IP0

Jrgen Moser Lecture: Catastrophes, Symmetry-Breaking, Synchrony-Breaking

The ideas that surrounded catastrophe theory (codimension, unfoldings, organizing centers, ...) have shaped much progress in bifurcation theory during the past forty years and, indeed, in many of its applications. I will try to trace some of these developments and to indicate why this same way of thinking might lead to interesting discoveries in network dynamics.

Martin Golubitsky
Ohio State University
Mathematical Biosciences Institute
mg@mbi.osu.edu

IP1

Collapse of the Atlantic Ocean Circulation

The Atlantic Ocean Circulation is sensitive to the patterns of atmospheric forcing. Relatively small changes in atmospheric conditions may lead to a spectacular collapse of Atlantic Ocean currents, with a large impact on European climate. In ocean-climate models, a collapse is associated with the existence of saddle-node bifurcations. The challenge is to efficiently determine the position of these bifurcations in the multi-parameter, large-dimensional dynamical systems derived from these models. In this presentation, I will give a brief overview of numerical techniques currently used and then focus on the issue of determining the probability that a collapse will occur before the year 2100.

Henk Dijkstra
Institute for Marine and Atmospheric Research Utrecht (IMAU)
Utrecht, the Netherlands
h.a.dijkstra@phys.uu.nl

IP2

Dynamics, Instability, and Bifurcation in the Mechanics of Biological Growth

Biological growth is at the heart of many developmental, physiological, and pathological processes. Growth relies on the fine tuning of different genetic and biochemical processes but, ultimately, expresses itself through a change of geometry mediated by physical forces. These forces generated by growth also influence growth itself, creating a complex feedback mechanism. The coupling between geometry, stresses, and growth in elastic tissues can be modeled within the framework of nonlinear anelasticity, a theory which includes both reversible and irreversible deformations. The consequences of growth can then be studied on simple geometries or reduced models. I will explain the basic foundational principles of nonlinear anelasticity and, motivated by the behavior of biological systems, I will describe generic instabilities and bifurcations occurring in the growth dynamics.

Alain Goriely
University of Arizona
Program in Applied Mathematics
goriely@math.arizona.edu

IP3

Network Topology: Sensors and Systems

Networks arise in innumerable contexts from mobile communications devices, to environmental sensors nets, to biological systems at all scales. This talk explores the relationships between what happens on the network nodes (signals, sensing, dynamics) and the underlying spatial distribution of the nodes — an especially delicate interplay in the context of coordinate-free, non-localized systems. The key tools are an adaptation of homology theory. Algebraic topology yields an enrichment of network topology that integrates cleanly with statistics and dynamics of networks, and which allows for solutions to problems of coverage, communication, and control.

Robert W. Ghrist
University of Pennsylvania
ghrist@seas.upenn.edu

IP4

Mechanisms of Instability in Nearly Integrable Hamiltonian Systems

There are many systems that appear in applications that have negligible friction, like in celestial mechanics and Astrodynamics, motion of charged particles in magnetic fields, chemical reactions, etc. A general model for this kind of systems is to consider time periodic perturbations of integrable Hamiltonian systems with 2 or more degrees of freedom. One problem that has attracted attention for a long time is whether the effect of perturbations accumulate over time and lead to large effects (instability) or whether these effects average out (stability). The first result in proving instability for this model was presented by Arnold in 1964, but the perturbation considered was not general enough (there do not appear "large gaps" in the resonant tori). In this talk we present some mechanisms that cause instabilities for general perturbations if the unperturbed systems considered are a priori-unstable, that is, they can be written as a product of d rotators and n penduli, $d \geq 1$, $n \geq 1$. The main technique is to develop a toolkit to study, in a unified way, tori of different topologies and their invariant manifolds, their intersections as well as shadowing properties of these bi-asymptotic orbits. Part of this toolkit is to unify standard techniques (normally hyperbolic manifolds, KAM theory, averaging theory) so that they can work together. A fundamental tool used here is the scattering map of normally hyperbolic invariant manifolds. The conditions needed are explicit. This makes it possible to show that this phenomenon occurs in concrete examples, as the restricted three body problem in celestial mechanics.

Tere M. Seara
Univ. Politecnica de Catalunya
Tere.M-Seara@upc.edu

IP5

Analysis of Large-Scale Interconnected Dynamical Systems

The problem of analysis of large-scale networked systems is one of the most interesting current challenges in Dynamical Systems. In this talk, I will present a perspective on this problem that combines an operator-theoretic and graph theoretic approach, but also incorporates, in a strong way, the geometric point of view that is so fruitful in low dimensions. This approach leads to a new proposal for model reduction that is rooted in the dynamics of the system rather than in energy-minimization arguments. It also enables analysis of uncertain and stochastic systems - where initial conditions and/or parameter values are not known exactly - within the same framework. Most of the tools apply equally to discontinuous systems. I will motivate the approach by a number of examples, ranging from biomolecular models to power grid systems, that exhibit large scale ("emergent") transitions between states.

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

IP6
The Multiscale Dynamics of Lightning and a Moving Boundary Problem

Streamers pave the way of lightning strokes and of many other discharges in nature and technology. They are plasma fingers that penetrate non-ionized matter by a strong field enhancement at their tips. Each streamer has an intricate inner structure, and a discharge can form fractal-like trees with ten thousands of streamer branches. First I will review how far their very fast dynamics and multiscale structure are resolved by recent experiments and simulations. Then I will focus on derivation, tests and solutions of a moving boundary approximation for streamer fingers. The boundary approximation with kinetic undercooling regularization revives the question of the selection of Saffman-Taylor fingers and similar solutions. Quantitative predictions of the field enhancement at the streamer tips are important practical results.

Ute Ebert
CWI Amsterdam
Ute.Ebert@cwi.nl

IP7
Systems Biology: How Dynamical Systems Theory Can Help to Understand the Basis of Life

The 21st century has been noted to be the century of biology and new technologies and methods are vastly accelerating the pace of discovery in biology and medicine. Systems biology, the systems level understanding and investigation of biological phenomena, is one of those key methods that act as a driving force for progress in biological research. In this talk the role of dynamical systems theory for the development of this new research field will be discussed. By means of several examples, among others from oncology (cancer research) and osteology (bone research), it will be shown how methods from dynamical systems theory can help to better understand the basis of life.

