antiretroviral treatment (ART) for HIV typically leads to rapid viral load rebound to pre-treatment levels. However, reports suggest that early ART initiation may delay viral rebound, for months, years, or permanently (post-treatment control, PTC), after ART suspension. We present a model of post-treatment HIV dynamics. From a branching process formulation we derive viral rebound time probability densities and the probability of PTC. Using these, we discuss viral rebound times and conditions for PTC.

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MS98

Modeling HCV Infection: Viral Dynamics and Genotypic Diversity

Hepatitis C virus (HCV) is present in the host with multiple variants generated by its error prone RNA-dependent RNA polymerase. We developed a series of models of viral dynamics for non-overlapping generations, based on difference equations, that allows us to follow the diversification of HCV virus early on during infection. We compared the analytical solutions of these models with a more detailed agent-based model of the HCV lifecycle. We found that the simplified model describes infection well, as long as

saturation effects are not present. We then compared the predictions of these models with data from acute infection in 9 plasma donors, with frequent sampling early in infection.

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MS98

Modeling Equine Infectious Anemia Virus Infection: Virus Dynamics, Immune Control, and Escape

Equine Infectious Anemia Virus is a retrovirus that establishes persistent infection in horses. Mathematical models of within-host infection dynamics including immune responses will be presented. Analysis of the models yields thresholds that would be necessary for immune responses to successfully control infection. Furthermore, model results predict the conditions under which multiple competing strains coexist or a subdominant viral strain escapes antibody neutralization and dominates the infection. Numerical simulations are presented to illustrate the results.

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MS98

Modeling HIV Infection Dynamics under Conditions of Drugs of Abuse

Drugs of abuse are associated with higher viral loads and lower host-immune responses in HIV-infected drug abusers. To explore effects of drugs of abuse on HIV infection, I will present dynamical system models that agree well with experimental data from simian immunodeficiency virus infections of morphine-addicted macaques. Using our models, we evaluate morphine-induced alterations in target cell susceptibility and HIV-specific immune response that result in higher viral replications and accelerated disease progressions.

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MS99

The Domain Dependence of Chemotaxis in a Two-Dimensional Turbulent Flow

Coherent structures are ubiquitous in environmental and geophysical flows. Recent advances in the identification of finite-time transport barriers have enabled the extraction of organizing templates for passive scalars in the limit of infinitesimal diffusion. In this presentation, we try to relate Lagrangian mixing and its corresponding measures to reaction processes in turbulent flows. Using a specific example of chemotaxis process in turbulence, we demonstrate that elliptic regions of the flow trigger higher uptake advantage for motile species of microorganisms. We analyze how the flow field and the relevant flow topology lead to such a relation.

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MS99

Flow and Grow: Experimental Studies of Time-Dependent Reaction-Diffusion-Advection Systems

When a reaction-diffusion-advection system becomes non-autonomous, a new dimensionless parameter emerges: γ, the ratio of growth to flow timescales. For $\gamma \sim 1$, the interaction between growth and flow can produce complex resonance phenomena. My team and I have developed an experimental apparatus capable of simultaneous measurements of velocity fields and front locations in RDA. I will present studies varying $\gamma = 1$ and discuss implications for phytoplankton growth in Earth's oceans, where $\gamma = 0.8$.

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MS99

Lagrangian Coherent Structures for Reaction Fronts in Unsteady Flows

Recent theoretical and experimental investigations have highlighted the role of invariant manifolds, termed *burning invariant manifolds* (BIMs), as one-way barriers to reaction fronts propagating through time-independent or time-periodic flows. This talk extends the concept of BIMs to unsteady flows, thereby constructing coherent structures that organize and constrain the propagation of reaction fronts through general flows. Following Farazmand, Blazevski, and Haller [Physica D 278279, 44 (2014)], we characterize coherent structures as curves of minimal Lagrangian shear.

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MS99

Transport in Chaotic Fluid Convection

Many interesting problems can be formulated as a diffusing concentration field that is also advected by a complex fluid flow in a large spatially-extended domain. We explore the case where this field is also reacting, as in chemical and combustion problems, or motile, as in bioconvection. Using large-scale parallel numerical simulations we quantify the dynamics of a propagating front in a chaotic flow field and the complex patterns of bioconvection for conditions

accessible to experiment.

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MS100

Some Nonsmooth Problems Inspired by Conceptual Climate Models

In this talk, I'll outline the development of a global energy balance model that includes ice-albedo feedback and greenhouse gas effects. I'll explore how the choice of temperature-dependent albedo affects transitions between stable steady states and periodic orbits of the system by applying modern techniques from nonsmooth dynamical systems.

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MS100

Continuation of Chatter in a Mechanical Valve

This presentation considers the analysis of periodic chatter in a mechanical pressure-relief valve, with emphasis on global interactions associated with a Shilnikov bifurcation. It reviews work in non-smooth systems by Piiroinen and Nordmark for the numerical parameter continuation of periodic orbits with infinitely many switches in finite time, using forward integration and nonlinear root solvers, and describes an alternative formulation expressed in terms of coupled boundary-value problems, implemented in the COCO framework.

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MS100

Lost in Transition: Nonlinearities in the Dynamics of Switching

When a system transitions abruptly from one behaviour to another, empirical models often describe well what happens just after and just before the transition, but not *during*. Worse, attempts to model the switch itself may involve complex higher dimensional and smaller scale processes. We can access the *hidden dynamics* of the transition, though, using simple dynamical principles. To do so fully requires a nonlinear theory of transitions in piecewise smooth dynamical systems.

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MS100

Grazing Bifurcations in Engineering and Medical Systems

Abstract not available.

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MS101

Nonlinear Dynamics of Variational Data Assimilation

Using the path integral formulation of statistical data assimilation, we show how to find the consistent global minimum path, show its dependence on the number of measurements at each observation time, and demonstrate that in certain parameter regimes, the corrections to the variational approximation is small and computable.

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MS101

Attractor Comparisons Based on Density

In this work a chaotic attractor is described as a density distribution in phase space. Describing the attractor as a density allows attractors to be compared using a small number of coefficients. Fits of these comparison coefficients as a function of some parameter change in the attractor can be used to predict how the attractor will change as a parameter changes. These density comparisons are used here to detect nonlinearity in a simple electronic circuit or to track parameter changes in a circuit based on the Rossler system. Comparisons between attractors could be useful for tracking changes in an experiment when the underlying equations are too complicated for vector field modeling.

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MS101

Manifold Learning Approach for Modelling Collective Chaos in High-Dimensional Dynamical Sys-

tems

It has been known that a certain dynamical system exhibits lower-dimensional motion at a macroscopic level whereas it also keeps high-dimensional chaos at a microscopic level, called collective chaos. In this study, we propose an approach based on manifold learning in order to extract variables constructing nonlinear coordinate to the attractor of collective chaos. We apply the proposed approach to models including sparse networks of chaotic maps and leaky integrate-and-fire neurons.

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MS101

Precision Variational Approximations in Statistical Data Assimilation

Data assimilation (DA) comprises transferring information from observations of a complex system to physically-based system models with state variables $\mathbf{x}(t)$. Typically, the observations are noisy, the model has errors, and the initial state of the model is uncertain, so the DA is statistical. One can thus ask questions about expected values of functions $\langle G(X) \rangle$ on the model path $X = \{\mathbf{x}(t_0), \ldots, \mathbf{x}(t_m)\}$ as it moves through an observation window $\{t_0, \ldots, t_m\}$. The probability distribution on the path $P(X) = \exp[-A_0(X)]$ determines these expected values. Variational methods seeking extrema of the 'action' $A_0(X)$ are widespread for estimating $\langle G(X) \rangle$ in many fields of science. In a path integral formulation of statistical DA, we consider variational approximations in a standard realization of the action where measurement and model errors are Gaussian. We (i) discuss an annealing method for locating the path X^0 giving a consistent global minimum of the action $A_0(X^0)$, (ii) consider the explicit role of the number of measurements at each measurement time in determining $A_0(X^0)$, and (iii) identify a parameter regime for the scale of model errors which allows X^0 to give a precise estimate of $\langle G(X^0) \rangle$ with computable, small higher order corrections.

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MS102

Shadow Networks: Discovering Hidden Nodes with Models of Information Flow

Complex, dynamic networks underlie many systems, and understanding these networks is the concern of a great span of important scientific and engineering problems. Quantitative description is crucial for this understanding yet, due to a range of measurement problems, many real network datasets are incomplete. Here we explore how accidentally missing or deliberately hidden nodes may be detected in networks by the effect of their absence on predictions of the speed with which information flows through the network. We use Symbolic Regression (SR) to learn models relating information flow to network topology. These models show localized, systematic, and non- random discrepancies when applied to test networks with intentionally masked nodes, demonstrating the ability to detect the presence of missing nodes and where in the network those nodes are likely to reside.

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MS102

A Network Measure for the Analysis and Visualization of Large-Scale Graphs

Given an undirected graph, we describe a two-dimensional integer-valued measure, the Q-matrix, based on the connected component size distribution of its degree-limited subgraphs. This generalization of the degree distribution yields a small sparse matrix representing the number of weakly connected components of a particular size during a prescribed percolation process. When viewed as a two-dimensional histogram, this landscape yields a canonic visual representation, i.e. an identification portrait, revealing important network properties.

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MS102

Revealing Collectivity in Evolving Networks: A Random Matrix Theory Approach

Networks are the result of the tangled interconnections among their nodes. As the network evolves, group of nodes often undergo similar evolution patterns, giving rise to collective behavior. Here, we aim to uncover and quantify the degree of collectivity in the evolution of a complex network. In particular, we use Random Matrix Theory to identify significant correlations between the temporal topological properties (e.g. degree, centrality) of nodes. We apply our method to both functional networks, obtained from stocks and climate correlation data, and structural networks, obtained from Internet AS-level connectivity data.

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MS103

On the Computation of Attractors for Delay Differential Equations

In this talk we will introduce a numerical method which allows to approximate (low dimensional) invariant sets for infinite dimensional dynamical systems. We will particularly focus on the computation of attractors for delay differential equations. The numerical approach is inherently set oriented - that is, the invariant sets are computed by a sequence of nested, increasingly refined approximations -, and does not rely on long term simulations of the underlying system.

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MS103

Computing Coherent Sets in Turbulent Systems

In time dependent dynamics, it is often possible to divide phase space into sets which are seperated by transport barriers. Finding these sets helps to understand the global dynamical behavior of systems arising in, e.g. atmospheric flows, plasma physics and biological models. In this talk we present a new approach for the computation of coherent sets by incorporating time-continuous diffusion into the model. This leads to an advection-diffusion equation (the Fokker-Planck equation) whise solution we approximate using spectral collocation. The approach does not need any particle trajectories and is therefore suited for systems where these are hard to obtain, e.g. turbulent systems.

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MS103

The Geometry of Lagrangian Coherent Structures

We propose a novel, geometric method to identify subsets of phase space that retain small boundary size relative to volume as they are evolved by a nonlinear dynamical system. We describe a computational method to identify coherent sets based on eigenfunctions of a new dynamic Laplacian operator. Finally, we demonstrate that the dynamic Laplacian operator can be realised as a zero-diffusion limit of the classical probabilistic method for finding coherent sets, which is based on small diffusion.

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MS103

Coherent Families: Spectral Theory for Transfer Operators in Continuous Time

The decomposition of the state space of a dynamical system into metastable or almost-invariant sets is important for understanding macroscopic behavior. This concept is well understood for autonomous dynamical systems, and has recently been generalized to non-autonomous systems via the notion of coherent sets. We elaborate here on the theory of coherent sets in continuous time for periodically-driven flows and describe a numerical method to find periodic families of coherent sets without trajectory integration.

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MS104

Finite-Time Lagrangian Transport Through Surfaces in Volume-Preserving Flows

We present a Lagrangian approach to the quantification of transport of conserved quantities through a given hypersurface in general time-dependent, n-dimensional volume-preserving flows. This is of significant importance for (i) the calculation of coherent transport by Lagrangian material sets such as coherent vortices in geophysical fluid flows, and (ii) semi-Lagrangian approaches to numerically solving scalar advection equations.

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MS104

A Direct Method for Computing Failure Boundaries of Non-autonomous Systems

We present an efficient method, based on continuation of a two-point boundary value problem, to investigate the parameter dependence of system behaviour for models that are subject to an external forcing. As an example we consider a model of a post-tensioned self-centring frame that experiences an earthquake. The failure boundary is the boundary of the region in the space of possible earthquakes for which the frame displacement remains within a given range.

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MS104

Interactions Between Noise and Rate-Induced Tipping

A non-autonomous system passes a tipping point when gradual changes in input levels cause the output to change suddenly. I investigate a new way to help detect tipping before it occurs. For rate-induced tipping, analysing how much the system deviates from the quasi-steady state equilibrium gives an early-warning indicator. I show that early-warning indicators are present as soon as the most likely path for escape deviates from the quasi-steady state.

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MS104

Rate-Induced Bifurcations in Slow-Fast Systems

Rate-induced bifurcations describe the failure to track a moving stable state in systems with drifting parameters. Unlike classical bifurcations, they occur only above some critical drift rate. We investigate rate-induced bifurcations in slow-fast systems, using the theory of folded singularities and canards, to uncover thresholds with intricate band structures, separating initial states that track the moving stable state from those that destabilise. These novel thresholds explain non-obvious tipping point and excitability phenomena that often puzzle scientists.

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MS105

First Passage Time Problems for Stochastic Hybrid Systems

We review recent work on the analysis of first-passage time problems in stochastic hybrid systems. A stochastic hybrid system involves the coupling between a piecewise deterministic dynamical system and a time-homogeneous Markov chain on some discrete space. Examples include voltage-gated ion channels, intermittent transport by molecular motors, and stochastic neural networks. We construct a path-integral representation of solutions to the underlying master equation, and use this to derive a large deviation principle for escape problems. We show that the resulting Hamiltonian is given by the principle eigenvalue of a linear operator that depends on the transition rates of the Markov chain and the nonlinear functions of the piecewise deterministic system.

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MS105

Exploration and Trapping of Mortal Random Walkers

The calculation of first passage times has a long history, more recently extended to "anomalous" walks (subdiffusive or superdiffusive) in addition to those that lead to ordinary diffusion. However, the possible death of a walker before reaching its target has only recently been considered. Evanescence obviously profoundly affects quantities such as the survival probability of a target. I will talk about the effects of evanescence on first passage properties.

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MS105

Trajectory-to-Trajectory Fluctuations in the First-Passage Phenomena in Bounded Domains

We propose a novel method to quantify the trajectory-to-trajectory fluctuations of the first passage of a Brownian motion (BM) to targets on the boundary of compact domains, based on the distribution of the uniformity index, measuring the similarity of the first passage times of two independent BMs starting at the same location. This analysis permits us to draw several general conclusions about the importance of the trajectory-to-trajectory fluctuations on the first-passage behavior.

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MS105

Application of First-Passage Ideas to the Statistics of Lead Changes in Basketball

We investigate occurrences of lead changes in NBA basketball games. For evenly-matched teams, so that the score difference can be modeled as unbiased diffusion, the probability P(t) that a lead change occurs at time t in a game of length T is exactly soluble and surprisingly has maxima at t=0 and t=T. We generalize to teams of unequal strengths and also provide a criterion for when a lead of a given size is safe.

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MS106

Bifurcation Analysis of a Model for the El Niño Southern Oscillation

We consider a phenomenological model for the El Niño Southern Oscillation system in the form of a delay-differential-equation. We conduct a bifurcation analysis of the model in the two parameters of seasonal forcing strength and oceanic wave delay time, dividing the parameter plane into regions of different solution types. Our analysis highlights parameter sensitivity, explains and expands on previously published results and uncovers surprisingly complicated behaviour concerning the interplay between seasonal forcing and delay-induced dynamics.

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MS106

Interplay of Adaptive Topology and Time Delay in the Control of Cluster Synchronization

We suggest an adaptive control scheme for the control of zero-lag and cluster synchronization in delay-coupled networks. Based on the *speed gradient method*, our scheme

adapts the topology of a network such that the target state is realized. The emerging topology is characterized by a delicate interplay of excitatory and inhibitory links leading to the stabilization of the desired cluster state. As a crucial parameter determining this interplay we identify the delay time. Furthermore, we show how to construct networks such that they exhibit not only a given cluster state but also with a given frequency. We apply our method to coupled Stuart-Landau oscillators, a paradigmatic normal form that naturally arises in an expansion of systems close to a Hopf bifurcation. The successful and robust control of this generic model opens up possible applications in a wide range of systems in physics, chemistry, technology, and life science.

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MS106

Connection Between Extended Time-Delayed Feedback and Nonlinear Fixed-Point Problems

Time-delayed feedback control is an elegant method to find periodic orbits in an experiment without a-priori knowledge of their shape. However, the method has various topological restrictions, limiting the cases where it can be used. This presentation will use a singular perturbation argument to show that for the extended time-delayed control (as introduced by Socolar) the classical odd-number limitation still holds in the limit of slow updating of the reference signal.

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MS106

Pattern Formation in Systems with Multiple Delayed Feedbacks

Dynamical systems with complex delayed interactions arise commonly when propagation times are significant, yielding complicated oscillatory instabilities. We consider systems with multiple, hierarchically long time delays, and using a suitable space-time representation we uncover features otherwise hidden in their temporal dynamics. The behavior in the case of two delays is shown to 'encode' two-dimensional spiral defects and defects turbulence. A multiple scale analysis sets the equivalence to a complex Ginzburg-Landau equation. We also demonstrate this phenomenon for a semiconductor laser with two delayed optical feedbacks.

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MS107

Voltage Stability in Power Networks and Microgrids

The AC power flow equations in a complex network display a rich phenomenology, but despite more than four decades of investigation the solution space remains poorly understood. Here we present a sharp and intuitive parametric condition for the existence of a stable power flow solution. Our condition immediately leads to non-conservative loading margins, grid stability indices, and an accurate series expansion of the stable solution. We illustrate our results with monitoring and control applications.

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MS107

Finding Useful Statistical Indicators of Instability in Stochastically Forced Power Systems

Via a case study of a multi-machine power system, we identify those (relatively few) system variables whose measured autocorrelation and variance provide reliable warning of instability sufficiently before a collapse occurs. Our search for such useful early warning signs (EWS) is enabled by a semi-analytical calculation based on the Lyapunov equation and is confirmed by simulations. We also study how these statistics are impacted by measurement noise and discuss methods to reduce that impact. Several numerical experiments confirm the validity of the identified EWSs and also reveal potential limitations.

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MS107

A Parametric Investigation of Rotor Angle Stability Using Direct Methods

An estimate of the critical clearing time (CCT) for a fault is formulated using the direct methods for power system transient stability. By perturbing the energy functions used in the direct methods we present an analytic stability metric that can be used as a lower bound for the CCT. This new

metric is used to support a parametric enquiry into the stability of a small but non-trivial power system.

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MS107

Synchronization Stability of Lossy and Uncertain Power Grids

Direct energy methods have been extensively developed for the transient stability analysis and contingency screening of power grids. However, there are no analytical energy functions proposed for power grids with losses. The difficulty originates from the nonlinear and asymmetric couplings among generators, which make the natural energy function nondecreasing. This paper extends the recently introduced Lyapunov Functions Family method to certify the synchronization stability for lossy multimachine power grids. We present techniques to explicitly construct Lyapunov functions and propose algorithms for Lyapunov function adaptation to specific initial states, both by solving a number of linear matrix inequalities (LMIs). The Lyapunov Functions Family approach is also applicable to uncertain power grids where the stable equilibrium is unknown due to possible uncertainties in the mechanical torques. We formulate this new control problem and introduce techniques to certify the robust stability of a given initial state with respect to a set of equilibria.

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MS108

Bifurcations of Generalised Julia Sets Near the Complex Quadratic Family

We consider a nonanalytic perturbation of the complex quadratic family that is associated to wild Lorenz-like chaos. The perturbation opens up the critical value to a disk and saddle points and their stable and unstable sets appear. These sets interact with the generalised Julia set, leading to the (dis)appearance of chaotic attractors and to generalised Julia sets in the form of Cantor bouquets, Cantor tangles and Cantor cheeses.

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MS108

A Global Bifurcation of Mixed-mode Oscillations

This talk describes the existence of an elusive Shilnikov bifurcation in the Koper model. This result closes a chapter in one of the early and influential investigations of complex and chaotic mixed-mode oscillations. The bifurcation is located using a mixture of investigations of invariant manifold intersections and continuation methods. We also study structural stability and global returns, leading us to formulate a modified geometric model for a Shilnikov bifurcation in the slow-fast regime.

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MS108

Parameterization Method for Local Stable/unstable Manifolds of Periodic Orbits

I will discuss a numerical method for computing stable/unstable manifolds of periodic orbits for differential equations that leads to high order Fourier-Taylor expansions for the invariant manifolds. The inputs are Fourier series approximations of the periodic orbit and its Floquet normal form which are computed using iterative algorithms and Galerkin projections. The Fourier approximation of the Floquet normal form is then used in order to efficiently compute the parameterization of the local invariant manifold.

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MS108

Practical Stability Versus Diffusion in the Spatial Restricted Three-body Problem

We examine the role of the four-dimensional centre manifold $W^c_{L_3}$ of the equilibrium L_3 of the Spatial Restricted Three-Body Problem, and its stable and unstable invariant manifolds, in two dynamical processes for a small mass parameter. The first one consists of the Arnold diffusion mechanism associated to the existence of transition chains of heteroclinic connections. The second process consists of long-term confinement of trajectories in a practical stability domain in a large vicinity of $L_{4,5}$.

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MS109

Perspectives on Theories of Diabetogenesis and Glucose Management

The personalization of treatment is a key difficulty in the clinical management of type 2 diabetes today. Although it is widely agreed that glucose control is central to antidiabetic therapy, there is little consensus on how to achieve it. We believe that the concurrent measurement of redox status, such as through glutathione in particular, can be used to assess the progress of therapy as well as provide quantitative targets for glucose control. In my talk I will describe reasons in support of this argument, and a minimal model for achieving it. I will also present a theory of diabetogenesis that implicates oxidative stress as a central causal factor, and our attempts at modeling it.

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MS109

Therapeutic Mechanisms of High Frequency DBS in Parkinsons Disease: Neural Restoration Through Loop-Based Reinforcement

High frequency deep brain stimulation (HFS) is clinically recognized to treat parkinsonian movement disorders but its mechanisms remain elusive. Current hypotheses suggest that the therapeutic merit of HFS stems from increasing the regularity of the firing patterns in the basal ganglia (BG). Although this is consistent with experiments in humans and animal models of Parkinsonism, it is unclear how the pattern regularization would originate from HFS. To address this question, we built a computational model of the cortico-BG-thalamo-cortical loop in normal and parkinsonian conditions. We simulated the effects of subthalamic deep brain stimulation both proximally to the stimulation site and distally through orthodromic and antidromic mechanisms for several stimulation frequencies (20-180Hz) and, correspondingly, we studied the evolution of the firing patterns in the loop. The model closely reproduced experimental evidence for each structure in the loop and showed that neither the proximal effects nor the distal effects individually account for the observed pattern changes, while the combined impact of these effects increases with the stimulation frequency and becomes significant for HFS. Perturbations evoked proximally and distally propagate along the loop, rendezvous in the striatum, and, for HFS, positively overlap (reinforcement), thus causing larger post-stimulus activation and more regular patterns in striatum. Reinforcement is maximal for the clinically-relevant 130Hz stimulation and restores a more normal activity in the nuclei downstream. These results suggest that reinforcement may be pivotal to achieve pattern regularization and restore the neural activity in the nuclei downstream, and may stem from frequency-selective resonant properties of the loop.

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MS109

Unification of Neuronal Spikes, Seizures, and Spreading Depression

The pathological phenomena of seizures and spreading depression have long been considered separate physiological events in the brain. By incorporating conservation of particles and charge, and accounting for the energy required to restore ionic gradients, we extend the classic HodgkinHuxley formalism to uncover a unification of neuronal membrane dynamics. By examining the dynamics as a function of potassium and oxygen, we now account for a wide range of neuronal activities, from spikes to seizures, spreading depression (whether high potassium or hypoxia induced), mixed seizure and spreading depression states, and the terminal anoxic wave of death. Such a unified framework demonstrates that all of these dynamics lie along a continuum of the repertoire of the neuron membrane. Our results demonstrate that unified frameworks for neuronal dynamics are feasible, can be achieved using existing biological structures and universal physical conservation principles, and may be of substantial importance in enabling our understanding of brain activity and in the control of pathological states.

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MS109

Termination of Cardiac Alternans Using Isostable Response Curves

Phase reduction has been tremendously useful for understanding the dynamics of nonlinear oscillators, but has been difficult to extend to systems with stable fixed points, such as excitable systems. Using the notion of isostables, we present a general method for isostable reduction of excitable systems. This reduction is applied to both single- and multi-cell systems of cardiac activity in order to formulate an energy optimal control strategy to terminate cardiac alternans, a precursor to cardiac arrest.

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MS110

Triggers of Rogue Waves in Deep Water Envelope

Equations

Rogue ocean waves have caused considerable damage to ships and coastal structures. We analyze the role of spatial localization in triggering rogue waves in the modified nonlinear Schrodinger equation. Specifically, we develop a reduced order model that allows us to determine the characteristics of wave packets likely to focus and grow in amplitude. We use this analysis to develop a computationally efficient scheme for predicting rogue waves by identifying these potentially dangerous wave packets.

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MS110

Boundary Conditions and the Linking of Computational Domains in Patch Dynamics Schemes

Abstract not available.

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MS110

Resilient Algorithms for Reconstructing and Simulating Gappy Flow Fields in CFD

It is anticipated that in future generations of massively parallel computer systems a significant portion of processors may suffer from hardware or software faults rendering large-scale computations useless. In this work we address this problem from the algorithmic side, proposing resilient algorithms that can recover from such faults irrespective of their fault origin. In particular, we set the foundations of a new class of algorithms that will combine numerical approximations with machine learning methods.

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MS110

Better Buffers for Patches in Macroscale Simulation of Systems with Microscale Randomness

The 'equation-free' methodology couples many small patches of microscale computations across space to empower computational simulation over macroscale spatial domains of interest. We derive generally optimum coupling of patches and core averaging when the microscale is inherently 'rough' as in molecular or agent simulations. As a canonical problem in this universality class we analyse the case of inhomogeneous diffusion on a lattice. The minimal error on the macroscale is generally obtained by coupling patches with patch cores half as large as the patch, thus creating coupling active over the other half of the patch. The results indicate that patch dynamics is useful for computational simulation of a wide range of systems with fine scale roughness.

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MS111

Controlling Hyperbolic Trajectories and Invariant Manifolds in Flows

Hyperbolic trajectories are important in governing fluid motion, since their attached stable and unstable manifolds form crucial flow separators. We derive the control velocity ensuring that a hyperbolic trajectory follows specified nonautonomous motion in $\mathbb{R}^n$. We control both the Lorenz system, and a 3D droplet model, respectively obtaining a specified long-term attractor, and intra-droplet mixing. Ongoing work on determining control velocities for obtaining prescribed nonautonomous (un)stable manifold motion is also presented.

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MS111

Closed-Loop Control of Complex and Turbulent Flows Using Machine Learning Control: a Reverse Engineering Approach

We propose a model-free methodology to find closed-loop control laws for complex and turbulent flows using genetic programming. Avoiding the necessity to derive a model, the sensor-to-control law is derived by creating and evolving expression-trees according to a cost function. We show the efficiency of the method by the control of strongly nonlinear systems, and its practicality by exhibiting the results obtained on four turbulent experimental flows.

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MS111

Mesohyperbolicity, Mix-Norm and the Hunt for Mh370

The disappearance of MH370 has exposed the disconcerting lack of efficient methods for searching objects moving in a complex and dynamic environment. Lagrangian kinematics of mesoscale features are visible in mesohyperbolicity maps which can be used to predict the time evolution of any initial distribution and incorporated in the design of a search strategy. A modified version of DSMC search algorithm determines multiple search agents trajectories using ergodicity ideas and the Mix-Norm as a metric.

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MS111

Control of Thin-Layer Flows with Patterned Surfaces

When a shallow layer of inviscid fluid flows over a smoothly-patterned substrate, the fluid particle trajectories are, to leading order in the layer thickness, geodesics on the two-dimensional curved space of the substrate. We use 3D-printed substrates to show that the pattern made by a jet striking a bumpy surface is described by the geodesic equation. Because the geodesic equation is fourth order, the geodesics are chaotic even for simple substrates. This could offer a new method of improving mixing by varying the shape of the substrate.

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MS112

Experimental Observation of Rhythm Control of Human Gait Using Moving Floor

Human and animals maintain stability of gait and posture by tuning their motion rhythms. In order to approach this rhythm control mechanisms, human motion with floor disturbance is measured and rhythm characteristic of human is discussed. Response to high frequency floor disturbance during walking is observed for calculating the phase response curve, and response to rotational floor is measured for considering the posture control.

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MS112

What Can Coupled, Nonlinear Oscillators Say About Noisy, Perturbed Cockroaches

Cockroaches are remarkably stable runners, exhibiting rapid recovery from external perturbations. To uncover the mechanisms responsible for this, we recorded leg kinematics of freely running animals in both undisturbed and perturbed trials. Perturbations were applied to single legs via magnetic impulses and the resulting transient effects on all legs and recovery times to normal pre-perturbation kinematics were studied. We estimated coupling architectures and strengths by fitting data to a six leg-unit phase oscillator model. Using maximum likelihood techniques, we found that a network with nearest-neighbor interleg coupling best fitted the data, and that, while coupling strengths vary among preparations, overall inputs entering each leg are approximately balanced and consistent. Simulations of models encountering perturbations suggest that the coupling schemes estimated from our experiments allow animals relatively fast and uniform recoveries from perturbations. This is joint work with E. Couzin-Fuchs, T. Kiemel, O. Gal and A. Ayali.

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MS112

Formation Mechanism for Basin of Attraction of Bipedal Working Models

In this presentation, I will talk about the stability of simple bipedal walking models. Especially, I focus on the geometric structure of basin of attraction. By some numerical computations for the basin of attraction, interesting and complex geometric structures, for example, the region is thin and fractal-like, but the formation mechanism is not known. I will explain the mechanism with the saddle property and hybridness of bipedal walking models.

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MS112

Lateral Balance of Human Walking and Human Structure Interaction

Although synchronisation of pedestrian frequencies to lateral ground vibrations has been observed in the past, the mechanism leading to this behaviour is still not well understood. To this end experimental data from pedestrians freely-walking on a laterally oscillating treadmill are analysed revealing adaptive stepping patterns. At the same time simple spring-mass models of this motion are derived and analysed. The applicability of Kuramoto synchronisation model to capture this behaviour is examined.

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MS113

The Evolution of Complexity in Arctic Melt Ponds: a Statistical Physics Perspective

Recent analysis of Arctic melt pond images reveals that the pond shape transitions from simple to complex around a critical area of 100 square meters. To explain this onset of complexity, a two-dimensional Ising model for pond evolution is proposed that incorporates ice-albedo feedback and the underlying thermodynamics. A second-order phase transition from isolated to clustered ponds is found, with the pond complexity in the clustered phase consistent with the observations.

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MS113

Statistical Physics Models for Critical Phenomena in Permafrost Lakes

There is an interesting problem, where geometrical changes of the patterns and its stochastic behavior can lead to the critical phenomena in a climate system. As a result of tundra permafrost thawing, permafrost lakes have extended, and methane from ground has entered the atmosphere. We have suggested a nonlinear model for phase transitions in permafrost lakes (based on Ginzburg-Landau theory from statistical physics). We have applied this model to study abrupt permafrost methane emission.

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MS113

Growth and Fluctuations of Suncups on Alpine Snowpacks: Comparison of Field Observations with a Nonlinear Pde Model

A mathematical model for suncups on alpine snow exposed to solar radiation is compared with field observations. The model consists of a fourth order nonlinear partial differential equation similar to the KPZ equation. The patterns fluctuate chaotically in time, and the fluctuations can be described in terms of diffusion of individual suncups. The rate at which the suncups diffuse contains information about the effect of the suncups on the albedo of the snow.

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MS113

How Climate Model Complexity Impacts the Stability of the Sea Ice Cover

Two types of idealized climate models find instabilities during the retreat of sea ice under global warming: (i) annual-mean latitudinally-varying diffusive energy balance models and (ii) seasonally-varying single-column models. Comprehensive global climate models, however, typically find no instabilities. To bridge this gap, we develop an idealized model that includes both latitudinal and seasonal variations. Our results suggest that the ice cover is significantly more stable than found in previous idealized models.

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MS114

Possible Mechanisms for Generation of Beta Oscillations in Parkinsons Disease

In Parkinson's disease abnormal oscillations in neural activity in beta frequency range (13-30Hz) have been observed in the basal ganglia, and their power correlates with the severity of symptoms. We consider a simple model of cortico-basal-ganglia circuit. We show that there exist different regions of its parameters for which the model can match the dataset of Tachibana et al. describing neural activity in Parkinson's disease. These different regions correspond to different mechanisms of oscillations' generation.