Frank Allgöwer
Institute for Systems Theory in Engineering
University of Stuttgart
allgower@ist.uni-stuttgart.de

IP8
Stochasticity in Deterministic Systems

Chaotic dynamics gives rise to apparent randomness in deterministic systems. A natural question is the stochasticity of time series from such systems. This presentation surveys recent results in ergodic theory which apply to large classes of systems including Henon and Lorenz attractors. Applications range from (1) classical examples in Mathematical Physics: Lorentz gases as deterministic models for stochastic behaviour; to (2) pattern forming excitable media: hypermeander of spiral waves where the spiral tip appears to undergo a random walk in the plane. For (1), Nicol and the speaker proved recently that the positions of almost all gas molecules behave asymptotically like sample paths of Brownian motion. For (2), a mechanism (and experiment) is proposed for mathematically verifiable Brownian-like motion for the spiral tip.

Ian Melbourne
University of Surrey
Department of Mathematics and Statistics
i.melbourne@surrey.ac.uk

IP9
Living on the Edge of Noise-Driven Order

Transient or unstable behavior is often ignored in considering long time dynamics in the deterministic world. However, stochastic effects can change the picture dramatically, so that the transients can dominate the long range behavior. This talk will compare a few seemingly unrelated canonical models with noise-driven regular behaviors, such as coherent oscillations, synchronization, mixed mode oscillations and even quiescence, that are transient in the absence of noise. Perspectives combining ideas from coherence resonance, meta-stability, and multiples scales show that the order in these models can be attributed to transients "stabilized" by stochastic effects. These perspectives suggest analysis on reduced models to better understand and predict these phenomena.

Rachel Kuske
University of British Columbia
rachel@math.ubc.ca

IP10
The Fluid Trampoline: Droplets Bouncing on a Soap Film

We present the results of a combined experimental and theoretical investigation of droplets falling onto a horizontal soap film. Both static and vertically vibrated soap films are considered. A quasi-static description of the soap film shape yields a force-displacement relation that allows us to model the film as a nonlinear spring, and yields an accurate criterion for the transition between droplet bouncing and crossing. On the vibrating film, a variety of bouncing behaviours were observed, including simple and complex periodic states, multiperiodicity and chaos. A simple theoretical model is developed that captures the essential physics of the bouncing process, reproducing all observed bouncing states. The system is among the very simplest fluid mechanical chaotic oscillators. A seemingly unlikely biological application, predator avoidance in flying fish, is discussed

John Bush
Department of Mathematics
Massachusetts Institute of Technology
bush@math.mit.edu

CP1
Modeling Swarming Systems Through Adaptive Networks

Adaptive networks combine dynamics on a network with topological evolution of the network. We use an adaptive network to model a simple swarming experiment where agents circle a ring-shaped arena either clockwise or counterclockwise. Using moment closure approximations on different levels we show analytically that the system undergoes a pitchfork bifurcations yielding collective agent circulation. By extending our model we then construct a family of models representing similar dynamics and find their corresponding bifurcation diagrams.

Cristian Huepe
Unaffiliated NSF grantee
cristian@northwestern.edu

Anne-Ly Do
Max Planck Institute for the Physics of Complex Systems
ly@pks.mpg.de

Felix Becker
Max Planck-Institute for the Physics of complex systems
Nöthnitzer Strasse 38, 01187 Dresden, Germany
felixbecker3@gmx.de

Thilo Gross
MPI for the Physics of Complex Systems
gross@pks.mpg.de

CP1
Individual-Based Models for the Dynamics of Populations in Advective Media

Many populations, including aquatic insects, live and disperse in advective media. In stream ecology, the question as to how such organisms persist has been called the "drift paradox". Recent models in the form of reaction-advection-diffusion equations or integrodifferential equations predict a "critical domain size", below which a population cannot persist. We formulate individual-based models to explore the effects of demographic stochasticity, life history characteristics, dispersal patterns, and environmental heterogeneity on population persistence.

Allison Kolpas
Department of Ecology, Evolution, and Marine Biology
University of California, Santa Barbara
kolpas@lifesci.ucsb.edu

Roger Nisbet
University of California Santa Barbara
nisbet@lifesci.ucsb.edu

CP1
Coupled Oscillator Models for Analysis and Control of Interaction Networks

A design paradigm for control of an unmanned-vehicle network is to represent the collective dynamics as a system of coupled oscillators. This paradigm underlies a decentralized framework for the stabilization of collective motion. In this talk, we will describe a recent extension that stabilizes collective motion in the presence of an external flow field. The extension includes a phase variable — the time-phase — that is introduced to regulate vehicle spacing on convex loops. We also discuss recent results for oscillator-based modeling and analysis of critically damped interaction networks.

Derek A. Paley, Cameron Peterson
University of Maryland
Department of Aerospace Engineering
dpaley@umd.edu, cammykai@yahoo.com

CP2
Within-Burst Synchrony Changes for Coupled Elliptic Bursters

We study the appearance of a novel phenomenon for linearly coupled identical bursters: synchronized bursts where there are changes of spike synchrony within each burst. The examples we study are for normal form elliptic bursters where there is a periodic slow passage through a Bautin (codimension two degenerate Andronov-Hopf) bifurcation. This burster has a subcritical Andronov-Hopf bifurcation at the onset of repetitive spiking while end of burst occurs via a fold limit cycle bifurcation. We study synchronization behavior of two and three Bautin-type elliptic bursters for a linear direct coupling scheme. Burst synchronization is known to be prevalent behavior among such coupled bursters, while spike synchronization is more dependent on the details of the coupling. We note that higher order terms in the normal form that do not affect the behavior of a single burster are nonetheless responsible for changes in synchrony pattern; more precisely, we find within-burst synchrony changes are associated with a turning point in the spiking frequency.

Abul Kalam A. Azad
Mathematics Research Institute, University of Exeter, UK.
aka203@ex.ac.uk

Peter Ashwin
University of Exeter
School of Mathematical Sciences
p.ashwin@exeter.ac.uk

CP2
Oscillatory Neural Model of Spiking Elements for Sequential Memory

We develop a new oscillatory model which is designed as a network of coupled oscillators. Oscillator comprises excitatory and inhibitory spiking elements of Hodgkin-Huxley type. Connections are all-to-all type and they are established between excitatory neurons of different oscillators. Learning rule takes into account activity level of oscillators in two sequential time windows. Simulations show a good model performance. The model is used to explain experimental findings on back and forward recall of hippocampal place cells.

Roman M. Borisyuk
University of Plymouth
Centre for Theoretical and Computational Neuroscience
rborisyuk@plymouth.ac.uk

David Chik
Center of Theoretical and Computational Neuroscience
University of Plymouth, UK.
david.chik@plymouth.ac.uk

CP2
Clustering Behaviors in Networks of Pulse-Coupled Integrate-and-Fire Oscillators

We study the dichotomy between synchronization and clustering behaviors in a model of integrate-and-fire oscillators with impulsive all-to-all coupling. The present contribu-

tion focuses on clustering phenomena by proving the global convergence to such configurations for identical oscillators and by studying their robustness against frequency discrepancies. Different models (LIF, QIF,...) will be considered. Finally, we present the continuous limit of the model, which deals with infinite populations.