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MS114

Identifying and Tracking Transitions in Neural Spiking Dynamics in the Subthalamic Nucleus of Parkinsons Patients

Accurate statistical modeling of spiking dynamics in neurological disease is important for understanding how the disease develops, progresses, and manifests clinical symptoms. In particular, abnormal oscillatory firing patterns of neurons in the subthalamic nucleus (STN) of patients with Parkinson's disease (PD) have been postulated to play a role in the pathogenesis of motor deficits. We present a point process analysis framework that allows us to identify and characterize the rhythmic dynamics in STN spike trains, test for statistically significant changes to those dynamics, and track the temporal evolution of such changes. The approach incorporates generalized linear modeling theory for point processes with state space modeling to estimate, instant by instant, changes in the influence of past spiking history on the current spiking probability. We demonstrate the method on both simulated and actual data recorded from human STN.

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MS114

Oscillations and Action Selection in a Multi-Channel Model of the Basal Ganglia

We present a population-level model of basal ganglia action selection based on segregated oscillatory channels, star-like connectivity and partial synchronisation. Although a pair of STN and GP populations (a ”micro-channel”) cannot oscillate without self-excitation, in pairs they show rhythmic activity at a range of intrinsic frequencies, chosen during training. Adjusting the intrinsic frequency of a central channel selects groups of micro-channels via partial synchronisation. We describe the analysis and possible biological interpretation of our model.

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MS114

Cortical Impact on the Dynamics of Subthalamo-pallidal Networks

Parkinsonian hypokinetic motor symptoms are associated with the beta-band synchronized oscillations throughout basal ganglia-thalamo-cortical circuits. This study explores the oscillatory interactions between cortical and basal ganglia networks in Parkinson's disease in the model of the basal ganglia. The patterns of responses of beta-band bursting in the model suggest that the experimentally observed beta-band synchronization in Parkinson's disease may be promoted by the simultaneous action of both cortical and subthalamo-pallidal network mechanisms.

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MS115

Topology Predicts Dynamics; Dynamics Constrain Topology

Networks are often the structure on which high dimensional dynamical systems operate. Inferring network topology from dynamics and constructing networks to exhibit target dynamics are complimentary strategies to understand their interplay. Recent efforts can infer the structure of a network from manipulations and observations of network dynamics. A computational study of a detailed model of a neuronal network suggests that networks with similar dynamics exist in connected sets in the space of all possible networks.

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MS115

Data-Driven Network Inference: Achievements, Problems, Possible Research Directions

Complex networks are powerful representations of spatially extended systems and can advance our understanding of their dynamics. A large number of analysis techniques is available that aim at inferring the underlying network structure from data. Despite great successes in various fields, there still exist a number of problems for which there are currently no satisfactory solutions. This talk will discuss these problems as well as possible research directions to help find better solutions.

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MS115

Network Structure from Responses of Time-invariants

Inferring how complex systems are interconnected solely from dynamical experiments [1] constitutes a fundamental inverse problem with practical relevance across the natural and technical sciences. So far, most inference approaches either require a high degree of knowledge about the units and the coupling modes or rely on the system being in simple states such as close to fixed points. Moreover, most approaches require the knowledge of the temporal order of the units' states or their relations. Here we present a complementary approach that instead employs invariant measures (i.e. distributions of points sampled in state space) in response to small driving forces. Given sufficiently long time series, inference is successful for very distinct systems, from networks of chaotic oscillators to genetic regulatory circuits underlying the circadian clock. These results expand our ability to infer structural connectivity of networks given temporally unordered observations, possibly stemming from different experiments with uncontrolled initial conditions. [1] J. Phys. A: Math. Theor. 47:343001 (2014).

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MS115

Data Based Modelling: Inferring the Direct Directed Network Structure from Data

Recent years have seen a large increase in the availability of data. Increasing amounts of data play a key role in every aspect of our lives. Dealing with these data sets efficiently determines the success of projects, treatments, assessments, and analyses. This necessity to better understand and analyze data has led to an outburst of research into advanced methods of data based modeling. We address various approaches to network inference based on time series data.

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MS116

Averaging and Kam Theory in Torus Canards

We consider rotated slow-fast systems of van der Pol type. Depending on the rotation speed, the resulting 3D system has 2 fast or 2 slow variables. There exists also an intermediate region with three timescales. In the region of two fast variables we prove the existence of an invariant torus and in the intermediate regime we use KAM theory to show the existence of chaotic dynamics.

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MS116

Averaging and Generic Torus Canards

Recently, torus canards have been identified in a range of neuronal burster models, and the majority of these slow/fast systems have a single slow variable. The transition from spiking to bursting occurs via a torus canard explosion, resulting in the existence of non-generic torus canards within a small parameter range. We analyse a coupled neuron model with two slow variables, and using averaging, identify folded saddle and node singularities. These structures and their bifurcations result in generic torus canards, leading to rich dynamics over a wide parameter range.

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MS116

Torus Canard Breakdown

We discuss the conditions giving rise to torus and period-doubling bifurcation pathways from tonic spiking to bursting in slow-fast systems typical in life science applications. We employ Poincare return maps to disclose fine details of the torus breakdown resulting in the rapid onset of spontaneous bursting in a Hodgkin-Huxley type model of a hair cell. Hair cells are peripheral receptors serving on the first stage in transduction of mechanical stimuli to electrical signals in the senses of hearing and balance of vertebrates. These sensors rely on nonlinear active processes to achieve astounding sensitivity, selectivity and dynamical range.

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MS116

The Interaction Between Classical Canards and Torus Canards

Canards are separatrices of slow/fast systems that lie at the intersection of attracting and repelling invariant slow manifolds. Closely associated with folded equilibria, canards have been studied extensively in $\mathbb{R}^3$. Less well-understood are torus canards, which lie at the intersection of attracting and repelling families of limit cycles. In this work, we explore the relationship between folded node/saddle canards and torus canards in various model systems.

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MS117

The Kuramoto Model of Coupled Oscillators with a Bi-Harmonic Coupling Function" Maxim Komarov

We study synchronization in a Kuramoto model of globally coupled phase oscillators with a bi-harmonic coupling function, in the thermodynamic limit of large populations. We develop a method for an analytic solution of self-consistent equations describing uniformly rotating complex order parameters, both for single-branch (one possible state of locked oscillators) and multi-branch (two possible values of locked phases) entrainment. We show that synchronous states coexist with the neutrally linearly stable asynchronous regime. The latter has a finite life time for finite ensembles, this time grows with the ensemble size as a power law.

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MS117

On the Mechanical Origin of Chimera States

Previously, we have demonstrated the emergence of chimera states in an experiment with mechanical oscillators (Martens, E. A., *et al.* PNAS (2013)) and introduced a mathemtical model based on mechanical principles. Here, I analyze this model and establish a link to abstract mathematical models in which chimera were originally discovered. With the analysis, I explain the stability diagram, discuss a new state and provide the first physical interpretation of how chimeras may arise in real world situations.

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MS117

Chimera States in Globally Coupled Oscillators

Chimera states in coupled oscillator systems, where despite of full symmetry, part of the oscillators are synchronized while other are desynchronized, have attracted large interest recently, also because of several experimental realizations. Probably, the most nontrivial situation is that of a globally coupled populations, where one and the same force acts on all oscillators in the ensemble. We give two examples of chimera formation in such a setup, and describe the underlying mechanisms of sel-induced bistability between synchrony and asynchrony.

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MS117

Mean Field Theory of Assortative Networks of Phase Oscillators

In this talk I present a technique to study synchronization in large networks of coupled oscillators, combining a mean field approximation with the ansatz of Ott and Antonsen. The formulation is illustrated on a network Kuramoto problem with degree assortativity and correlation between the node degrees and the natural oscillation frequencies. We find that degree assortativity can induce transitions from a steady macroscopic state to a temporally oscillating macroscopic state through Hopf and SNIPER bifurcations.

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MS118

Singular Bogdanov-Takens Bifurcations in the Plane

We present perturbations from planar vector fields having a line of zeros and representing a singular limit of Bogdanov-Takens (BT) bifurcations. We introduce the notion of slow-fast BT-bifurcation and we provide an overview of a complete study of the bifurcation diagram and the related phase portraits, based on geometric singular perturbation theory, including blow-up.

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MS118

Canard Orbits in Planar Slow-Fast Piecewise-Linear Systems

The basis of most neuron models is to assume that a neuron behaves as an electrical circuit, which are faithfully modeled by piecewise linear (PWL) systems. Also, neuron models are characterized by different time scales. In this work, we analyze the existence of canard orbits in a family of planar PWL slow-fast systems. The purpose is to use the results to provide models of neurons equally efficient to the smooth models, offering better mathematical tractability.

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MS118

Theoretical Analysis of Homoclinic Canards

Abstract not available.

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MS118

Folded Nodes, Canards and Mixed Mode Oscilations in 3D Piecewise-Linear Systems

New advances in 3D piecewise-linear slow-fast systems (PWL) are presented. In particular, a complete comparison with the smooth case near folded singularities is shown: singular phase portraits, singular weak and strong canards and control of the number of maximal canards are obtained in a way that is entirely compatible with the smooth case. Furthermore, by using previous analysis we present a minimal model displaying periodic canard induced mixed mode oscillations near a PWL folded-node.

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MS119

Symbolic Dynamical Unfolding of Spike-Adding Bifurcations in Chaotic Neuron Models

We show the systematic changes in the topological structure of chaotic attractors occurring as spike-adding and homoclinic bifurcations are encountered in the slow-fast dynamics of neuron models (detailed in the Hindmarsh-Rose model), where we show that the UPOs appearing after each spike-adding bifurcation are associated with specific symbolic sequences opened when the small parameter of the system decreases. This allows us to understand how these bifurcations modify the internal structure of the chaotic attractors.

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MS119

Stokes Phenomenon in a Singularly Perturbed Differential Equation

It is well known that bifurcation problems can often be studied with the help of singular perturbation theory. In these problems invariant manifolds and solutions can be found in the form of formal series. The series typically diverge and relations with analytical solutions is described by the Stokes phenomenon. In this talk we discuss the recent developments of the theory and illustrate it with examples.

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MS119

Canard Orbits and Mixed-Mode Oscillations in a Chemical Reaction Model

To study how mixed-mode oscillations are organised in Koper's three-dimensional chemical reaction model, we compute the two-dimensional attracting and repelling slow manifolds and their intersection curves, known as canard orbits. We also show how a tangency between the repelling slow manifold and the two-dimensional unstable manifold of a saddle-focus equilibrium shapes the dynamics locally

and globally.

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MS119

Homoclinic Orbits With Many Loops Near a $0^2 i\omega$ Resonant Fixed Point Of Hamiltonian Systems

In this talk we study the existence of homoclinic connections near the equilibrium point of a family of Hamiltonian systems in the neighborhood of a $0^2 i\omega$ resonance. For reversible non Hamiltonian vector fields, the splitting of the homoclinic orbits lead to exponentially small terms which prevent the existence of homoclinic connections with one loop to periodic orbits of size smaller than an exponentially small critical size. The same phenomenon occurs here but we get round this difficulty thanks to geometric arguments specific to Hamiltonian systems and by studying homoclinic orbits with many loops.

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MS120

Slow Manifolds for a Nonlocal Spde

This work is concerned with invariant manifolds for a slow-fast nonlocal stochastic evolutionary system quantified with a scale paramenter. Under suitable conditions, it is proved that an invariant manifold exists. Furthermore, it is shown that if the scale paramenter tends to zero, the invariant manifold tends to a slow manifold which captures long time dynamics.

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MS120

Slow Manifolds and Interface Motion for Stochastic PDEs

We consider examples of spatially one-dimensional stochastic partial differential equations like the Cahn-Hilliard equation perturbed by additive noise, and study the dynamics of interfaces for the stochastic model. The dynamic of the stochastic infinite dimensional system is given by the motion along a finite dimensional deterministic slow manifold M parametrized by the interface positions. Main results include stochastic stability for M, and a derivation of an effective equation for the interface positions. Joint work with Dimitra Antonopoulou and Georgia Karali.

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MS120

On the Complete Dynamical Behavior for Three Dimensional Stochastic Competitive Lotka-VolterraSystems

Abstract not available.

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MS120

Self-similarity in Stochastic PDEs

This talk present some methods to study the self-similarity of some SPDEs under certain assumptions. Attraction of the self-similar solution is shown by applying random invariant manifold theory (in almost sure sense) and a diffusion approximation (in distribution) in the case of additive noise and stochastic advection respectively.

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MS121

Exploring Experimental Paths for Reliable Mathematical Models of Friction

Structural vibration controlled by interfacial friction is widespread, ranging from earthquakes and violin strings, to vehicle brake squeal and friction dampers in gas turbines. To predict, control or prevent these systems' behaviours, a constitutive description of frictional interactions is inevitably required. We shall explore the validity of friction models from the nonlinear dynamics of a driven forced single degree of freedom oscillator in view of recent experimental data gathered from the Cambridge pin-on-disc experiment.

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MS121

Testing of a Spacecraft Structure with Non-Smooth Nonlinearities

The dynamics of the SmallSat, a real-life spacecraft possessing a complex isolation device with multiple nonsmooth nonlinearities, is investigated. Experiments show that nonlinearities induce modal interactions between modes with non-commensurate linear frequencies. A model of the structure with a simplified description of the nonlinear connections is first built using techniques available in industry. Numerical continuation is then exploited to compute nonlinear normal modes and uncover the interaction phenomena which can jeopardize the structural integrity.

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MS121

Painlevé Paradox: Lessons That We Do Not Learn from Simple Examples

Painlevé's paradox (non-uniqueness and non-existence in the dynamics of rigid multi-body system with friction) is usually studied via single-contact examples, which exhibit a limited variety of interesting dynamics. In this talk, I show new phenomena based on the analysis of systems with two unilateral, sliding contacts. These include seemingly regular systems, which fail to follow a unique and existing solution; and systems, in which the lack of solutions is not resolved by 'tangential impacts'.

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MS121

Nonlinear Dynamics and Bifurcations of Rotor-Stator Contact in Rotating Machines

A modified Jeffcott rotor model is studied that includes the effects of coupled lateral-torsional deformations and rotor-stator contact with friction. Numerically, bifurcations are found that cause instability or lift-off of either forward or backward whirl. The results are compared for three different nonsmooth friction laws and are favorably compared with analytical predictions. Implications of the results for the dynamics of drill-strings and turbomachinery are discussed.

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MS122

Nonlinear Waves in a Lugiato-Lefever Model

The Lugiato-Lefever equation is a cubic nonlinear Schrödinger equation with damping, detuning and driving force arising as a model in nonlinear optics. Steady waves of this equation are found as solutions of a four-dimensional reversible dynamical system in which the evolutionary variable is the space variable. Relying upon tools from bifurcation theory and normal forms theory, we show the existence of various types of steady solutions, including spatially localized and periodic solutions. Finally, we discuss some stability properties of periodic solutions.

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MS122

Stability of Traveling Waves in a Model for a Thin Liquid Film Flow

We consider a model for the flow of a thin liquid film down an inclined plane in the presence of a surfactant, which is known to possess various families of traveling waves. We use a combination of analytical and numerical means to show that the spectra of these waves are within the closed left-half complex plane.

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MS122

Oscillons Near Hopf Bifurcations of Planar Reaction Diffusion Equations

Oscillons are planar, spatially localized, temporally oscillating, radially symmetric structures often arising near forced Hopf bifurcations.Using spatial dynamics, we show that the dynamics on the center manifold of a periodically forced reaction diffusion equation (fRD) near a Hopf bifurcation can be captured by the forced complex GinzburgLandau equation (fCGL). Thus, oscillon solutions to the fRD can be thought of as a foliation over localized solutions to the fCGL.

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MS122

The Entry-exit Function and Geometric Singular Perturbation Theory

For small $\epsilon > 0$, the system $\dot{x} = \epsilon$, $\dot{z} = h(x,z)z$, with $h(x,0) < 0$ for $x < 0$ and $h(x,0) > 0$ for $x > 0$, admits solutions that approach the x-axis while $x < 0$ and are repelled from it when $x > 0$. The limiting attraction and repulsion points are given by the well-known entry-exit function. For $h(x,z)z$ replaced by $h(x,z)z^2$, we explain this phenomenon using geometric singular perturbation theory. The linear case can be reduced to the quadratic case, which is related to periodic traveling waves in a diffusive predator-prey model.

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MS123

Pattern-formation in Semiarid Vegetation: Using

Bifurcation Theory for Model Comparison

In semi-arid ecosystems, water is considered a limiting resource for vegetation growth. This principle gives rise to a variety of PDE models describing vegetation-water interactions that predict the formation of self-organized spatial patterns in vegetation communities as a response to resource scarcity. We use bifurcation theory to identify robust structures that persist across different models of this phenomenon. From this perspective, we find system behaviors that are robust to uncertainty in model choice, and we identify models that are not sensitive to small structural perturbations.

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MS123

Models of Patchy Invasion: A Mathematical Toy Or a New Paradigm?