Alexandre Mauroy
University of Liège / Montefiore Institute (B28)
Departement of Electrical Engeneering and Computer Science
Alexandre.Mauroy@ulg.ac.be

Rodolphe Sepulchre
University of Liege
Belgium
R.Sepulchre@ulg.ac.be

CP3

Direct Observation of Vein Morphogenesis in a Giant Biological Cell

Physarum polycephalum (or slime mold) is a giant biological cell, which size is typically in the several cm range. Though primitive, this system displays complex spatiotemporal behaviors. Here we focus on experimental analysis of velocity fields in regions where a transition occurs from liquid cytoplasm to gel state, i.e., at places of vein formation. The main objective is to obtain time-resolved, quantitative data, against which microfluidic theories of vein formation will be developed and tested.

Paul Dely
Lab PhLAM/Universite Lille 1
pauldely@phlam.univ-lille1.fr

Christophe Szwaj
Universite de Lille (France)
Laboratoire PHLAM
christophe.szwaj@univ-lille1.fr

Serge Bielawski
PhLAM/Université Lille I,
France
serge.bielawski@univ-lille1.fr

Toshiyuki Nakagaki
Research Institute for Electronic Science
Hokkaido University
nakagaki@es.hokudai.ac.jp

CP3

Dynamics of Bacterial Infections in Humans

We construct, in axiomatic fashion, a simple model for the human innate immune response to bacterial infection. The immune response is manifested by the activity of neutrophils, the most common phagocytic cells, that provide the first line of defence against bacterial infection at the acute stage. The study is relevant for instances of severe systemic infections and for instances of acute bacterial infections occurring in neutropenic patients (patient with low neutrophils counts).

Roy Malka
Weizmann Institute of Science
roy.malka@weizmann.ac.il

Vered Rom-Kedar
The Weizmann Institute
Applied Math & Computer Sci
vered.rom-kedar@weizmann.ac.il

Eliezer Shochat
PDIMM Modelling & Simulation,
F. Hoffmann - La Roche AG, Bas
eliezer.shochat@roche.com

CP3

Asynchronous Oscillations of Plasmodium Infection (Malaria) and Its Immune Response

We show that small delays in the activation of the immune response to infection by Plasmodium leads to persistent oscillations in the parasitic load. We analytically and numerically describe variant specific oscillations that can can be either synchronous or asynchronous. The biological consequence of the former is that there will be sizable oscillations in the parasitic load. However, if the asynchronous oscillations are antiphased, then even though there may be strong variations in each variant the total parasitic load is relatively constant.

Jonathan Mitchell, Thomas W. Carr
Southern Methodist University
Department of Mathematics
jmitchell@smu.edu, tcarr@smu.edu

CP4

Complex Ginzburg-Landau Equation in Finite Domains

For large regions of parameter space the supercritical complex Ginzburg-Landau equation has chaotic solutions when studied on large periodic, or infinite, domains. However, this is not necessarily the case when nonperiodic boundary conditions are used. For example, in the Benjamin-Feir stable regime chaotic states exist only as transients, eventually decaying to spatially uniform oscillations. We show that the lifetime of this transient behaviour increases algebraically with the domain size, and discuss analogous behaviour in the presence of externally imposed advection (Physica D **238** (2009) 184-196).

Steve Houghton
University of Leeds, United Kingdom
smh@maths.leeds.ac.uk

Edgar Knobloch
University of California, Berkeley
knobloch@berkeley.edu

Steve Tobias
University of Leeds, United Kingdom
smt@amsta.leeds.ac.uk

Michael Proctor
DAMTP
mrep@damtp.cam.ac.uk

CP4

Oceanic Internal Waves Spectra: Towards Synthesis of Observations, Theory and DNS

We present results of observations, theory and numerical simulations aimed at explaining the spectral energy den-

sity of internal waves in the deep ocean. Observations document substantial variability of spectral energy densities around the canonical GarrettMunk spectrum both in terms of variability of spectral power law indices and deviations from power law behavior. We use our isopycnal Hamiltonian to derive a wave turbulence kinetic equation for describing the evolution of the internal wave energy spectrum. We show that the scale-invariant solutions to the kinetic equation leads to divergences for almost all spectral power-law exponents. These divergences come from resonant interactions with infra-red and/or ultraviolet wavenumbers with extreme scale-separations, and violate assumptions necessary to derive kinetic equation. We find one convergent steady state solution, and we also demonstrate that there are possible solutions for which infra-red and ultra-violet divergences are balanced. Our Direct Numerical Simulations are consistent with these findings. Finally, we elucidate on how a first principles theory for strongly interacting internal waves might be developed.

Yuri V. Lvov
Rensselaer Polytechnic Institute
lvovy@rpi.edu

CP4

Cross-Diffusion Driven Instability and Pattern Formation for a Nonlinear Reaction-Diffusion System

We investigate the formation of patterns for a system of reaction-diffusion equations with nonlinear self and cross diffusion terms. The linear stability analysis provides the conditions on the parameters by which a homogeneous steady state (stable for the kinetics) becomes unstable via a Turing bifurcation. In particular, it is proved that cross-diffusion effects are the responsible for the initiation of spatial patterns. Close to bifurcation we perform a weakly nonlinear analysis and are able to predict the shape and the amplitude of the pattern. In the case of a 2–D spatial domain we observe and analyze patterns such rolls, square, rhombi, hexagons and targets. When the domain size is large, the pattern is formed sequentially and traveling wavefronts are analyzed using the Ginzburg-Landau equations.

Marco Sammartino, Gaetana Gambino, Maria Carmela Lombardo
Department of Mathematics
University of Palermo
marco@math.unipa.it, gaetana@math.unipa.it, lombardo@math.unipa.it

CP5

Coarse-Graining of Evolutionary Models

In order to analyze complex evolutionary agent-based models we developed a coarse-grained method, where we perform short simulations to estimate the derivatives of macroscopic variables describing the trait distribution. Thus the evolution and steady states of the trait distribution can be investigated through the macroscopic variables. We apply our method to a continuous snowdrift game on an adaptive network, where players can delete links to uncooperative neighbors.