A theory based on diffusion-reaction equations predicts the invasive species spread as a traveling population front separating the invaded and non-invaded regions. However, it appears to be at odds with some recent observations. In some cases, the spread takes place through formation of a distinct patchy spatial structure without any continuous boundary. I will revisit the traditional diffusion-reaction framework and show that the patchy spread is its inherent property in case the invasive species is affected by predation or pathogens. The patchy spread described by a diffusion-reaction model appears to be a scenario of alien species invasion "at the edge of extinction". I will also show that patchy spread is not an exclusive property of the diffusion-reaction systems but can be observed as well in different types of model.

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MS123

The Effect of Slow Spatial Processes in a Phytoplankton-Nutrient Model

We consider a system of reaction-diffusion equations describing the interaction of phytoplankton in the deep ocean with its nutrient. Recently, we have studied bifurcations and stability of two types of patterns exhibited by this PDE system. The result is two-fold. On the one hand, our analysis captures field observations, thereby validating the model we used. On the other hand, our analysis is of mathematical interest. In a formal derivation, using asymptotic methods, we extend a classic version of center manifold reduction to a regime where the, usually necessary, spectral gap condition is violated. With this tool, we capture parameter regimes in which each of the patterns is stable and flourishes.

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MS123

Stripe Pattern Selection by Advective RD Systems: Resilience of Banded Vegetation on Slopes

We study a Gray-Scott type system of PDEs that models vegetation in (semi-)arid regions. Observations of stripe patterns along slope contours are widespread. We focus on stripe break up into rectangles/hexagons. It is shown that an increase in slope/advection leads to an increase of resilience/stability of vegetation stripes. The analytical results generalize to classes of systems.

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MS124

Input-Ouptut Analysis in Channel Flows and Implications for Flow Control

The Navier-Stokes equations for channel flows are a prototype model for turbulent boundary layer flow control, specifically for the problem of skin-friction drag reduction. To carry out model-based control designs, control-oriented dynamical models of the processes to be controlled are needed. Such models need to contain the phenomena that are to be controlled and stabilized. We present an input-output analysis of channel flows, and control-oriented linearized models that contain much of the phenomenology of bypass transition.

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MS124

Nematic Liquid Crystal Flow in a Microfluid: Topological Transitions

Motivated by recent experimental work by Sengupta and co-workers on flow of a nematic liquid crystal (NLC) within a microfluidic, we consider flow of NLC within a channel, with homeotropic (perpendicular) anchoring on the director field at the walls. We find that this setup admits two exact steady solutions, with distinct director topology; and that based on energetic arguments, as the flow rate is increased, there is a transition from one solution to the other.

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MS124

Correlating Dynamical Structures with Forcing in 2D Flow

Lagrangian Coherent Structures (LCSs) have been widely studied in recent years, and have been shown to be a useful characterization of complex fluid flows. However, current methods to detect LCSs require knowledge of future information, and it is not known how to generate LCSs on demand. As a step toward moving past simple observation, I will discuss the correlations between forcing in an experimental quasi-2D flow and the resulting LCSs.

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MS124

Multi-Objective Optimal Control of Transport and Mixing in Fluids

Aspects of controlling transport and mixing in fluid flows have received considerable scientific interest in the last few years. Here we describe a multi-objective optimal control framework for the optimization of advective processes with respect to certain transport or mixing properties. We demonstrate it with a number of example systems, which may serve as simple models of microfluidic devices.

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MS126

Effects of Implementing Contraction to Calcium-Voltage Models

In this study we present a systematical methodology to incorporate a contraction model (Negroni_Lascano_1996) into fourteen well known single cell electrophysiology (EP) models. To evaluate how well these coupled electromechanical (EM) models behave, we study them under postextrasystolic pacing (PESP) protocol. We first compare the dynamics between the new EM models and the original EP models then we compare the contractile strength of the new EM models with the experiment (Yue et al 1985).

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MS126

Synchronization of Calcium Sparks and Waves

In this presentation, we show how membrane potential affects Ca sparks and waves, especially during delayed afterdepolarizations (DADs). We use a physiologically detailed mathematical model to investigate individual factors which affect Ca spark generation and wave propagation. We found that depolarization promotes Ca wave propagation and hyperpolarization prevents it. We will discuss the details of the underlying mechanisms in the talk.

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MS126

Nucleation and Dynamics of Spontaneous Ca Waves in Cardiac Cells

Spontaneous Calcium release (SCR) occurs when ion channel fluctuations lead to the nucleation of calcium waves in cardiac cells. This phenomenon is important since it has been linked to various cardiac arrhythmias. However, to date it is not understood what determines the timing and location of the spontaneous events within cells. Here we have developed a simplified model of SCR and analyzed a determinstic mean field limit sheds light on the essential features of this phenomenon. We find that SCR is typically nucleated at preferred sites of the cell which can determined by studying the structure of eigenvectors of a class of Euclidean random matrices. Using this approach we estimate the timing of SCR in terms of physiological parameters such as the spatial arangement of calcium release units, and the local ion channel kinetics.

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MS126

Complex Dynamic Patterns of Voltage and Calcium in Mammalian Hearts

Cardiac dynamics is govern with bidirectional coupling between transmembrane-voltage (Vm) and free intracellular calcium (Cai). Altering this coupling it is known to be the important precursor of different forms of cardiac arrhythmia and cardiac alternans as triggers for cardiac reentry. We present our experimental method for simultaneous measurements of Vm and Cai with a single sensor, and obtained experimental results of alternans and ventricular fibrillation development in different mammalian hearts (pig, rabbit, cat).

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MS127

Dynamic Information Routing in Complex Net-

works

Abstract not available.

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MS127

Unraveling Network Topology from Derivative-Variable Correlations

A method of network reconstruction from the dynamical time series is introduced, relying on the concept of derivative-variable correlation. Using a tunable observable as a parameter, the reconstruction of any network with known interaction functions is formulated via simple matrix equation. We suggest a procedure aimed at optimizing the reconstruction from the time series of length comparable to the characteristic dynamical time scale. Our method also provides a reliable precision estimate. We illustrate the method's implementation via elementary dynamical models, and demonstrate its robustness to both model and observation errors.

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MS127

Reconstructing Network Connectivity by Triplet Analysis

We discuss recovery of the directional connectivity of a small oscillator network via the phase dynamics reconstruction from multivariate data. Instead of the pairwise analysis, we analyse triplets of nodes and reveal an effective phase connectivity which is close but generally not equivalent to a structural one. By comparing the coupling functions reconstructed from all possible triplets, we achieve a good separation between existing and non-existing connections, and thus reliably reproduce the network structure.

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MS127

From Neural Dynamics to Network Properties and Cognitive Function

It remains unclear to what extend structural and functional network measurements are complementary, or rather provide orthogonal information about network state. We developed framework to capture neuronal correlations over short timescales and use them to quantify large-scale functional connectivity shifts indicative of slower structural network changes. We applied it to simulated as well as experimental data. We observed state dependent, network-wide structural modifications and significant changes in network stability, which is linked to behavior.

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MS128

Rigorous Numerics for Symbolic Dynamics and Topological Entropy Bounds

Outer approximations of continuous, discrete-time systems, or maps, incorporate bounded error and allow for the rigorous extraction of dynamics via Conley Index theory and other tools. Recent advances, including joint work with W. Kalies, M. D. LaMar, R. Trevino and R. Frongillo, have extended the class of maps to which these methods may be applied and improved the types of results that one may obtain, specifically in terms of semi-conjugate symbolic dynamics and associated lower bounds on topological entropy. I will describe some of this recent work and show sample results.

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MS128

Orbital Stability Investigations for Travelling Waves in a Nonlinearly Supported Beam

We consider the fourth-order problem

$$\varphi_{tt} + \varphi_{xxxx} + f(\varphi) = 0, \quad (x,t) \in \mathbf{R} \times \mathbf{R}^+,$$

with a nonlinearity f vanishing at 0. Solitary waves $\varphi = u(x+ct)$ satisfy the ODE

$$u'''' + c^2 u'' + f(u) = 0 \quad \text{on } \mathbf{R},$$

and for the case $f(u) = e^u - 1$, the existence of at least 36 travelling waves was proved in [Breuer, Horák, McKenna, Plum, Journal of Differential Equations 224 (2006)] by computer assisted means. We investigate the orbital stability of these solutions via computation of their Morse indicies, which heavily relies on spectral bounds for the linearized operator, and using results from [Grillakis, Shatah, Strauss, Journal of Functional Analysis 74 (1987) and 94 (1990)]. We make use of both analytical and computer-assisted techniques.

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MS128

The Parametrization Method in Infinite Dimensions

Understanding the dynamics near the equilibrium solutions of a PDE is a first step towards a global dynamical scaffold. Their (un)stable manifolds are a powerful tool in this analysis. We apply the Parameterization Method of Cabre, Fontich and de la Llave in order to study finite dimensional unstable manifolds in infinite dimensional phase space. We present both numerical implementations for some dissipative PDEs and a-posteriori theorems which provide rigorous error bounds for the numerical approximations.

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MS128

Rigorous Numerics for Some Pattern Formation Problems

This talk is about applications of recently developed techniques from rigorous computational dynamics to pattern formation phenomena. We discuss the differences and similarities in the analytic setup of three examples, namely radially symmetric spots in the Swift-Hohenberg model, transitions between hexagonal spots and stripe patterns, and phase separation in diblock copolymers. These examples, which entail both ODEs and PDEs, also showcase the interplay between rigorous numerical methods and asymptotic techniques.

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MS129

Neural Field Models Which Include Gap Junctions

Neural field models are normally derived under the assumption that connections between neurons are synaptic rather than via gap junctions. I will show how to derive a neural field model from a network of "theta neurons" with both synaptic and gap junction connectivity. The derivation is exact in the limit of an infinite number of neurons.

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MS129

From Ensembles of Pulse-Coupled Oscillators to Firing-Rate Models

Ensembles of pulse-coupled oscillators are often encountered in biological and technological systems. We report on two recent findings: 1) The solution of the prototypical model proposed by Winfree in 1967. Using the Ott-Antonsen ansatz, the effect of pulse width on the onset of macroscopic synchronization is clarified. 2) For ensembles of quadratic integrate-and-fire neurons, a "Lorentzian ansatz" permits us to obtain exact low-dimensional firing-rate equations; in contrast to the current heuristic models used in neuroscience.

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MS129

Suppressing Complex Collective Behavior in a Network of Theta Neurons by Synaptic Diversity

A large heterogeneous network of globally coupled theta neurons can demonstrate a range of collective behavior from simple equilibrium states to a collective rhythmic state. Other complexity such as multistability, quasi-periodicity, and macroscopic chaos can also occur. In the current work, we introduce heterogeneity in the neurons coupling strength and we find that synaptic diversity increases the robustness of equilibrium states and suppresses the emergence of the collective rhythmic state and other complex network behavior.

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MS130

Mixed-Mode Bursting Oscillations (MMBOs): Slow Passage Through a Spike-adding Canard Explosion

Mixed-Mode Bursting Oscillations (MMBOs) are solutions of slow-fast dynamical systems that exhibit both small amplitude oscillations (SAOs) and bursts consisting of one or multiple large-amplitude oscillations (LAOs). The name MMBO is given in analogy to Mixed-Mode Oscillations (MMOs), which consist of alternating SAOs and LAOs, without the LAOs being organized into burst events. I will show how MMBOs are created naturally in systems that have a spike-adding bifurcation, or spike-adding mechanism, and in which the dynamics of one (or more) of the slow variables causes the system to pass slowly through that bifurcation due to the presence of a folded node. The analysis is carried out for a prototypical fourth-order system of this type, which consists of the third-order Hindmarsh-Rose burster, known to have the spike-adding mechanism, and in which one of the key bifurcation parameters also varies slowly.

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MS130

An Organizing Center for Spatiotemporal Bursting

As the fundamental model of two timescales spatiotemporal excitability, FitzHugh-Nagumo model has the interpretation of a normal form reduction organized by the hysteresis singularity. We mimick the analog geometric construction in the universal unfolding of the winged cusp and obtain a three timescales model for spatiotemporal excitability. Bursts and traveling bursts are shown to be the prototypical behaviors of the proposed model, in full analogy with the spikes and traveling pulses of FitzHugh-Nagumo model.

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MS130

Three Timescale Phenomena in Coupled Morris-Lecar Equations

Theory for the analysis of systems with two timescales is well established, but some dynamical phenomena are not captured by two timescale models and less is understood about how to efficiently study systems with three or more timescales. Motivated by applications in neural dynamics, we study a pair of Morris-Lecar systems coupled so that there are three timescales in the full system. We identify complex oscillations that appear to be intrinsically three timescale phenomena, and use geometric singular perturbation theory to explain the mechanisms underlying these solutions.

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MS130

Averaging, Folded Singularities and Torus Canards in a Coupled Neuron Model

We consider transitions between various bursting and tonic spiking regimes in a coupled neuron model. Analysis of an averaged reduced system reveals the critical roles of folded singularities and the associated bifurcation scenarios, including a novel FSN III bifurcation; some of these bifurcations correspond to torus bifurcations, yielding torus canards, in the full system. We also show that the complete set of bifurcations is captured in a canonical system that can be treated analytically.

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MS131

Unitary Representations of Diffeomorphisms: Halfway Between Koopmanism and Transfer Operator Theory

Koopmanism is derived from a representation of diffeomorphisms on the space of real valued functions. Dual to this pictures is the Frobenius-Perron operator where a diffeomorphism is represented as a linear operator on densities. In this talk we will present a unitary representation of the diffeomorphism group on the Hilbert space of half-densities. The resulting representation induces numerical advection schemes which will be useful in a variety of scenarios. In particular, we may create spectral methods which preserve the ring structure of functions, conserve total mass, deform vector fields, and more. Such structure preservation is important as one considers problems in higher dimensions and requests qualitative accuracy in exchange for numerical precision.

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MS131

Optimal Control Design and Value Function Esti-

mation for Nonlinear Dynamical Systems

This presentation considers the infinite-time discounted optimal control problem for continuous time input-affine polynomial dynamical systems subject to polynomial state and box input constraints. We propose a sequence of sum-of-squares (SOS) approximations of this problem obtained by first lifting the original problem into the space of measures with continuous densities and then restricting these densities to polynomials. These approximations are tightenings, rather than relaxations, of the original problem and provide a sequence of rational controllers with value functions associated to these controllers converging (under some technical assumptions) to the value function of the original problem.

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MS131

Transfer Operator Methods for Stability Analysis and Control

Linear transfer Perron-Frobenius operator-based methods are developed for global stability analysis and control design of deterministic and stochastic nonlinear systems. The transfer operator-based Lyapunov measure is introduced as a new tool to verify weaker set-theoretic notion of almost everywhere stability. Just as an invariant measure is a counterpart of the attractor (recurrence), this measure is demonstrated as a stochastic counterpart of stability (transience). The Lyapunov measure is shown to be dual to the Lyapunov function. In addition to the theoretical results, we also present a computational method for the approximation of the Lyapunov measure and almost everywhere stabilizing feedback controller. These computational methods are based on set-oriented numerical approaches. The linear nature of the framework provides linear programming-based computational methods for finite dimensional approximation of the Lyapunov measure and stabilizing controller.

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MS131

Numerical Advection of Probability Densities for High Dimensional Systems

Understanding the effect of propagating uncertainty in initial condition through dynamical systems is critical while engineering verifiably safe systems. Given its importance, many numerical methods have been proposed to advect probability densities over an initial condition set by carefully manipulating nonnegative valued functions and densities. This management of nonegative objects unfortunately restricts the applicability of these numerical methods to low dimensional dynamical systems. In this talk, I describe a method to address this shortcoming by developing a linear advection equation over half densities, which can be thought of as the square root of classical nonnegative densities. This construction allows us to prove a rate of convergence for various numerical methods and allows us to successfully advect smooth probability densities through high dimensional systems.

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MS132

Stochastic Center Manifolds Without Gap Conditions

The existence of invariant manifolds requires that the spectrum of linear part of a deterministic system or stochastic system contains large gaps. However, for some dynamical systems, the condition of spectral gap condition is not satisfied. In this case, it is still unknown whether there exists invariant manifolds. This paper concerns the center manifolds of the stochastic systems without the spectral gap condition.

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MS132

How to Quantify Non-Gaussian Stochastic Dynamics?

Dynamical systems arising in engineering and science are often subject to random fluctuations, which may be Gaussian or non-Gaussian described by Brownian motion or a-stable Levy motion, respectively. Non-Gaussianity of the noise manifests as nonlocality at a macroscopic level. Stochastic dynamical systems with a-stable Levy motions have attracted a lot of attention recently. The non-Gaussianity index a is a significant indicator for various dynamical behaviors. The speaker will present a few aspects of non-Gaussian stochastic dynamical systems, highlighting some delicate and profound impact of noise on dynamics. Then, he will focus on understanding stochastic dynamics by examining certain deterministic quantities.

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MS132

Random Dynamical Systems for Non-Densely Defined Evolution Equations

We consider abstract random evolution equations given by

$$x'(t) = Ax(t) + F(\theta_t\omega, x(t)), x(0) = x_0 \in \overline{D(A)}. \quad (1)$$

Here, we suppose that A is a non-densely defined linear operator. Therefore, the C_0-semigroup approach no longer applies. Such situations can occur for instance due to nonlinear boundary conditions. By using integrated semigroup theory, we can show under suitable assumptions, the existence of a random dynamical system for the above equation and discuss its asymptotic behavior. Finally, we analyze a class of non-densely defined stochastic differential equations driven by a Banach-space valued Brownian motion. Our aim is to construct an Ornstein-Uhlenbeck process, which allows us to reduce the stochastic problem into a pathwise one.

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MS133

Lessons Learnt from the Two-Ball Bounce Problem

I revisit a popular classroom demonstration where a light rigid body and a larger heavier ball are vertically aligned and dropped together. Experimental results obtained using a high-speed camera are compared to a discrete model using Newtonian restitution, showing poor agreement as the separation distance becomes small. An alternative model based on membrane theory is developed and compared favourably to experimental data in the limits of very small separation distance and mass ratio.

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MS133

Predicting Conditions for Self-sustained Vibration in Drillstrings

High amplitude vibration in drillstrings is often the result of a self-sustained regime of vibration such as torsional stick-slip oscillation; forward whirl; or backward whirl. The nonlinear interactions underlying these regimes come from bit-rock interaction and side-wall contact. We present a novel approach for modelling these regimes: assuming local nonlinearity, we derive conditions necessary to sustain a given regime once it has already initiated. Results are numerically validated and give insight into each phenomenon.

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MS133

Contact and Friction Within Geometrically Exact Shell Theory - Modeling Microslip and Dissipation in Structural Systems

We consider the representation of the dissipation due to frictional interfaces within large-scale structural systems. In this work contact and friction are incorporated within geometrically exact shell theory, providing insight into the relationship between the observed dissipation and the loading characteristics on the shell. Finally, the use of such formulations as a basis for reduced-order modeling and extensions to the larger problem of structural damping are highlighted.

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MS133

A New Semi-Analytical Algorithm for Two-Dimensional Coulomb Frictional System

A closed form solution for the trajectory of a planer particle loaded by constant external force with Coulomb friction has been proposed. Together with analytical patches close to slip/stick transitions, this solution has been employed to build a new semi-analytical algorithm for two-dimensional frictional system subjected to time-varying external loads under the assumption that the external loads can be treated as constant if the time step is sufficient small.

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MS134

Stability of Combustion Fronts in Hydraulically Resistant Porous Media

We study front solutions of a system that models combustion in porous media. The spectral stability of the fronts is studied on the linear and nonlinear level. For the spectral stability analysis we use a combination of energy estimates and numerical Evans function computations.

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MS134

Invasion Fronts in Systems of Reaction Diffusion Equations

We study invasion speeds in a system of coupled Fisher-KPP equations. For certain parameter regimes we prove that the speed selected by compactly supported initial data is faster for the coupled system than for the uncoupled one. The proof relies on the construction of sub and super solutions.

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MS134

An Overview of Evans Function Computation

We give an overview of Evans function and the numerical techniques used to compute it. We provide a mini-tutorial on STABLAB, a MATLAB-based toolbox for Evans function computation, and show how to avoid some of the common pitfalls that arise in Evans function computation. There are also a number of best practices that we highlight, noting that there are many variations on methods and formulations. Different situations call for different approaches.

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MS134

Orbital Stability of Waves Traveling Along Vortex Filaments

By the term vortex filament, we mean a mass of whirling fluid or air (e.g. a whirlpool or whirlwind) concentrated along a slender tube. The most spectacular and well-known example of a vortex filament is a tornado. A waterspout and dust devil are other examples. In more technical applications, vortex filaments are seen and used in contexts such as superfluids and superconductivity. One system of equations used to describe the dynamics of vortex filaments is the Vortex Filament Equation (VFE). The VFE is a system giving the time evolution of the curve around which the vorticity is concentrated. In this talk, we develop a framework for studying the stability solutions of the VFE, based on the correspondence between the VFE and the NLS provided by the Hasimoto map. We use this framework to establish the orbital stability of certain classes of solutions including solitons and closed solutions taking the form of torus knots.

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PP1

The Breakup of Invariant Tori in 4-D Maps Using the Slater's Criterion

In the late of 40s, N. B. Slater proved that an irrational translation over an unity circle can take at most three different return counts to a connected interval ($\delta < 1$). In addition, these three recurrence times are expressible by the continued fraction expansion of the irrational number used to the translation. This remarkable result has an immediate connection with invariant tori, whose rotation number in the bi-dimensional phase space is also irrational and can be related to a motion over the circle. Thus, the evaluation of three recurrence times has been used to predict breakup of such invariant tori in several 2-D dynamical systems. Here we introduce the Slater's theorem in the context of higher dimension Hamiltonian systems to estimate the breakup of invariant tori in a 4-Dimensional symplectic map.

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PP1

Theta Model for Quartic Integrate-and-Fire Neuron Model

The theta model is convenient to investigate the population dynamics of coupled noisy neurons due to the periodic boundary conditions of the corresponding Fokker-Planck equation. However, quantitative relationships between the theta model and conductance-based neuron models has not been thoroughly explored. We propose a version of the theta model derived from a quartic integrate-and-fire model, which has quantitatively equivalent dynamics to biophysically realistic Wang-Buzsaki model. We also analyze the population dynamics of this new model.

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PP1

A Solution of Linear Programming Problems with Interval Coefficients

In this talk, we consider a linear programming problem where the coefficients are interval. For these problems, we cannot apply the technique of the classical linear programming directly. We focus on a satisfactory solution approach based on the inequality relations that was introduced by Alolyan and to solve the interval linear programming problem. In order to solve such a problem, we present an algorithm that find the solution of such a problem and show the efficiency of the algorithm and present a numerical example.

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PP1

Developing a Model Approximation Method and Parameter Estimates for a Solar Thermochemistry Application

We will show the model and software development process used in creating a robust parameter optimizer for a solar reactor. The basic reaction model is numerically difficult to solve, so several proprietary elements of code were developed to interface with standard optimization routines. Integrating complex toolboxes and non-standard code led to several insights into good development practices which will be highlighted.

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PP1

Hamiltonian Hopf Bifurcations in Schrdinger Trimers

The cubic nonlinear Schrdinger equation is fundamentally important in the physics of waves, arising in optical fibers, waveguides, Bose-Einstein condensates, and water waves.

We investigate the phase space of the three-mode discrete NLS in the weakly nonlinear regime. We enumerate the families of standing waves and use normal forms to describe several families of relative periodic orbits whose topologies change due to Hamiltonian Hopf bifurcations and others.

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PP1

Computing the Optimal Path in Stochastic Dynamical Systems

In stochastic systems, we are often interested in quantifying the optimal path that maximizes the probability of switching between metastable states. However, in high-dimensional systems, the optimal path is often extremely difficult to approximate. We consider a variety of problems from population biology and demonstrate a constructive methodology to quantify the optimal path using a combination of finite-time Lyaponuv exponents, statistical selection criteria, and a Newton-based iterative minimizing scheme.

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PP1

Effects of Quasi-Steady-State Reduction on Biophysical Models with Oscillations

Many mathematical models of biological systems possess multiple time scales. A common first step in the analysis of such models is the elimination of one or more of the fastest variables via quasi-steady-state reduction (QSSR). However, this process sometimes leads to changes in the dynamics by introducing or removing bifurcations. We discuss the persistence of Hopf bifurcations under QSSR and show examples of qualitative changes to oscillatory dynamics that can be induced by QSSR.

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PP1

Analyzing Cycling Dynamics in Stochastic Systems

We consider a Langevin model where external noise causes random switching between metastable states. A chain of these states, such as those found in a multi-well potential, enables cycling dynamics. Switching times are found using a variational approach. Additionally, a probabilistic argument is used to understand the cycling dynamics. Analytical results agree well with numerical simulations for a range of well depths and noise intensities.

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PP1

Limit Cycles in a Simplified Basal Ganglia Model

Muscle rigidity associated with Parkinson's disease is thought to be correlated with the loss of dopamine and the emergence of beta oscillations in the basal ganglia. As dopamine-producing neurons die off, synaptic connection strengths change leading to a favoring of the Indirect Pathway. Though a model of the entire basal ganglia process is quite complicated, we show that a simplified version can exhibit both steady-state and limit cycle behavior by changes in connection strength alone.

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PP1

Mathematical Modelling of Spatial Sorting and Evolution in a Host-Parasite System

We examine the spatial self-structuring of traits in both a cane toad population and lungworm parasite population, which evolves with the cane toad population. In particular, the traits we focus on are dispersal ability for the cane toad population and both prepatent period and larval size for the lungworm parasite population. Along with the spatial self-structuring of these traits, our results confirm observations made in empirical studies; particularly, that there is a noticeable lag between the host and parasite population, that older populations regress to lower dispersal speeds and that "spatial sorting" of dispersal ability can still occur with a disadvantage in reproductivity and/or survival in more motile individuals. Moreover, we find that such a disadvantage in reproductivity and/or survival is unlikely to be large if spatial sorting is to have a noticeable effect

on the rate of range expansion, as it has been observed to have over the last 60 years in northern Australia.

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PP1

Using Tangles to Quantify Topological Mixing of Fluids

Topological entropy (TE), a measure of topological mixing, can be studied by the braiding of ghost rods. We study the system of Grover et al. [Chaos 22,043135 (2012)] using a heteroclinic tangle. In this approach, we explain TE through intersecting stable and unstable manifolds using homotopic lobe dynamics (HLD). The HLD method uses ghost rods placed on heteroclinic orbits, which allows us to compute TE in excess of that given by simple periodic braiding.

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PP1

New Computational Tools for Non-Smooth Dynamical Systems

We will present development of new computational tools capable to comprehensively analyse the non-smooth dynamical systems. They will allow for high accuracy and speed brute force numerical simulation of dynamical systems having various types of discontinuities. On the same platform a powerful and convenient path-following module is being developed allowing for modelling and analysis of non-smooth systems efficiently. As an example, we will present the modelling and analysis of soft impact oscillators. The ultimate aim of the project is to take the state-of-art of computational tools available for non-smooth systems a step further.

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PP1

Modeling the Lymphocytic Choriomeningitis Virus: Insights into Understanding Its Epidemiology in the Wild

The lymphocytic choriomenigitis virus (LCMV) is a rodent-spread virus commonly recognized as causing neurological disease that exhibits asymptomatic pathology. We looked to construct an epidemiological model of a mouse population to better understand how this virus can remain endemic. We used an SIRC model that incorporated gender dynamics as to capture the primary aspects of the disease, and establish some initial findings under which the carriers remained stable.

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PP1

Causal Relationships Between Time Series: Generalizing Takens' Theorem to a Dynamical Network

We consider a set of scalar time series measured from a dynamical system evolving on an invariant manifold M. Takens' Theorem says that the state space reconstruction (SSR) for a time series is generically diffeomorphic to M. A non-generic SSR does not faithfully represent M. We prove that it generically represents the dynamics of a feedback system within the larger dynamical system. Time series SSRs are compared to recover potential causal relationships between feedback systems.

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PP1

Regular Acceleration from Low Initial Energies in a Magnetized Relativistic System

We consider a relativistic particle interacting with a uniform magnetic field and a stationary electrostatic wave. According to the parameters of the wave, triangular islands appear in the low energy region of phase space. In this scenario, a particle with initial energy close to its rest energy is accelerated and achieves a considerable final energy. We obtain analytically the parameter region for which the particle can be regularly accelerated from very low initial energies.

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PP1

Estimating the L^∞-Norm of Linear Solutions of Cahn-Hilliard

Using a simple toy model we approach the problem of L^∞-bounds on linear solutions of the strong subspace of Cahn-Hilliard solutions and relate it to its pattern development.

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PP1

Spike Adding in Transient Dynamics

Many mathematical models of neuron activity exhibit complex oscillations in response to stimulus from an applied current or from other neurons. We consider the effect of a single short stimulus on a neuron that is otherwise quiescent, focussing on the transient response induced by the stimulus. We use numerical continuation methods and exploit the presence of different time scales in the model to explain how the oscillatory pattern in the transient response depends on parameters.

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PP1

Front-Dynamics and Pattern Selection in the Wake of Triggered Instabilities

Pattern-forming fronts are often controlled by some external stimulus which progresses at fixed speed, rendering the medium unstable. Such "triggers" control dynamics in two generic ways corresponding to pushed and pulled fronts. The former is governed by oscillatory nonlinear interactions, leading to hysteresis and multi-stability. The latter is governed by absolute spectra and interacts monotonically. We use heteroclinic bifurcation and functional analytic techniques to study prototypical examples in the complex Ginzburg Landau and Cahn-Hilliard equations.

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PP1

Pattern Sequences as Early-warning Signs of Critical Transition in Models of Dryland Vegetation

Regular spatial patterns (resembling tiger stripes and leopard spots) occur in the vegetation of many dryland ecosystems, and are hypothesized to be a self-organized response to water scarcity. Numerous partial differential equation models of vegetation-water interactions based on this hypothesis have been proposed to investigate how patterned ecosystems may respond to increased water scarcity. As a precipitation parameter decreases in value, a sequence of patterns, gaps → labyrinths → spots, is observed in simulations of many of these models. Observations of this kind have led this sequence to be suggested as an early-warning sign of dryland vegetation collapse. In a previous bifurcation theoretic analysis, we analytically studied transitions between two pattern-forming instabilities to assess the generic robustness of the "gaps → labyrinths → spots' sequence. We found that alternative sequences of patterns are possible in this generic setting, and we conjectured that a calculable quantity signals the appearance of the standard pattern transition sequence in the models. Here, we test this conjecture in two widely studied vegetation models through weakly nonlinear analyses and numerical simulations. We find that our conjecture holds in these models for the space of parameter values considered. In addition, we find that a sequence involving only spot patterns occurs as a common alternative to the standard sequence.

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PP1

Rigorous Computation of Radially Symmetric Stationary Solutions of Pdes

We present a rigorous numerical method for proving the existence of radially symmetric solutions of stationary PDEs on the entire space. By combining numerical methods with functional analytic estimates, we show the existence of a solution by showing the existence of a fixed point of an equivalent fixed-point problem $T(x) = x$. We shall apply this method to a previously unsolved Ginzburg-Landau type equation.

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PP1

Dynamics of Register Transitions in Human Vocal Fold Modeling

There are several theories as to the mechanism of register transitions in the human voice. The suddenness of the change under smooth variations of aerodynamic and biomechanical parameters suggests a bifurcation-like phenomenon with hysteresis. Often, the mechanics of the human vocal folds are modeled by a simple system of coupled oscillators. We show in theory and simulations what dynamical phenomena in these systems could generate such transitions.

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PP1

A Mathematical Model of Saliva Secretion and Calcium Dynamics

Oscillations in free intracellular calcium (Ca^{2+}) concentration carry signals that control cellular processes such as neuronal firing and secretion. Experimental data show that oscillations of Ca^{2+} in certain salivary duct cells are coupled to oscillations in inositol trisphosphate (IP_3). I will describe a recently constructed model of Ca^{2+} dynamics in salivary duct cells that captures important dynamical features of the data and shows how the dynamics of IP_3 affects certain features of the calcium oscillations.

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PP1

Mixed-Mode Oscillations and Twin Canards

We consider mixed-mode oscillations (MMOs), featuring a mix of small and large amplitudes, in dynamical systems with one fast and two slow variables. These oscillations are organised by canard orbits, which are intersection curves between attracting and repelling two-dimensional slow manifolds. We show how paired or twin canards with the same number of small oscillations arise in fold bifurcations of slow manifolds, and what this implies for the observed MMOs.

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PP1

A Dynamical Analysis of Steam Supply Network Based on Invariant Manifold

In this presentation, we analyze dynamics of heat supply in a simple steam supply system. The system consists of two steam boilers and a steam pipe which enables heat transfer between the two boilers. An invariant manifold representing steady operating condition of the system is located, and its existence and persistence are investigated. This clarifies the stability aspect of the steam supply system.

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PP1

Defects in Spatially Extended Systems

We look at the effects of defects on pattern formation as a perturbation problem. We present a few examples of spatially extended pattern forming systems, and explain why regular perturbation theory fails due to critical continuous spectrum. We show how Kondratiev spaces can help alleviate this difficulty: the linearization at periodic patterns becomes a Fredholm operator, albeit with negative index. Together with far-field matching procedures, we obtain deformed stripe patterns or pacemakers using implicit function type continuation.

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PP1

Delayed Feedback Model of Axonal Length Sensing

It has been proposed that an axon is able to gauge its own length based on the frequency of the oscillations of a molecular motor-based retrograde chemical signal. The frequency is inversely related to the length of the axon. We model the chemical oscillations using a system of delay differential equations and reproduce this relationship. We then investigate the behavior of these chemical signals as we model motor dynamics using stochastic partial differential equations.