Johannes M. Hoefener
Max-Planck Institut fuer Physik komplexer Systeme
Biological Physics Section
hoefener@pks.mpg.de

CP5

Synchronization and Causality in Multiscale Processes

Palus and Vejmelka (Phys. Rev. E 75 056211, 2007) describe an information-theoretic approach to inference of coupling asymmetry from experimental time series. Having an efficient method to estimate proper conditioning, one can identify drive-response relationships between systems characterized by different types of data (phase-amplitude) and with dynamics on different temporal scales, e.g. theta-gamma brain waves interactions and information transfer in multiscale processes requiring testing with multifractal surrogate data (Palus, Phys. Rev. Lett. 101 134101, 2008). Supported by the EC FP7 project BrainSync (HEALTH-F2-2008-200728).

Milan Palus, Martin Vejmelka
Academy of Sciences of the Czech Republic
Institute of Computer Science
mp@cs.cas.cz, vejmelka@cs.cas.cz

CP5

A Result on the Use of Haar Wavelets to Characterize Ergodicity in Fluid Flows

The theory behind a new multiscale idea for characterizing flows using deviation from ergodicity is introduced. Focus is given to a result that characterizes ergodicity via Haar wavelets. The theory is based in dynamical systems, ergodic theory and harmonic analysis and the motivation comes out of ocean science and engineering applications.

Sherry Scott
Department of Mathematics
Marquette University
scott@mscs.mu.edu

CP6

Delay Equations: A Bridge Between Difference and Ordinary Differential Equations

It is well known that autonomous ordinary differential equations of population dynamics are usually stable: the positive equilibrium (if exists) attracts all positive solutions. Relevant difference equations, for example, the Ricker and the logistic maps, are stable in some range of parameters only: as the intrinsic growth rate increases, the models experience transition to chaos through a series of period-doubling bifurcations. We demonstrate that delay equations have the same dynamics as ODEs for small delays and can mimic the dynamics of discrete maps for arbitrary delays. Finally, we explore the role of constant perturbations to control chaos in spatial discrete systems.

Elena Braverman
Department of Mathematics & Statistics
University of Calgary
maelena@math.ucalgary.ca

Sergey Zhukovskiy
PF University, Moscow
(PhD student)
sergey@math.ucalgary.ca

Jeff Haroutunian
University of Calgary
(MSc student)

jjharout@math.ucalgary.ca

CP6

Characterizing the Synchronization Between Coupled Nonlinear Time-Delayed Optoelectronic Feedback Loops

We present an analytical, numerical, and experimental study of the synchronization between two nonlinear time-delayed optoelectronic feedback loops. We evaluate the conditions under which these two systems synchronize and study how these regimes relate to the system parameters. We will focus on feedback strength and delay as the primary variables. Applications to private communications and sensing networks are discussed.

Karl Schmitt
University of Maryland, College Park
Dept. of Mathematics, AMSC
krbschmitt@math.umd.edu

Thomas Murphy
University of Maryland, College Park
Dept. of Electrical and Computer Engineering
tem@umd.edu

Bhargava Ravoori, Adam Cohen
University of Maryland, College Park
Dept. of Physics
ravoorib@umd.edu, abcohen@umd.edu

Rajarshi Roy
University of Maryland, College Park
IPST, Physics
lasynch@gmail.com

CP6

Delayed Time-Periodic Force Control

A 1 DOF model of force control is considered with discrete delayed feedback. A special case of periodic control is introduced: the feedback gain is constant for some sampling periods, then it is zero for a certain number of periods, then it is constant again, etc. If the period of gain variation is larger than the feedback delay, the system performance changes radically: the stability properties improve significantly. Experiments confirm the theoretical predictions.

Gabor Stepan, Tamas Insperger, Laszlo Kovacs
Budapest University of Technology and Economics
Department of Applied Mechanics
stepan@mm.bme.hu, inspi@mm.bme.hu, kovacs@mm.bme.hu

CP7

How to Generate Zonal Flow Faster?

We will consider the problem of alternating zonal jets, like Jupiter's stripes. Mathematically similar flows appear also in tokamak plasmas, where these zonal flows serve as barriers to the anomalous transport, and thereby improve the output of the nuclear fusion. So, there is a problem "How to generate zonal flow faster?'

Alexander M. Balk
University of Utah
balk@math.utah.edu

CP7

Distinguished Trajectories in Time Dependent Geophysical Flows

In this presentation we propose a generalisation of the concept of fixed to aperiodical dynamical systems: the distinguished trajectory. We discuss its application to describe transport of passive scalars in geophysical flows. Previous works have addressed the existence of distinguished hyperbolic trajectories but our new definition shows that non-hyperbolic orbits may also fall within this category. In oceanographic contexts non-hyperbolic trajectories are related to eddies or vortices.

Ana M. Mancho
Instituto de Ciencias Matematicas
Consejo Superior Investigaciones Cientificas
A.M.Mancho@imaff.cfmac.csic.es

Jose Antonio Jimenez Madrid
Instituto de Ciencias Matematicas
CSIC
madrid@imaff.cfmac.csic.es

CP7

Transitions in Irregular Geostrophic Turbulence

Thermal convection in a rapidly rotating finite cylinder with thermal driving well past critical is investigated using well-resolved direct numerical simulations of the full 3D Navier–Stokes equations with the Boussinesq approximation. Bulk convection sets in as a regular vortex grid which gives way to states of so-called 'irregular geostrophic turbulence' before thermal turbulence is reached at thermal driving several hundred times that required for the onset of convection. We seek to characterize the irregular geostrophic solutions in terms of symmetry breaking of the long-term time series statistics and changes to the morphology of the solutions.

Antonio M. Rubio, Juan Lopez
Arizona State University
antonio.rubio@asu.edu, lopez@math.la.asu.edu

Francisco Marques
Universitat Politecnica de Catalunya
Department of Applied Physics
marques@fa.upc.es

CP8

Frequency Switching in the Two-compartmental Model of the Dopaminergic Neurons

Midbrain dopaminergic (DA) neurons display two functionally distinct modes of electrical activity: low- and high-frequency firing. The high-frequency firing is linked to important behavioral events in vivo. However, it cannot be elicited in vitro by standard manipulations in vitro. A two-compartmental model of the DA cell that unites data on firing frequencies under different experimental conditions has been suggested. We analyzed dynamics of this model. An artificial timescale separation was introduced to conduct the singular perturbation analysis first. By comparison to that, the original case of poor timescale separation was investigated. Conditions under which the frequency of the coupled system was high were shown to require sufficient folding of a nullcline for the fast subsystem. Changes responsible for lowering frequency altered the regime gradually, without complex transitions, by contrast to the case

of a poor timescale separation. However, the difference in frequencies obtained under conditions corresponding to different experiments vanished under the additional timescale separation. Taken together, the results explain how the geometry of the phase space and the poor timescale separation in the model contribute to its characteristics replicating those of the DA neuron.