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PP1

Nonlinear Dynamical Systems in Finance

Dynamical system is very popular and important issue in todays World. It is important to understand systems in geology, mathematics, microbiology, biology, computer science, economics, engineering, finance, algorithmic trading, meteorology, philosophy, physics, politics, population dynamics, psychology, meteorology, robotics etc. Then with having clear understanding about system we can make better predictions. In poster, definition and usage areas of nonlinear dynamical system and chaos will be covered. Main aim is understanding the dynamical system in finance.

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PP1

Polyrhythmic Synchronization in Modular Networks

CPGs comprised of coupled interneuron circuits underlie wide ranges of natural rhythmic behaviors. Phase lag return maps describing polyrhythmic behavior in three-node reciprocally-inhibitory Fitzhugh-Nagumo type networks characterize regimes of robustness and stability similar to natural patterns. Further, we examine complex rhythm generation in modular network settings coupling two such networks. Transition from small local-networks to so-called network-of-networks permits within-circuit multiphase coordinated pattern storage that may underlie learning and memory of more complex motor rhythm patterns.

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PP1

Discriminating Chaotic and Stochastic Dynamics Through the Permutation Spectrum Test

In this poster a new test for detecting determinism from time series data will be presented. The test involves looking for reoccurring patterns in time series data. The test will be described and the results of the test applied to several model systems and real-world data sets will be presented. The presentation will conclude with a discussion of future avenues of research related to the test.

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PP1

Coupling Methods As a Tool for Sensitivity Analysis of Stochastic Differential Equations

Under appropriate assumptions of Ergodicity, the expected value of observables for dynamical systems can be approximated by time averages. The introduction of stochastic forcing in the form of additive white noise can result in greatly increased varience of the observable estimates, making sensitivity analysis a delicate task. In this setting, coupling methods can be employed as a tool for varience reduction. The methods and their applications to Stochastic Differential Equations will be discussed.

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PP1

Transient Dynamics in Ensemble of Inhibitory Coupled Rulkov Maps

We study numerically three Rulkov maps with mutual inertia inhibitory couplings. We study numerically different dynamical regimes that can be obtained in this ensemble by governing coupling parameters, in particular, sequential activity regime and multistable regime, and bifurcation transition from one regime to another.

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PP1

Complex Collective Behavior in a Network of Theta Neurons is Suppressed by Synaptic Diversity

In the wake of a study that examined the collective dynamics of a large network of uniformly coupled Type 1 neurons, we explored how the patterns of macroscopic behavior change with respect to alterations in different neuron parameters of a model that includes realistic biological diversity through connection variability. Our analysis demonstrated that heterogeneity in coupling strength increases the robustness of equilibrium states and increasing synaptic diversity suppresses the emergence of the collective rhythmic state.

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PP1

Shape Coherence and Finite-Time Curvature Evo-

lution in Time-Dependent Dynamical Systems

We present finite-time curvature (FTC) as a local propensity of curvature elements to change. The FTC simplifies the recent study of shape coherence in nonautonomous dynamical systems. Trough (low) FTC curves indicate shape coherent sets. Finding slowly evolving boundary curvature describes slowly changing shapes in otherwise complex nonlinear flows, where stretching and folding may dominate. FTC troughs are often nearby the popular Finite-Time Lyapunov Exponent (FTLE) ridges, but often the FTC indicates entirely different regions.

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PP1

Snaking on Networks: From Local Solutions to Turing Patterns

The emergence of patterns of activity on complex networks with reaction-diffusion dynamics on the nodes is studied. The transition is investigated between the single-node solutions, studied previously [Wolfrum, Physica D (2012)], and the fully developed global activation states (so called Turing states). Numerical continuation reveals snaking bifurcations connecting different solutions, similar to those found in reaction diffusion systems on regular lattice network topologies, shedding light on the origin of the multistable "Turing' patterns reported previously [Nakao & Mikhailov, Nature 2010].

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PP1

Fractal Boundaries in the Parameters Space of Deterministic Dynamical Systems

Nonlinear dynamical systems may exhibit sensitivity to small perturbations in their control parameters. Such sensitivity is source of uncertainties on the predictability of tunning parameters that lead these systems to either a chaotic or a periodic behavior. In this work, by quantifying such uncertainties in different classes of nonlinear systems, we obtain the exterior dimension of parameters sets that lead the system to chaotic or to periodic behavior. we show that this dimension is fractal, explaining the sensitivity observed in tunning the parameter to those two behaviors. Moreover, we show that this dimension is roughly the same for the classes of investigated systems.

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PP1

A Biophysical Model for the Role of Network Topology in Regulating a Two-Phase Breathing Rhythm

Respiration occurs in a two-phase pattern, with alternating inspiration and expiration. This arises from alternating activity among groups of neurons in the pre-Btzinger and Btzinger areas in the brainstem. However, much about the network mechanisms that produce this activity remains unknown. Using a biophysical computational model to explore different topological structures and their ability to generate a two-phase rhythm, we show how modular vs. random structure of the inhibitory connections affect global dynamics.

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PP1

Modeling Effects of Drugs of Abuse on Hiv-Specific Antibody Responses

Drugs of abuse enhance HIV replication and diminish host immune responses. Here, we present a dynamical system model that helps quantify the effects of drugs of abuse on altering HIV-specific antibody responses. Our model is consistent with the experimental data from simian immunodeficiency virus infection of morphine-addicted macaques. Using our model, we show how altered antibody responses due to drugs of abuse affect steady state viral load and CD4 count in HIV-infected drug abusers.

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PP1

Time-Delayed Model of Immune Response in Plants

When studying the dynamics of plant infections, it is essential to correctly account for detailed mechanisms of plant immune response. We have developed and analysed a new mathematical model of plant immune response that takes post-transcriptional gene silencing into account. We have performed analytical and numerical bifurcation analysis to investigate how stability of the steady states depends on time delays, and also to illustrate different dynamical regimes that can be exhibited by the model.

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PP1

Analysis and Control of Pre-Extinction Dynamics in Stochastic Populations

We consider a stochastic population model where the intrinsic noise causes random switching between metastable states before the population goes extinct. Switching and extinction times are found using a master equation approach and a WKB approximation. In addition, a probabilistic argument is used to understand the pre-extinction cycling dynamics. We also implement a control method to decrease the mean time to extinction. Analytical results agree well with numerical Monte Carlo simulations.

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PP1

An Explicit Formula for R_0 of Tick-Borne Relapsing Fever

Tick Borne Relapsing Fever (TBRF) is a disease spread among mammals by soft bodied ticks in the Western United States which is characterized by (possibly multiple) relapsing states of fever and muscle aches. There is a natural question regarding how the number of relapse states affects the spread. In this poster we will use analytical methods to derive an expression for TBRF's fundamental reproductive number R_0 as a function of the number of relapses.

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PP1

Title Not Available

Our work builds on Kurebayashi et al. (2013), where they derive a general phase equation for an autonomous system with a slowly varying parameter. We reproduce their result using the Fredholm alternative, and extend it to weakly coupled oscillators by deriving an equation for the interaction function with a slowly varying parameter. We test our theory with a lambda-omega system and a Traub+adaptation model using stochastic, periodic, and quasi-periodic slow parameters.

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PP1

Stochastic Motion of Bumps in Planar Neural Fields

We analyze the effects of spatiotemporal noise on stationary pulse solutions (bumps) in neural field equations on planar domains. Fluctuations in neural activity are modeled as a Langevin equation. Noise causes bumps to wander diffusively. We derive effective equations describing the bump dynamics as Brownian motion in two-dimensions. We also consider weak external inputs that can pin the bump so that it obeys an Ornstein-Uhlenbeck process with coefficients determined by input shape.

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PP1

Automatically Proving Periodic Solutions to Polynomial ODEs

Rigorously proving the existence of a solution to ODEs in a neighborhood of a given numerical approximation is of primary importance in order to determine the accuracy of the numerical approximation. One approach is to use a functional analytic setting that is well suited to continuation techniques. We discuss an implementation for periodic solutions to general systems of polynomial ODEs. We present several examples that serve as test problems for the automated algorithm.

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PP1

Repulsive Inhibition Promotes Synchrony in Excitatory Networks of Bursting Neurons

We show that the addition of pairwise repulsive inhibition to excitatory networks of bursting neurons induces synchrony, in contrast to one's expectations. Through stability analysis, we reveal the mechanism underlying this purely synergetic phenomenon and demonstrate that it originates from the transition between bursting of different types, caused by excitatory-inhibitory synaptic coupling. We also reveal a synergetic interplay of repulsive inhibition and electrical coupling in synchronization of bursting networks.

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PP1

Quasipatterns in Two and Three Dimensions

Quasipatterns (patterns with no translation symmetry but with rotation symmetry on average) can occur in a variety of systems, including Faraday waves, nonlinear optics, polymer micelles and coupled reaction-diffusion systems. This poster will explore how having two interacting wavelengths in the physical system can stabilise quasipatterns in two and three dimensions, or can lead to spatio-temporal chaos.

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PP1

Computing Chaotic Transport Properties in a Mixed Phase Space with Periodic Orbits

Chaotic transport can be quantified using periodic orbits, but difficulties arise in a mixed Hamiltonian phase space. Homotopic Lobe Dynamics uses topological forcing by intersections of stable and unstable manifolds of anchor orbits to find periodic orbits in such a space. We compute decay rates for the Hénon map in a variety of parameter regimes. In a hyperbolic plateau, periodic orbit continuation is used to accurately compute the decay rate for the entire interval.

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PP1

Rigorous Computations for BVPs with Chebyshev-series

The main goal of my research is to bridge the gap between non-rigorous numerical simulation of dynamical systems and mathematically sound results. Recently, a rigorous numerical procedure based on Chebyshev-series (a non-periodic analog of Fourier series) was developed to solve ODEs and BVPs. My research is concerned with extending this method by incorporating domain decomposition. Applications include rigorous computations of connecting and periodic orbits in the Lorenz-system.

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PP1

Central Configurations of Symmetrically Restricted Five-Body Problem

We study the central configuration of a highly symmetric five-body problem where four of the masses are placed at the vertices of the isosceles trapezoid and the fifth body can take various positions on the axis of symmetry. We identify regions in the phase space where it is possible to choose positive masses which will make the configuration central. We propose a global regularization scheme which removes singularities associated with single-binary collisions. Finally we numerically show existence of quasi-periodic orbits in the central configuration regions.

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PP1

Finite Time Diagnostics and Transport Barriers in Non Twist Systems

Internal transport barriers that appear in Hamiltonian dynamical systems have been proposed as an explanation for the cessation or reduction of transport in physical systems at describe fluids and plasmas. These barriers may have various physical or dynamical origins, yet they can and have been used to control experiments and sometimes to improve desired confinement of trajectories. We use the so-called standard nontwist map, a paradigmatic example of non twist systems, to analyze the parameter dependence of the transport through a broken barrier. On varying a proper control parameter, we identify the onset of structures with high stickiness that give rise to an effective barriers. We use the finite-time rotation number to identify transport barriers that separate different regions of stickiness. The identified barriers are comparable to those obtained by using finite-time Lyapunov exponents.

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PP1

Robust Pulse Generators in An Excitable Medium

We study a spontaneous pulse-generating mechanism in an excitable medium with jump-type heterogeneity. We investigate the conditions for the onset of robust-type pulse generators, and then we show the global bifurcation structure of heterogeneity-induced patterns, including the homoclinic orbits that are homoclinic to a special type of heterogeneity-induced ordered pattern. These numerical approaches assist us in identifying a candidate for the organizing center as a codimension-two gluing bifurcation.

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PP1

Dynamical Building Blocks in Turbulent Two-Dimensional Channel Flow

Although the classical sweep-ejection cycles cannot be self-sustaining itself, two-dimensional channel flows keep them regenerating for a quite long time. The relation between localized coherent structures and their collective dynamics is investigated numerically focusing on a turbulent-laminar interface. The existence of interfaces reduces the complexity of the collective dynamics arising around them. We use the damping filter technique to simulate a laminar-turbulent interface in a periodic box.

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PP1

Phase Models and Oscillators with Time Delayed All-to-All Coupling

We consider a system modeling a network of globally delayed coupled identical oscillators. Assuming weak coupling, we reduce the system to a phase model where the delay acts as a phase shift. We show how the delay affects the stability of different symmetric cluster states, and applied the results to a network of six globally coupled Morris-Lecar oscillators with synaptic coupling. Furthermore, we compare the phase model results to bifurcation studies of the full model.

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PP1

Efficient Design of Navigable Networks

Navigation is a dynamic process where individual agents try to reach targets given limited knowledge. In a network of agents, we term a successive gradient-like navigation path to the target as a greedy path, and show that (interestingly) it violates many known properties of usual network paths such as symmetry and transitivity even for undirected networks. Despite these complications, we are able to design an efficient scheme that allows every network to be navigable.

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PP1

Instability of Certain Equilibrium Solutions of the Euler Fluid Equations

We look at the stability of the family of stationary solutions $\cos(mx+ny)$ of the Euler Equations on a toroidal domain. We use a Poisson structure preserving truncation described by Zeitlin [1991] to turn the problem into a finite-mode system, and a splitting into subsystems described by Li [2000]. We show that for many m and n these stationary solutions are unstable.

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PP1

A Symbolic Method in Chua's Circuit

A symbolic method is introduced in a three-dimensional Chua's circuit with a smooth cubic nonlinearity. The new method is able to reveal thousands of homoclinic bifurcation curves in a bi-parametric plane with a small amount of computational cost. Co-dimension two points, t-points and close homoclinc curves are detected as well. Based on the bi-parametric plots of the Chua's circuit, chaotic structure

of the Chua's circuit is studied.

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PP1

Interactions of Solitary Modes in Models of Bacterial Chemotaxis

We study the interaction of two colliding bacterial populations in a one-dimensional nutrient gradient. The outcome of such collisions varies. For example, upon collision, two populations of *E. coli* will either mix together to become one indistinguishable population or deflect off and move away from one another. We use a Keller-Segel model of bacterial chemotaxis to determine mechanisms by which each observed outcome may occur and make experimental predictions about the behavior following a collision.

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PP1

The Spread of Activity with Refractory Periods over Directed Networks

We study propagation of activity in a discrete time dynamical system on several directed network topologies. At each time step, active nodes send the signal onward through their outgoing connections, and fall into a refractory period. In particular, we investigate the number and length of attractors (node sequences that can sustain activity indefinitely) and transients on networks of varying topologies including random, small-world, scale-free.

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PP2

Intermittent Synchronization/desynchronization in Population Dynamics

Synchronous dynamics of spatially distinct oscillating populations is a well-known phenomenon in ecology. Mathematical modeling of this phenomenon has been largely focused on the synchronization conditions and the properties of synchronized dynamics. Yet the synchrony in the real populations is not necessary strong and therefore exhibit intervals of uncorrelated, desynchronized dynamics. We explore the properties of these time-intervals and discuss potential advantages and disadvantages of short numerous desynchronization intervals vs. few long desynchronization intervals.

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PP2

Parabolic Bursting in Inhibitory Neural Circuits

We study the rhythmogenesis of network bursting emerging in inhibitory motifs comprised of tonic spiking interneurons described by an adopted Plant model.Such motifs are the building blocks in larger neural networks, including the central pattern generator controlling swim locomotion of sea slug Melibe leonine.

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PP2

An Accurate Computation of the Tangent Map for Computation of Lagrangian Coherent Structures

The tangent map (flow map gradient) is often used in dynamical systems for computation of Lagrangian coherent structures. In more sophisticated methods it is important to recover the complete spectrum of this operator, as well as the eigenvectors. Traditional methods to compute the tangent map using finite differencing often fail in accurately computing these quantities. Due to nonlinear effects of the flow, perturbations of trajectories mapped forward by the tangent map may grow excessively and they collapse on the dominant eigenvector of the map. We describe alternative techniques to overcome these issues. Both continuous or discrete singular value decompositions with efficient implementations are used to automatically carry out computation of finite time Lyapunov exponents and directions. Results on sum of Lyapunov exponents for divergent free flow, as well as sensitivity to integration time are compared

in contrast to previous methods.

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PP2

Nonlinear Dynamics in Coupled Semiconductor Laser Network Implementations

Coupled semiconductor lasers subject to optical injection and/or feedback are known to exhibit complex dynamics in their emitted output. Current implementations usually employ only a few lasers in order to map the regimes of the exhibited dynamics. In the present work, a large-scale network of coupled semiconductor lasers is built experimentally, including up to 24 laser devices. Rich dynamics are recorded, depending on the conditions of coupling strength and time delays among the laser nodes.

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PP2

Symplectic Maps with Reversed Current in a Tokamaks

Plasmas are confined in tokamaks by magnetic field lines. We derive a bidimensional conservative map which describes these lines considering a non-monotonic profile of safety factor with reversed current density, first in equilibrium [C. Martins et al., Analytical solutions for Tokamak equilibria with reversed toroidal current, PoP 18(2011)], and then we will apply a perturbation (ergodic magnetic limiter). We will investigate island chains, chaos and particle transport.

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PP2

Analysis of Spatiotemporal Dynamical Systems from Multi-Attribute Satellite Images

We deduce and then analyze oceanic fluid systems by remote sensing from satellite images. Time varying vector fields are computed from the nonautonomous system by temporal intensity changes of observed product movements. To emphasize prior assumed physics, an objective function and consequent calculus of variations follows. As an important initial task, we show how to remove sensor-data biased of stripes from images by developing a new approach in terms of a nonisotropic total variation denoising.

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PP2

Phase Response Analysis of the Circadian Clock in Neurospora Crassa

Circadian rhythm is crucial in maintaining an organism's daily routine. We present a model which accurately simulates the molecular components governing the circadian clock of the model organism, *Neurospora crassa*. Environmental cues such as light perturb the phase of the circadian oscillator, a phenomenon generally measured with a phase response curve (PRC). Our model advocates that Neurospora's phase response to light is primarily regulated by the degradation of the clock protein White Collar-1 (WC-1).

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PP2

Time Series Based Prediction of Extreme Events in High-Dimensional Excitable Systems

We investigate extreme events in a high-dimensional deterministic system: a network of FitzHugh-Nagumo units. We present a data-driven approach to predict extreme events which is only based on the time series of some observables and on the coupling topology of the network. By iterative predictions, we are able to forecast the onset of an extreme event as well as the propagation and extinction of excitation, i.e. the full life-cycle of an extreme event.

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PP2

Slow-fast Analysis of Earthquake Faulting

We consider a rate and state dependent friction law to study earthquake fault dynamics. We show that the system has an embedded slow-fast structure. Using techniques from geometric singular perturbation theory and centre manifold theory we perform an analytical investigation of the problem.

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PP2

Quasicycles in the Stochastic Hybrid Morris-Lecar Neural Model

Intrinsic noise from the stochastic nature of voltage-gated ion channels affects a neuron's ability to produce subthreshold oscillations and respond to weak periodic stimuli. While it is known that stochastic models can produce oscillations in regimes where the deterministic model has only a stable fixed point, little work has explored these connections to channel noise. Using a stochastic hybrid Morris-Lecar model, we use various approximation schemes to derive a stochastic differential equation, then derive the power spectrum and quantify how oscillations are affected by channel noise.

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PP2

Computation of Normally Hyperbolic Invariant Manifolds

In this poster we explain a method for the computation of normally hyperbolic invariant manifolds (NHIM) in discrete dynamical systems. The method is based in finding a parameterization for the manifold formulating a functional equation. We solve the invariance equation using a Newton-like method taking advantage of the dynamics and the geometry of the invariant manifold and its invariant bundles. Particularly, we present two different kind of methods to compute normally hyperbolic invariant tori, NHIT. The first method is based on a KAM-like theorem in a-posteriori format for the existence of quasi-periodic invariant tori, which provides us an efficient algorithm for computing NHIT, by adjusting parameters of the family. The second method allows us to compute a NHIT and its internal dynamics, which is a-priori unknown. We implement both methods to continue the invariant tori with respect to parameters, and to explore different mechanisms of breakdown.

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PP2

Equivalent Probability Density Moments Determine Equivalent Epidemics in An Sirs Model with Temporary Immunity

In an SIRS compartment model for a disease we consider the effect of different probability distributions for remaining immune. We show that to first approximation the first three moments of the corresponding probability densities are sufficient to well describe oscillatory solutions corresponding to recurrent epidemics. We consider six different distributions and show that by tuning their parameters such that they have equivalent moments that they all exhibit equivalent dynamical behavior.

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PP2

A Novel Speech-Based Diagnostic Test for Parkinsons Disease Integrating Machine Learning with Web and Mobile Application Development for Cloud Deployment

Parkinson's disease remains one of the most poorly diagnosed neurological conditions despite the critical need of early diagnosis for effective management and treatment. This work presents a new method of diagnosing Parkinson's disease and accompanying scalable web and mobile applications towards the goal of employing this diagnostic test to the cloud. This method provides a more simple, inexpensive, and rapid approach than traditional diagnosis strategies by requiring the patient to only speak into a microphone attached to their computer or mobile device before providing a diagnosis within seconds. This work employs speech processing algorithms, an artificial neural network for machine learning, and an application framework with a user-friendly interface that packages the speech test and diagnosis results for easy access by patients and physicians. The diagnosis test developed was tested with actual patient data and was shown to be highly accurate.

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PP2

An Agent-Based Model for mRNA Localization in Frog Oocytes

During early development of Xenopus laevis oocytes, mRNA moves from the nucleus to the periphery. We use an agent-based model to study the movement of mRNA by molecular motor transport and diffusion. Our results suggest that an anchoring mechanism is required to achieve the observed localization of mRNA: simulations indicate that anchoring of a particular motor-mRNA complex may be sufficient for relocation and that binding between different molecular motors may contribute to transport.

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PP2

Effects of Stochastic Gap-Junctional Coupling in Cardiac Cells and Tissue

Action potentials propagate in cardiac tissue in part through gap junctions. Gap-junction gating dynamics are functions of both gap-junctional voltage and time and also are stochastic in nature. We derive a system of stochastic differential equations to model these gating dynamics within the context of the Luo-Rudy-1 description of ionic currents. We perform simulations on a 1D cable and show the effects of stochastic gating on action potential propagation. Results on conduction block, action potential propagation speed and gap junctional resistance will be presented.

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PP2

Maximizing Plant Fitness Under Herbivore Attack

When attacked by insect herbivores, plants emit volatile chemicals. These chemicals are known to induce local defenses, prime neighboring plants for defense, and attract predators and parasitoids to combat the herbivores, but these chemical defenses are coupled with fitness costs. We examine the interactions between the model plant, goldenrod, and one of its insect herbivores, Trirhabda virgata, in order to draw conclusions about what defense strategies will maximize a goldenrods fitness.

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PP2

The Derivation of Mass Action Laws: Issues and Questions

There are well-trodden paths that enable one to pass from stochastic individual-based models to deterministic population-level models. I will point out a few issues that arise along the way: these make the journey slightly more involved and interesting than one might expect.

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PP2

Heterogeneity and Oscillations in Small Predator-Prey Swarms

Real-world predator-prey interactions often involve a predator chasing a flock of prey. We examined a dynamical systems model of predator-prey interactions, governed by isometric interaction kernels incorporating classical swarming for the prey. Since many parameter values lead to the predator splitting the swarm into smaller, unevenly-sized groups, we investigate the effects of heterogeneity among predator-prey interactions in small swarms. We show that a variety of behaviors, including oscillations, are possible in the small swarm case.

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PP2

Bacterial Disinfection with the Presence of Persisters

Many important diseases like Tuberculosis are caused by biofilms.Among the bacteria within a biofilm, persisters are a subpopulation which are tolerant to antibiotics and knowing more about them is very critical and helpful. In this poster we will look at the behavior of the bacteria with three phases: Susceptible, Stationary and Persisters, and we will show that considering the third phase gives us more accurate results comparing to the previous studies with just Susceptible and Persisters and this new model matches the experimental results better.

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PP2

Chaotic Mixing in a Curved Channel with Slip Surfaces

In this work, we show that laminar flow in a planar curved channel can generate chaotic trajectories, if the top and bottom walls are alternately patterned with slip surfaces. Existing micro-mixers based on flow through curved sections, have either complex 3D geometries, or are effective only at relatively high Reynolds numbers [Stremler, Phil. Trans. A., 362, 10191036]. Using slip surfaces, we overcome both these limitations, while simultaneously reducing viscous drag on the fluid.

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PP2

Feasibility of Binding Heteroclinic Networks

Many neuronal systems exhibit multi-sensory dynamics. Multisensory integration is a process by which information from different sensory systems is combined to influence perception, decisions, and overt behavior. In this context, the different sensory systems, such as sight, sound, smell, taste and so on, are called sensory modalities. In each modality, there are cognitive modes which are large collections of neurons firing at the same time in synchrony in a functional network. In order to explain the sequential mental processes in the brain, we study a heteroclinic binding model where active brain modes form different modalities which are processed in parallel. Under certain assumptions, the existence of the so-called multimodality heteroclinic network was established. we prove that for each collection of successive heteroclinic orbits inside the network, there is an open set of initial points such that the trajectory going through each of them follows the prescribed collection of successive heteroclinic orbits and stays in a small neighborhood of it. We also show that the symbolic complexity function of the system restricted to this neighborhood is a polynomial of degree $L - 1$ where L is the number of modalities.

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PP2

Dynamic Square Patterns in 2D Neural Fields

We present analysis and simulation of periodic solutions near $D_4 x T^2$ symmetric Hopf bifurcations in two different neural field models. The first model consists of a scalar integral equation that incorporates finite transmission speed through spatiotemporal delays. The second model incorporates finite transmission speed using a telegraph equation (ie. a hyperbolic PDE), but also includes local ion channel dynamics and 2 interacting populations of neurons.

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PP2

Controllability of Brain Networks

Cognitive function is driven by dynamic interactions between large-scale neural networks, enabling behavior. We use control theory to offer a mechanistic explanation for how the brain moves among cognitive states. Our results suggest that densely connected areas facilitate the movement of the brain to easily-reachable states. Weakly connected areas facilitate the movement of the brain to difficult-to-reach states. Areas located on the boundary between network communities facilitate the integration or segregation of diverse cognitive systems.

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PP2

Compressive Sensing with Exactly Solvable Chaos

Recent advances in sampling theory allow the reconstruction of signals sampled at sub-Nyquist rates. Compressive sensing operates under the premise that signal acquisition and data compression can be carried out simultaneously. Building on recent work in chaotic communications, a compressive negative Beta encoder/decoder is presented that represents data in an irrational radix. Using an exact chaotic oscillator and pulsed linear filter, a complete A/D and D/A architecture based on chaotic dynamics can be built in hardware.

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PP2

Identifying the Role of Store-Operated Calcium Channels in Astrocytes Via An Open-Cell Model

Astrocytes are the most common glial cells in the brain, communicating via calcium transients, and possibly modulating neuronal signals. However, these calcium dynamics differ between in vivo and in vitro. We suggest a new open-cell mathematical model that allows us to vary parameters such as cell volume and flux through calcium channels not easily accessible by experimentalists. Our results support the idea that store-operated calcium channels play a key role, and suggest realistic, follow-up experiments.

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PP2

Behavioral Dynamics and STD Transmission

Many mathematical models of infectious disease transmission represent contact patterns using fixed rate parameters. However, individual contact and protective behaviors are likely to respond elastically to disease outbreaks. We use the replicator-mutator equations from evolutionary game theory to couple the dynamics of protective sexual behavior to a simple SIS compartmental model. Our combined model demonstrates a shift in effective contact reduction behavior over the course of the outbreak, driven by the behavioral-disease interaction dynamics.

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PP2

Master Stability Functions for the Fixed Point Solution of Synchronized Identical Systems with Linear Delay-Coupling and a Single Constant Delay

This poster presents master stability functions for the fixed point solution of any network of synchronized identical systems with linear delay-coupling and a single constant delay. The connection between these master stability functions and amplitude death islands is also provided using numerical simulations of small oscillator networks with identical chaotic node dynamics.

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PP2

Rigorous Numerics for Analytic Solutions of Differential Equations: The Radii Polynomial Approach

The radii polynomial method has been used for validating numerical approximations to C^k periodic solutions of differential equations. This paper discusses the extension (via weighted Fourier sequence spaces) of the method to solutions in the analytic category, which often leads to better bounds and the possibility of continuation of the solution as a manifold in parameter space. It then details two examples in which our numerics have led us to computer-assisted proof of solutions.

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PP2

Windows of Opportunity: Synchronization in On-Off Stochastic Networks

We study dynamical networks whose topology and intrinsic parameters stochastically change, on a time scale that ranges from fast to slow. When switching is fast, the stochastic network synchronizes as long as synchronization in the averaged network, becomes stable. We prove global stability of synchronization in the fast switching limit. Beyond fast switching, we reveal unexpected windows of intermediate switching frequencies in which synchronization becomes stable despite the instability of the averaged/fast-switching network.

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PP2

Two-Theta Neuron: Phase Models for Bursting Networks

We continue our reduction approach to study bursting outcomes of central pattern generators using coupled two-theta phase models. We examine configurations of 3-cell CPGs with inhibitory, excitatory and electrical synapses, and model and compare with corresponding real-world exemplary networks. Occurrence, robustness and transformations of CPG outcomes are studied using 2D return maps, stable fixed points and invariant circles correspond to bursting patterns with fixed and varying phase lags.

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PP2

A mathematical model for adaptive crawling locomotion

Crawling with locomotory wave is a fundamental method of biological locomotion in invertebrate including limbless and legged animals. We conducted observations of crawling locomotion in largely different conditions. In particular, it was found that centipedes can variously change their leg-density waves which represent spatio-temporal coordination pattern of ground friction. Here, we present a simple mechano-mathematical model for crawler so that it provides observed mode transition depending on the external / internal conditions.

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PP2

Canard-Mediated Dynamics in a Phantom Burster

We present canard-mediated dynamics arising in a phantom burster, formed by a multiple timescale model composed of FitzHugh-Nagumo systems, which represents an alternating pulse and surge pattern in a neuro-secretory context. So far, global and local features of the model have been studied in the context of slow-fast dynamics and mixed-mode oscillations where folded singularities and associated canard trajectories have a particular importance. Here, we study the effect of the folded singularities in slow-fast transitions.

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PP2

Effective Dispersion Relation of the Nonlinear Schrödinger Equation

The linear part of the Nonlinear Schrödinger Equation (NLS) ($iq_t = q_{xx}$) has dispersion relation $\omega = k^2$. We don't necessarily expect solutions to the NLS to behave nicely or have any kind of effective dispersion relation, since we expect nonlinear waves to be strongly coupled and not sinusoidal in time. However, I have seen that solutions to the NLS are actually weakly coupled and are often nearly sinusoidal in time with a dominant frequency. In fact, when I look at long-time average of either a solution with many solitons or with many unstable modes, the power spectral density does indicate a quadratic dispersion relation that has been shifted by a constant proportional to the amplitude of the initial condition: $\omega = k^2 - 2A$ where $A = \frac{\|\hat{q}(k,0)\|^2}{2\pi}$. I will show a number of plots confirming this.

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PP2

Mathematical Model of Bidirectional Vesicle Transport and Sporadic Capture in Axons

We model the transport of vesicles along an axon using an advection-diffusion equation which includes vesicle degradation and sporadic capture by presynaptic targets. Our model shows that the steady state concentration of vesicles distributed along the axon does not decay exponentially in space for some parameter values. We also study how heterogeneity in the distribution of targets can enhance cargo delivery by performing a multi-scale homogenization in space.

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PP2

Modelocking in Chaotic Advection-Reaction-Diffusion Systems

Systems undergoing chaotic advection-reaction-diffusion dynamics have rich topological structures that define the front propagation. Here we use burning invariant manifolds (BIMs) to provide a theoretical framework that explains modelocking as observed experimentally and in numerical simulations. The existence of a relative periodic orbit and the shape of the BIM determine the type of modelocking. Using this technique we find higher order modelocking types and discuss the switching of modelocking types observed in experiments.

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PP2

Effect of Multi-Species Mass Emergence on Biodiversity

Mass emergences are a regular occurrence in rivers and streams. Many aquatic insects depend on safety in numbers to escape the water and reproduce. This strategy not only allows individual species to enhance reproductive success by reducing predation rates, but also creates opportunities for scarcer species that synchronize their emergence with more prevalent species. We construct a heuristic model to study inherent protections afforded by biodiversity and consider implications for repopulation efforts in pollution-impacted systems.

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PP2

A B Cell Receptor Signaling Model and Dynamic Origins of Cell Response

The kinase Syk is imperative for the intricate signaling events that occur in B cells, events which lead to cellular responses when antigens bind to B cell receptors (BCRs). We have constructed a deterministic model for BCR signaling centered around Syk. After tuning feedbacks between key kinases and phosphatases, we demonstrated qualitative agreement between the model and dose response data from

literature. We investigate the role of positive and negative feedbacks in determining cell response.

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PP2

Stability of Morphodynamic Equilibria in Tidal Basins

Interesting bed patterns are observed in the tidal basins of, for example, the Wadden Sea along the Dutch, German and Danish coast. To get a better understanding of these phenomena, a morphodynamic model has been constructed. The goal is to find the morphodynamic equilibria and their stability, and to investigate their sensitivity to parameter variations. Therefore, the equations have been scaled and asymptotically analysed. Using finite element method and continuation techniques, the equilibrium of the bed has been determined.