Joon Ha, Alexey Kuznetsov
Indiana University-Purdue University Indianapolis
jha@math.iupui.edu, akuznetsov@math.iupui.edu

CP8

Sustainability Analysis of Models for Commercial Fishing: Viable Economic Aspects

A non-linear dynamic model in two state variables and one control is presented for the purpose of finding the sustainability combination of exploitation, capital investment in the commercial fishing industry. To achieve this, we pay much attention to the viability of the system or, in a symmetric way, to crisis situations defined by a set of economic and biological state constraints. Using the mathematical concept of viability kernel we exhibit the sustainable ecological-economic states required to obtain a perennial system.

Chakib Jerry, Nadia Rassi
Equipe EIMA, Departement de Mathematiques et d'Informatique
Faculty of Sciences
jechakib@yahoo.fr, n.raissi@mailcity.com

CP8

The Response of Stable Limit Cycle Dynamics to Spatial Dispersal in Heterogeneous Habitat

Through four spatially explicit models, we investigate how habitat fragmentation affects cyclic predator-prey population dynamics. In the absence of dispersal, solution trajectories are either periodic orbits or limit cycles. We use a Partial Differential Equation (PDE) framework to describe the dispersal of predators and prey in a heterogeneous landscape made of high quality and low quality habitat patches. Two of our models show that even small levels of habitat fragmentation significantly affect the amplitude of the predator-prey population cycles. Average population density is relatively insensitive to habitat fragmentation. All of the models exhibit reduced cycle amplitude and average population density when the size of good habitat patches is reduced below a critical level. We suggest that solution behaviour in response to spatial dispersal in heterogeneous habitats can be used as another measure of the structural stability of models.

Rebecca Tyson, Shaun Strohm
University of British Columbia Okanagan
rebecca.tyson@ubc.ca, shaun.strohm@gmail.com

CP9

A Kam Theorem Without Action-Angle Variables for Elliptic Reducible Lower Dimensional Tori

Our aim is to study elliptic reducible lower dimensional tori in Hamiltonian systems via parameterizations. We want to highlight that, even though our results are not new, the approach presents a lot of advantages in contrast with classical methods. For example, neither a perturbative setting nor action-angle variables are required. Furthermore, the presented proof is simple and lead to numerical algorithms for the computation of these objects.

Alejandro Luque
Universitat Politècnica de Catalunya
alejandro.luque@upc.edu

Jordi Villanueva
Universitat Politecnica de Catalunya
jordi.villanueva@upc.edu

CP9

A Nested Tangles Approach to the Symbolic Dynamics of Mixed Phase Spaces

An area-preserving map of the plane typically exhibits a mixture of chaos and regularity that complicates the process of extracting a complete symbolic description of the dynamics. The topology of the dynamics in the vicinity of stable islands can be particularly complex. We demonstrate a technique that extracts symbolic dynamics for such systems by utilizing networks of nested homoclinic and heteroclinic tangles – fundamental geometric objects that organize the transport in phase space. The topological dynamics in the vicinity of a stable island chain is modeled by including information about the heteroclinic tangle connecting the hyperbolic orbits between the stable islands. The net result is a symbolic description that serves as a topological approximation to the map that includes the influence of stable island chains. Such symbolic descriptions are useful in the study of fractal self-similarity in chaotic scattering and escape data, the computation of escape rates, the calculation of topological entropies, etc. We also discuss the extension of this symbolic technique to higher dimensional phase spaces.

Kevin A. Mitchell
Univ of California, Merced
School of Natural Sciences
kmitchell@ucmerced.edu

CP10

Period-Doubling Cascades and Mode Interactions in Coupled Systems

We consider two coupled maps which have a period-doubling cascade in the synchronised subspace and a symmetry-breaking bifurcation. A period-doubling/symmetry-breaking mode interaction may result in a secondary symmetry-breaking bifurcation from the period 2 solutions, which is then involved in another mode interaction with the next period-doubling bifurcation. In this way a complete cascade of mode interactions can occur. Such cascades are classified and illustrated by examples, including two coupled vertically forced pendulums.

Philip J. Aston
University of Surrey
Department of Mathematics
P.Aston@surrey.ac.uk

Himat Mir
University of Surrey
Dept of Maths & Stats
h.mir@surrey.ac.uk

CP10

Hybrid Coupled Cells - Switching Symmetries in Dynamical System Networks

Time-varying networks of dynamical systems play an important role for the mathematical description of various real-world problems. In this contribution, I will consider symmetrically coupled systems and explore the impact of discrete changes in the coupling architecture on the dynamics of an initially given dynamical system network. In order to model such non-autonomous behaviour, a hybrid system approach is presented using the formalism of hybrid automata. This is joint work with Michael Dellnitz.

Sebastian Hage-Packhäuser
Chair of Applied Mathematics
University of Paderborn
shage@math.uni-paderborn.de

CP10

Transfer Operator Structure for Coupled Cell Systems

We consider structural properties of the transfer operator for coupled cell systems. For a classically symmetric network, representation theory tells how to decompose the domain to obtain a diagonalisation of the operator. However, global symmetries need not be present even for highly structured coupled cell systems. We present a new decomposition of the transfer operator that is reflecting the network structure, and relate it to a weaker, local, notion of symmetry in the coupling structure.

Mirko Hessel-von Molo
Institute for Mathematics
University of Paderborn
mirkoh@uni-paderborn.de

CP11

Dynamics of the N-Body Problem: Applications of the Geometric Phase in Classical and Quantum Molecular Dynamics

A classical geometric phase describes net overall rotation of a molecule due to internal motions. The quantal geometric phase is a net phase change in a Born-Oppenheimer electronic wavefunction. A classical-quantum correspondence relates the quantal geometric phase to its classical counterpart in N-body molecular dynamics. Each geometric phase is the holonomy of a connection and has been observed (e.g., in computational protein dynamics and in theoretical studies of vibrational spectra of a triatomic molecule, respectively).

Florence J. Lin
University of Southern California
fjlin@usc.edu

CP11

Heteroclinic Connections Between Triple Collisions and Relative Periodic Orbits in the Isosceles Three-Body Problem

We consider the spatial isosceles three-body problem in which two masses are equal and remain symmetric about an axis while the other mass moves along the axis: the three masses continue to configurate an isosceles triangle. The triple collision singularity is blown-up to an invariant manifold called the collision manifold and some heteroclinic orbits to equilibria were found in the blown-up system. We prove the existence of infinitely many, new heteroclinic and periodic orbits. In particular, the periodic orbits shadow the heteroclinic orbits. To demonstrate the theoretical results, we also give numerical computations by the continuation tool AUTO for the stable and unstable manifolds and heteroclinic orbits to the equilibria and periodic obits in the blown-up system, which correspond to relative periodic orbits in the original three-body problem.

Kazuyuki Yagasaki
Gifu University
Department of Mechanical and Systems Engineering
yagasaki@gifu-u.ac.jp

Mitsuru Shibayama
Kyoto University
sibayama@kurims.kyoto-u.ac.jp

CP11

A Family of Comets in the Newtonian Three-Body Problem

Using variational techniques, I look at curves with three bodies of equal mass that have collinear initial position and, after a given time, end up in an isosceles configuration with a fixed amount of rotation. I find a family of periodic orbits where the "comet" passes close to both primaries. These orbits have the same topology which are deformed into each other without passing through collision.

Elizabeth Zollinger
Hiram College
zollingerea@hiram.edu

CP12

Controlling Swarm Formations Without a G.P.S.

We present a model of distributed, autonomous robotic agents moving in R^2. Agents estimate the group's centroid and shape moments via a dual-layer consensus estimator. The estimator uses other agents' relative positions and state estimates as inputs, which are communicated over a range-limited network. Each agent uses its estimates as input into a motion controller that drives the agents into a target shape that moves at a target velocity.

Daniel M. Kiefer
Dept. of Engineering Sciences and Applied Mathematics
Northwestern University
DanielKiefer2009@u.northwestern.edu

Mary C. Silber
Northwestern University
Dept. of Engineering Sciences and Applied Mathematics
m-silber@northwestern.edu

Cristian Huepe
Unaffiliated NSF grantee
cristian@northwestern.edu

CP12

Analysis of the Macroscopic Behaviour of Microscopic Traffic Systems

Microscopic models for single lanes and for traffic networks are considered. The influence of microscopi parameters like the drivers behaviour on macroscopic phenomena such as traveling waves are investigated. Under certain conditions a stepwise approaching to stationary states can be observed and investigated. An equation-free approach for continuation techniques and numerical bifurcation analysis as well as analytical methods are used.

Jens Starke
Technical University of Denmark
Department of Mathematics
j.starke@mat.dtu.dk

CP12

Self-Organization in Animal Groups by Mechanical Interactions

Collective motion of animal groups can be organized by social attraction, and alignment towards adjacent individuals. We study global patterns of motion in groups of self-propelled, finite, rigid objects of various shapes in the absence of 'social' alignment. Groups of round objects resemble unoriented swarms, however mechanical interactions (collisions) between elongated objects may give rise to oriented group motion. This result uncovers a new mechanism of self-organization in dense animal groups via mechanical constraints.

Peter L. Varkonyi
Budapest University of Technology and Economics
vpeter@mit.bme.hu

CP13

Deterministic Activation in Coupled Oscillator Arrays

Metastable transitions are ubiquitous in many physical systems and are becoming a concern in engineering design as these designs become more and more inspired by dynamics of biological, molecular, or other natural systems (eg. swarms of vehicles, coupled building energetics, etc). While considering internal resonance, we derive a multi-phase averaged approximation for a locally bistable deterministic oscillator chain which illustrates the influence of actions in modal coordinates on the coarse behavior of the oscillator chain. An analytic activation condition that characterizes energy needed and temporal escape rates is derived. An inverse energy cascade through these actions is identified as well. The behavior of the oscillator array in this context is also compared to stochastic rates obtained from Kramers estimates.

Bryan Eisenhower
UCSB
bryane@engr.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

CP13

Mathematical Modelling of a MicroRNA Regulated Gene Network in Caenorhabditis Elegans

MicroRNAs are known to regulate gene expression by repressing translation or directing sequence-specific degradation of target mRNAs, and are therefore considered to be key regulators of gene expression. A gene regulatory pathway involving heterochronic genes controls the temporal pattern of *Caenorhabditis elegans* postembryonic cell lineages. Based on experimental data, we propose and analyze a mathematical model of a gene regulatory module in this nematode involving two heterochronic genes, *lin-14* and *lin-28*, which are both regulated by *lin-4*, encoding a microRNA. Our analytical findings have boarder implication in biology.

Mainul Haque
University of Nottingham, UK
pmxmh1@nottingham.ac.uk

John King
University of Nottingham
School of Mathematical Science
john.king@nottingham.ac.uk

David Pomerai, Matthew Loose
University of Nottingham, UK
david.depomerai@nottingham.ac.uk,
matt.loose@nottingham.ac.uk

CP13

Dynamics of Cascading Failures in Complex Networks

We study the spreading dynamics in networks, where a triggering event may start a cascade of overload failures. By means of dynamic models for the nodes and links and simulations we found a topology dependent critical threshold for the undamped spreading of failures. Moreover, we found that considering the transient dynamics becomes important if an instantaneous redistribution of loads is not realized, such that models with quasistatic redistibution processes dramatically overestimate the robustness of the network.

Karsten Peters
TU Dresden
karsten.peters@tu-dresden.de

CP14

Noise During Rest Explores the Brains Dynamic Repertoire

Traditionally brain function is studied through measuring physiological responses in controlled sensory, motor and cognitive paradigms. However, even at rest, in absence of overt goal-directed behavior, collections of cortical regions consistently show temporally coherent activity. In humans, these resting state networks have been shown to greatly overlap with functional architectures present during consciously directed activity, which motivates the interpretation of rest activity as day dreaming, free association, stream of consciousness and inner rehearsal. In monkeys, it has been shown though that similar coherent fluctuations are present during deep anesthesia when there is no consciousness. Here, we show that comparable resting state networks emerge from a stability analysis of the network dynamics using biologically realistic primate brain connectivity, although anatomical information alone does not identify the network. We specifically demonstrate that noise and time delays via propagation along connecting fibres are essential for the emergence of the coherent fluctuations of the default network. The spatiotemporal network dynamics evolves on multiple temporal scales and displays the intermittent neuroelectric oscillations in the fast frequency rgimes, 1-100Hz, commonly observed in electroencephalographic (EEG) and magnetoencephalographic (MEG) recordings, as well as the hemodynamic oscillations in the ultraslow rgimes, ¡0.1Hz, observed in functional magnetic resonance imaging (fMRI). The combination of anatomical structure and time delays creates a space-time structure, in which the neural noise enables the brain to explore various functional configurations representing its dynamic repertoire.

Viktor Jirsa
Florida Atlantic University
Physics Department
jirsa@ccs.fau.edu

CP14

Neuronal Networks as an Excitable Medium

Spiral- and target-like fire and voltage patterns were discovered in networks of conductance-based, integrate-and-fire, point model neurons synaptically connected to their close neighbors. The geometry for the model is a lattice of about 60,000 excitable neurons on a torus, coupled to nearest and/or next-nearest neighbors. The external spike train is chosen so that, with the neuron-to-neuron synaptic connections turned off, the average voltage of each neuron is very close to the firing threshold, which is the excitable medium regime. Due to the fluctuations in the incoming spike trains, a neuron is occasionally driven to firing, which provides a seed for the formation of firing patterns when neighboring neurons are coupled. The wavelength and wave speed of the patterns were investigated.