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PP2

Frequency-Dependent Left-Right Coordination in Locomotor Pattern Generation

Coordination between left and right activities in the spinal cord during locomotion is controlled by commissural interneurons (CINs). Several types have been genetically identified including both excitatory (VOV) and inhibitory (V0D). Genetic elimination of these CINs caused switching from a normal left-right alternation to a left-right synchronized pattern. Ablation of V0D neurons resulted in a lack of left-right alternation at low locomotor frequencies, whereas selective ablation of V0V CINs switched the motor output to a left-right synchronized pattern at high frequencies. We developed a model of neural circuits consisting of four pacemaker neurons, left and right flexors and extensors, interacting via V0D and V0V commissural pathways. The model reproduced all experimentally identified regimes in the corresponding frequency ranges. We qualitatively analyzed the behavior of this network in the above regimes and transitions between them.

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PP2

Capacity for Learning the Shape of Arena in the Single-Celled Swimmer, Viewed from Slow Dynamics of Membrane Potential.

We have studied for some years the learning capacity for time and space in unicellular organisms. Here we present that protozoan ciliates, Paramecium and Tetrahymena, show the swimming trajectory adaptive to the shape (e.g. capillary and droplet) of swimming arena in which they experienced just before. As the swimming activity is regulated by membrane potential in the ciliates, a possible mechanism is considered according to the equations of Hodgkin-Huxley type with the additional slower variable.

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PP2

Co-Dimension Two Bifurcations in Piecewise-Smooth Continuous Dynamical Systems

The mean-field equations for a network of type I neurons is a piecewise-smooth continuous (PWSC) system of ordinary differential equations. This system displays two prominent co-dimension two non-smooth bifurcations involving collisions of a saddle-node equilibrium with a switching manifold, and a Hopf equilibrium with a switching manifold. These bifurcations are analytically resolved for the mean-field system in full detail. The genericity of these bifurcations for an arbitrary PWSC system is also discussed.

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PP2

Analysis of Malaria Transmission Dynamics with Saturated Incidence

Mathematical model for malaria transmission in a two-interacting population with saturated incidence was formulated and robustly analysed. The model was shown to exhibit a subcritical bifurcation whenever a unique threshold, R_0, increases through unity. However, under specific conditions, globally asymptotically stable malaria-free and endemic equilibria were established at $R_0 < 1$ and $R_0 > 1$ respectively. Further, sensitivity analysis and simulations were performed to examine the effects of some parameters on the model.

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PP2

Temporally Periodic Neural Responses from Spatially Periodic Stimuli

Certain static spatial visual patterns induce temporally varying neural responses, such as in pattern-sensitive epilepsy and some visual illusions. These temporal responses are often strong only in a very narrow spatial frequency band and nonexistent at other spatial frequencies. We present a spatially distributed neural field model that captures this resonant behavior in simulations, and demonstrate analytically this strong sensitivity to the spatial wavelength with a perturbation calculation near the instability.

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PP2

Using a Stochastic Field Theory to Understand Collective Behavior of Swimming Microorganisms

Large groups of active particles can show collective behavior and enhanced fluctuations, but mean field theories to understand them ignore fluctuations. We have extended these field theories to include stochastic fluxes and have quantified the dynamics in terms of enhanced diffusion and mixing and number fluctuations. We have also compared with results with the mean field theory and discrete particle-based simulations.

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PP2

Consensus and Synchronization over Biologically-Inspired Networks: From Collaboration to Antagonism

The vast majority of work on consensus and synchronization of coupled dynamical systems considers their interactions to be collaborative. In our present work, we study two different networks representing more realistic scenarios; one consists of dynamic leaders in a collaborative network and another consists of agonistic and antagonistic interactions. We establish closed form results for the rate of convergence to consensus for both the cases and conditions for stochastic synchronization in the second case.

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PP2

Oscillatory Shear Flow Influence on the Two Point Vortex Dynamics

Bounded and unbounded quasi-periodic dynamics of two point vortices of unequal strengths embedded in an oscillatory shear flow with rotation is addressed with an emphasis on their impact on passive tracer transport. All the sets of the vortex signs are shown to induce qualitatively divergent transport patterns. Regions enduring effective stretching, and consequently prone to intense mixing are identified by means of finite-time Lyapunov exponents.

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PP2

Waveaction Spectra for Fully Nonlinear MMT Model

We investigate a version of the Majda-McLaughlin-Tabak model of dispersive wave turbulence where the linear term in the time derivative is removed. We are interested in the long-time average of the distribution of waveaction throughout the system as a function of wavenumber. We consider driven-damped and undriven, undamped cases of the model. Our theoretical predictions, which include self-similarity arguments and statistical mechanical methods, are found to agree with time dynamics simulations.

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PP2

Wild Dynamics in Nonlinear Integrate-and-Fire Neurons: Mixed-Mode Bursting, Spike Adding and Chaos.

Nonlinear integrate-and-fire neuron models are hybrid dynamical systems combining continuous differential equations and discrete resets, where spikes are defined by the divergence of the membrane potential to infinity. The nature of the spike pattern has been related to the orbits of a discrete map, the adaptation map, which was studied in a number of situations where it was regular. We analyze here cases of discontinuous adaptation map and show that extremely wild behaviors can appear.

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PP2

Return Times and Correlation Decay in Linked Twist Maps

Linked twist maps form an archetypal class of non-uniformly hyperbolic system, of particular relevance to fluid mixing. Previous results demonstrate that they have a polynomial decay of correlations. Of practical interest is the time at which the system begins to experience this algebraic tail in the decay, after the faster, chaotic, exponential mixing has taken place.

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PP2

Osteocyte Network Formation

We construct a model of a dynamic network that consists of osteocytes, a type of cell within bone. On the bone-tissue interface, osteoblasts secrete the osteoid bone matrix and multi-nucleated osteoclasts resorb it. These osteoblasts can also differentiate into osteocytes. In pathological bone, the highly regulated bone remodelling signalling pathway is disrupted. By understanding these dynamics, we hope to gain insights into how to predict structural differences between healthy and cancerous tissue.

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PP2

On a FitzHugh-Nagumo Kinetic Model for Neural Networks

This paper undertakes the analysis of the existence and uniqueness of solutions for a mean-field FitzHugh-Nagumo equation arising in the modeling of the macroscopic activity of the brain. In particular, we prove existence of solution and non trivial stationary solution to evolution equation without restriction on the connectivity coefficient $\varepsilon > 0$ and, using a semigroup factorisation method in Banach spaces, uniqueness of the stationary solution and its exponential NL stability in the small connectivity regime.

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PP2

Examining Partial Cascades in Clustered Networks with High Intervertex Path Lengths

There has been significant study of cascades on networks with various properties. There is a well-known branching process approach developed by James Gleeson that is useful for sparse locally treelike networks, particularly those with low mean intervertex path lengths. We examine methods to apply to networks with longer intervertex path lengths, which may contribute to a partial cascade not seen with Gleeson's method.

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PP2

Almost Complete Separation of a Fluid Component from a Mixture Using the Burgers Networks of Micro-separators

Two ways of networking micro-separators to separate hydrogen, for example, from a mixture almost completely are proposed. Each separator has two outlets for slightly higher and lower concentrations whose difference is modeled by a quadratic map of the average concentration at its inlet. In the continuum the networks are governed by the Burgers equation or its variant with nonlinear no-flux boundary conditions. The initial boundary value problem is exactly solvable. A family of equilibria attract globally. The target component is shown to be extracted from one side of a stationary shock. Micro-devices for testing the idea are also proposed.

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PP2

New Data Anysis Approach for Complex Signals with Low Signal to Noise Ratio's

We propose a toolbox for signals comparisons with low SNR. We combine techniques from dynamical systems and information theory to quantify and extract information in the data sets. Data sets with SNR's of 0.3 to 0.002 were analyzed. Useful information was found and quantized with tight bounds on the estimate. We also compare to Gaussian noise and show our toolbox can be used to separate signals with low SNR from white noise.

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PP2

Data Assimilation for Traffic State and Parameter Estimation

Our goal is to apply data assimilation techniques to microscopic and macroscopic traffic models to estimate traffic states and parameters. We found ways in which sensor data as well as GPS data of moving cars can be assimilated in a unified freeway. We implemented this approach using both ensemble Kalman and particle filter and evaluated their efficacy using microscopic and macroscopic models. We applied our results to real traffic data from Minnesota Transportation Department.

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PP2

Stochastic Active-Transport Model of Cell Polarization

We present a stochastic model of active vesicular transport and its role in cell po- larization, which takes into account positive feedback between membrane-bound signaling molecules and cytoskeletal filaments. In particular, we consider the cytoplasmic transport of vesicles on a two-dimensional cytoskeletal network, in which a vesicle containing signaling molecules can randomly switch between a diffusing state and a state of directed motion along a filament. We show that the geometry of the cytoskeletal filaments plays a crucial role in determining whether the cell is capable of spontaneous cell polarization or only polarizes in response to an external chemical gradient.The former occurs if filaments are nucleated at sites on the cell membrane (cortical actin), whereas the latter applies if the filaments nucleate from organizing sites within the cytoplasm (microtubule asters).

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PP2

Statistical Properties of Finite Systems of Point-Particles Interacting Through Binary Collisions

In a finite system of point-particles interacting through binary collisions, particles number of collisions and time of last collision are functions of the initial distributions of the positions and velocities of all particles. We investigate a one-dimensional system of N particles interacting through either elastic or inelastic collisions. In particular, given random initial particle positions and velocities, we establish formulae for the distributions of the number of collisions and final collision times.

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PP2

Heteroclinic Separators of Magnetic Fields in Electrically Conducting Fluids

We partly solve the problem of existence of separators of a magnetic field in plasma. We single out in plasma a 3-body with a boundary in which the movement of plasma is of special kind which we call an (a-d)-motion. The statement of the problem and the suggested method for its solution lead to some theoretical problems from Dynamical Systems Theory. The work was supported by RFBR, Grants 12-01-00672-a and 13-01-12452-ofi-m.

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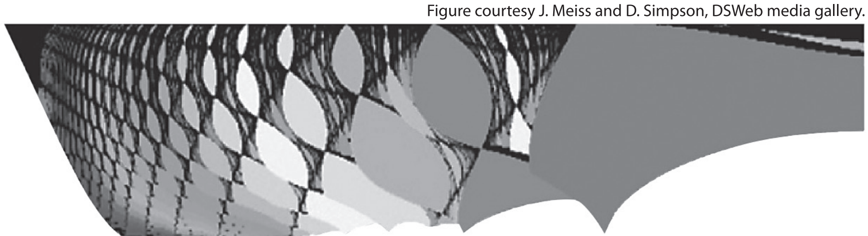
Organizer and Speaker Index

2015 SIAM Conference on Applications of Dynamical Systems

Figure courtesy J. Meiss and D. Simpson, DSWeb media gallery.



May 17-21, 2015
Snowbird Ski and Summer Resort
Snowbird, Utah, USA

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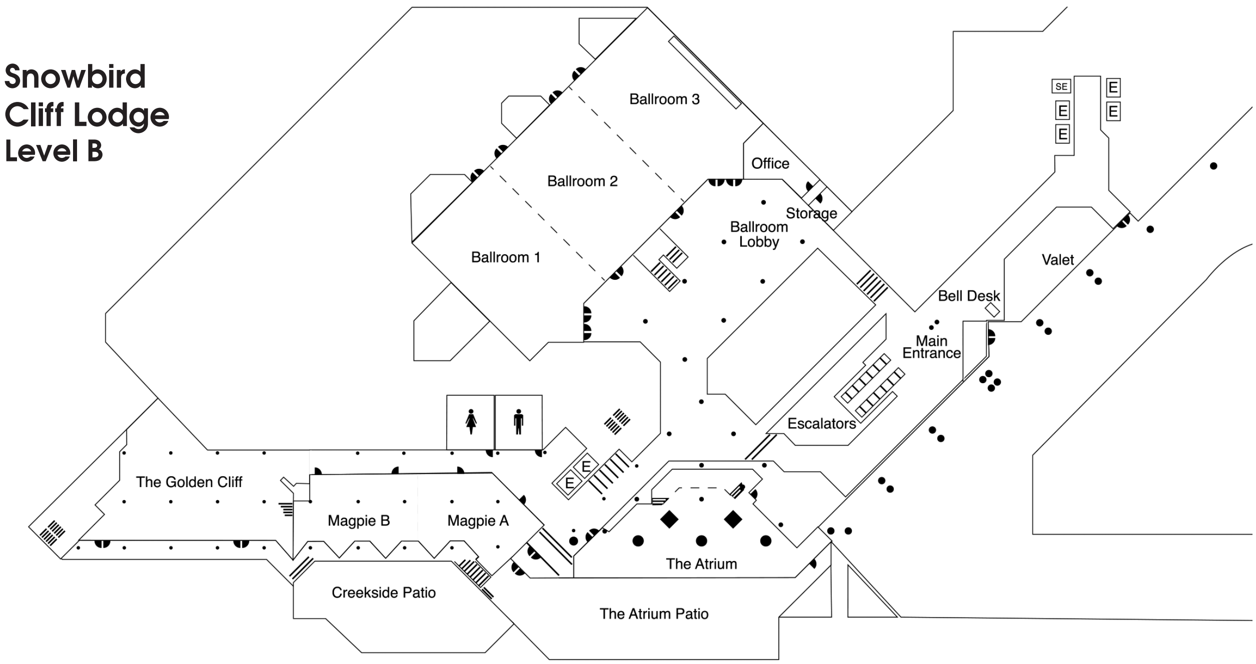
Notes

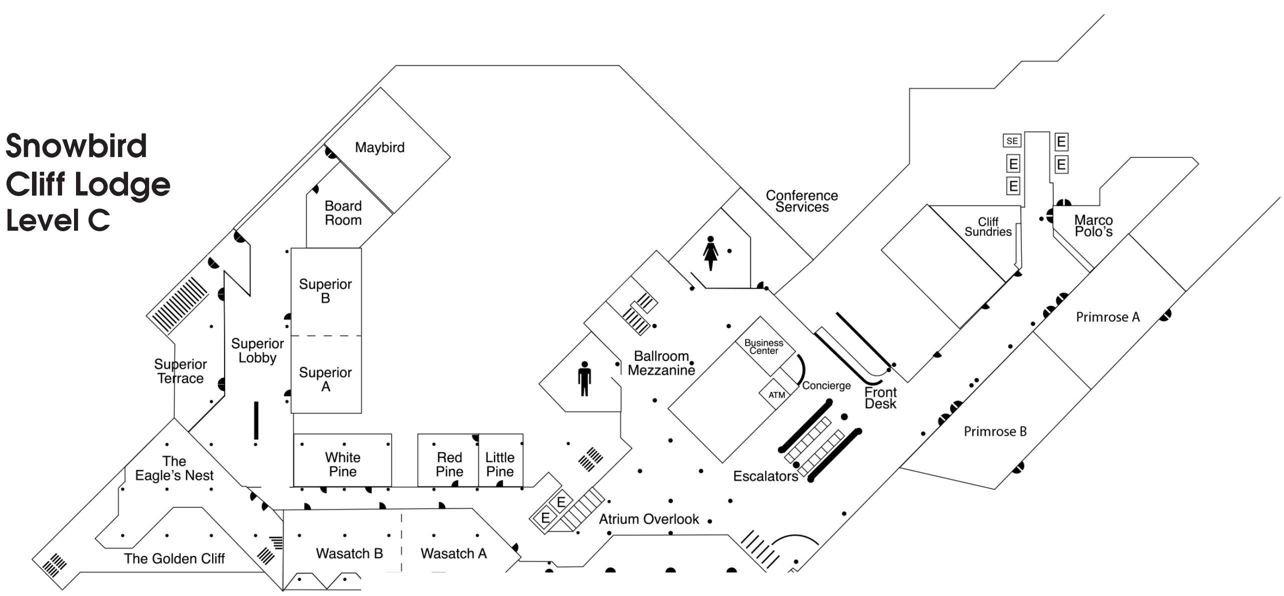
DS15 Budget

Conference Budget
SIAM Conference on Dynamical Systems
May 17 - 21, 2015
Snowbird, UT

Expected Paid Attendance	780	
Revenue		
Registration Income		$223,355
	Total	$223,355
Expenses		
Printing		$9,200
Organizing Committee		$6,500
Invited Speakers		$20,000
Food and Beverage		$35,800
AV Equipment and Telecommunication		$10,800
Advertising		$7,000
Conference Labor (including benefits)		$56,846
Other (supplies, staff travel, freight, misc.)		$19,400
Administrative		$18,578
Accounting/Distribution & Shipping		$9,907
Information Systems		$17,862
Customer Service		$6,747
Marketing		$10,597
Office Space (Building)		$6,703
Other SIAM Services		$7,079
	Total	$243,019
Net Conference Expense		($19,664)
Support Provided by SIAM		$19,664
		$0
Estimated Support for Travel Awards not included above:		
Early Career and Students	67	$50,550

Snowbird Ski and Summer Resort, Hotel Floor Plan





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