Christina H. Lee
Rollins College
Rensselar Polytechnic Institute
clee@rollins.edu

CP14

Information Flow Graphs Produced by One Hundred Neocortical Neurons

We used transfer entropy to assess information flow in cortical slice cultures placed on a 512 electrode array system (with Alan Litke of UC Santa Cruz). Cultures were active for periods exceeding 1 hr, allowing us to collect long data sets for entropy statistics. Analysis revealed wide differences in node degrees, but did not clearly point to a small-world or a scale-free structure.

Aonan Tang, Jon Hobbs
indiana university
aotang@indiana.edu, jphobbs@indiana.edu

Alexander Sher, Alan Litke
University of California Santa Cruz
sasha@scipp.ucsc.edu, alan.litke@cern.ch

John M. Beggs
Indiana University
Dept. of Physics
jmbeggs@indiana.edu

CP15

Applying Numerical Continuation to Track the Resonant Solutions of the Schrödinger Equation

In molecular reactions the appearance of resonances has an important influence on the reactivity. It is important to predict when a bound state transitions into a resonance and how these transitions depend on various system parameters such as internuclear distances. The dynamics of such systems are described by the Schrödinger equation. We interpret the problem as a bifurcation problem and track solutions and detect the bifurcations with pseudo-arc length continuation.

Przemyslaw Klosiewicz
Universiteit Antwerpen
Department of Mathematics and Computer Science
przemyslaw.klosiewicz@ua.ac.be

Wim I. Vanroose
Universiteit Antwerpen
Belgium
wim.vanroose@ua.ac.be

CP15

Coastal Ocean Flows and Nonlinear Optimal Control

Nonlinear, time-varying flow fields like those observed in ocean models exhibit complexities that make the optimal trajectory for a given starting point hard to find. But we show how computational tools like time-averaging of a cost function offer insight into solution behavior and methods for approximating it. Furthermore, we find exact solutions for the contrained final state finite horizon optimal feedback control problemthat is, solutions of the Hamiltonian-Jacobi-Bellman equationvia backward integration of the Euler-Lagrange equations.

Blane Rhoads
University of California Santa Barbara
blane.rhoads@gmail.com

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

CP15

On the Global Dynamics of the Nicholson Blowflies and the Mackey-Glass Equations

After many decades of intensive research, some seemingly simple nonlinear delay differential equations still pose massive problems to their understanding, even in the case of monotone feedback. We present recent results for celebrated model equations with non-monotone feedback: the Nicholson-blowflies (population dynamics) and the Mackey-Glass (haematological diseases) equations. We show that often the asymptotic behavior is governed by monotonone feedback. We give sharp bounds for the global attractor and construct heteroclinic orbits.

Gergely Röst
Bolyai Institute, University of Szeged
rost@math.u-szeged.hu

CP16

An Analytic Approach to the Self-organization of Networks of Competing Boolean Nodes

Boolean networks (BN) are considered revealing idealizations of neural and gene regulatory networks which makes properties of evolving BN an issue of keen interest. Here, we study an evolutionary model of an annealed BN in which nodes compete in a minority game. Simulations showed that the system self-organizes into a non-trivial

critical state. We propose an analytical approach providing insight into the underlying mechanism of the self-organization process and revealing further dynamical characteristics like the distribution of attractor lengths.

Anne-Ly Do
Max Planck Institute for the Physics of Complex Systems
ly@pks.mpg.de

Thilo Gross
MPI for the Physics of Complex Systems
gross@pks.mpg.de

Kevin E. Bassler
Department of Physics
University of Houston
bassler@uh.edu

CP16

Combinatorial Games with Passes: A Geometric Approach

Combinatorial games are a familiar class of games which includes Chess, Checkers, Go , Nim, Chomp, etc. We examine the effects of introducing a one-time “pass' into common combinatorial games. Using Nim as a prototype, we describe the (sometimes dramatic) consequences a pass can have on the underlying geometric structure of a game, and demonstrate (via recursion algorithms) that there exists a connection between “games with passes' and a recently introduced class of “generic games.'

Adam S. Landsberg
Claremont McKenna College, Pitzer College, Scripps College
landsberg@jsd.claremont.edu

Rebecca Morrison
UT Austin
rebeccae.morrison@gmail.com

CP16

Computer Systems Are Dynamical Systems

We propose a nonlinear dynamics-based framework for modeling and analyzing computer systems. Working with this framework, we use delay-coordinate embedding to study the dynamics of these complex nonlinear systems. We find strong indications of low-dimensional chaotic dynamics in the performance of a simple program running on one microprocessor—and periodic dynamics when the same program is run on a slightly different microprocessor. We discuss how our results impact the analysis and design of these engineered systems.

Todd D. Mytkowicz, Amer Diwan
University of Colorado, Boulder
Todd.Mytkowicz@colorado.edu, diwan@cs.colorado.edu

Elizabeth Bradley
University of Colorado at Boulder
elizabeth.bradley@colorado.edu

CP17

Agent-Based Modeling of Civil Violence

The agent-based computational model of civil violence is considered. The main concentration is put on determining the arrest probability function, which defines the probability for an agent to be arrested after becoming rebellious. Depending on the shape of this function, completely different results are observed, varying from the stable situation in the population to the very unstable one. Thus we showed that the arrest probability function is a sensitive parameter of the model.

Maria Fonoberova
AIMdyn, Inc
mfonoberova@aimdyn.com

Vladimir Fonoberov
Chief Scientist
AIMdyn, Inc
vfonoberov@aimdyn.com

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

Jadranka Mezic
Aimdyn, Inc.
mezici@aol.com

CP17

Stability and Control in Neutral Delay Differential Equations with Engineering Applications

Delay differential equations (DDEs) play an increasingly important role in the mathematical modelling of engineering applications. In this talk it will be shown how neutral DDEs arise in modelling hybrid testing of large structures. We will present analytical and numerical results for a second-order neutral DDE and show excellent agreement with experiments. In addition we will show how to control unstable steady states using time-delayed feedback control.

John Hogan
Bristol Centre for Applied Nonlinear Mathematics
Department of Engineering Mathematics, University of Bristol
s.j.hogan@bristol.ac.uk

Yuliya Kyrychko
University of Bristol
y.kyrychko@bristol.ac.uk

CP17

Analysis of An Epidemic-Like Model for the Spread of Religion

In many ways, the spread of religion behaves similar to the spread of a contagious disease through a population. Therefore, I describe a epidemic-like model for the spread of two religions through a nonconstant-size population. The model is analyzed and a threshold value for the growth of the religions is calculated. Numerical simulations using hypothetical data are also created.

Curtis L. Wesley, Helen Wise
Louisiana State University at Shreveport
curtis.wesley@lsus.edu, hpowell@lsus.edu

CP18

The Solitary Wave Solution for Korteveg-de Vries

(KdV) Equation with Quartic Nonlinearity

We consider new Fermi-Pasta-Ulam (FPU) chain model which has quintic force term. When we take the continuum limit of this FPU model, we obtain partial differential equation which models longitudinal vibration of rod. This equation is a new kind of KdV equation with quartic nonlinearity. We will present a solitary wave solution for this KdV equation.

Dong-Wook Lee, Marisol Koslowsi
School of Mechancial Engineering
Purdue University
leed@purdue.edu, marisol@purdue.edu

JiHwan Kim
Department of Mechanical Engineering
Texas Tech University
jihkimttu@yahoo.com

CP18

Spatial Diffusion Enhances Synchronization in Extended Systems

We study synchronization in a generic extended system where locally coupled phase oscillators are allowed to diffuse in space. The system exhibits several steady states apart from the disordered and the globally synchronized state. Spatial diffusion disrupts such states, and allows for the system to attain global synchronization. We show that for any finite system there is a critical spatial diffusion above which all non-global synchronization solutions become unstable, remaining only one steady state stable, which corresponds to global synchronization. For lower spatial diffusions, the onset of the transition is characterized by the coexistence of several stable steady corresponding to non-global and global synchronization order. The transition to global synchronization is governed by the relative size of the steady state attractor basins.

Fernando Peruani
Service de Physique de l'Etat Condense (CEA)
and Complex System Institute Paris Ile-de-France
fernando.peruani@iscpif.fr

Ernesto Nicola, Luis Morelli
Max Planck Insitute for the Physics of Complex Systems
nicola@pks.mpg.de, morelli@pks.mpg.de

CP18

Spectra of Periodic Approximations to Quasipatterns

True quasipatterns cannot be represented in a periodic domain, but some domains provide more accurate approximations than others. We identify which domains provide the most accurate approximations to quasipatterns, systematically investigate the Fourier spectra of the most accurate approximations, and explore the effect of small divisors, which are a key feature of quasipatterns, but which are absent in periodic approximations. Reference: "Design of parametrically forced patterns and quasipatterns,' A.M. Rucklidge and M. Silber, SIADS, in press.

Mary C. Silber
Northwestern University
Dept. of Engineering Sciences and Applied Mathematics
m-silber@northwestern.edu

Alastair M. Rucklidge
Department of Applied Mathematics
University of Leeds
A.M.Rucklidge@leeds.ac.uk

CP19

Basin Switching in the Presence of Non-Gaussian Noise

We study the effect of a non-Gaussian noise on basin switching activated primarily by Gaussian noise. Even weak non-Gaussian noise can strongly change the switching rate. The effect is expressed in a closed form in terms of the noise characteristic functional. The analytical results are compared with the results of simulations for an overdamped system driven by white Gaussian noise and a Poisson noise. Switching induced by a purely Poisson noise is also discussed.

Lora Billings
Montclair State University
Dept. of Mathematical Sciences
billingsl@mail.montclair.edu

Mark I. Dykman
Department of Physics and Astronomy
Michigan State University
dykman@pa.msu.edu

Ira Schwartz
Naval Research Laboratory
Washington DC
ira.schwartz@nrl.navy.mil

CP19

Diverging Probability Density Functions in Stochastic Nonlinear Wave Equations

We investigate the dynamics of flat-top solitary wave parameters in the presence of weak multiplicative-dissipative disorder. We show that for both the cubic-quintic nonlinear Schrödinger equation (CQNLSE) and the extended Korteweg-de Vries equation the probability density function (PDF) of the amplitude η exhibits loglognormal divergence near the maximum possible amplitude. For the derivative CQNLSE the same statistics is observed for the ratio $\eta/(1-\epsilon_s\beta/2)$, where ϵ_s is the self-steepening coefficient and β is the group velocity. Furthermore, we relate the loglognormal divergence of the PDF to the form of the solitary wave tail.

Avner Peleg
State University of New York at Buffalo
apeleg@nsm.buffalo.edu

Yeojin Chung
Southern Methodist University
ychung@mail.smu.edu

Tomáš Dohnal
Universitat Karlsruhe
dohnal@math.uka.de

Quan Nguyen
State University of New York at Buffalo
qnguyen2@buffalo.edu

CP19

Characterization of Chaotic Scattering in Noisy Environments

In this talk we present a study of the effects of noise in chaotic scattering problems. We use as prototype models both, a discrete map and a flow. We focus in the study of the survival probability of the particles in the scattering region that becomes exponential once the intensity of the noise reaches the critical value, ϵ_c. We surprisingly find a scaling law for the coefficient of the exponential decay, γ, and the intensity of noise, ϵ, once the intensity of noise reaches its critical value. We also compute the fractal dimension of the set of singularities of the scattering function when noise is presented observing the phenomena reported previously for the critical value of the noise amplitude. We also provide heuristic arguments that are in agreement with the numerical results. Finally, we expect that this work can be useful for a better understanding of chaotic scattering phenomena in different physical situations where noise appears.

Jesus M. Seoane
Nonlinear Dynamics and Chaos Group.
Universidad Rey Juan Carlos
jesus.seoane@urjc.es

Liang Huang
Department of Electrical Engineering
Arizona State University, Tempe, Arizona 85287, USA
liang.huang@asu.edu

Miguel Af Sanjuan
Nonlinear Dynamics and Chaos Group
Universidad Rey Juan Carlos. Madrid. Spain
miguel.sanjuan@urjc.es

Ying-Cheng Lai
Arizona State University
Department of Electrical Engineering
Ying-Cheng.Lai@asu.edu

CP20

Spectral Gradient Flow and Equilibrium Configurations of Point Vortices

We formulate the problem of finding equilibrium configurations of N point vortices in the plane in terms of a gradient flow on the smallest singular value of a matrix whose nullspace structure determines the (real) strengths, rotational frequency, and translational velocity of the configuration. We also formulate the constrained problem of finding equilibria when the point vortex strengths are prescribed. This method allows us to quickly find rigid configurations with $N \approx 50 - 100$.

Andrea K. Barreiro
Department of Applied Mathematics
University of Washington
barreiro@amath.washington.edu

Jared Bronski
University of Illinois Urbana-Champain
Department of Mathematics
jared@math.uiuc.edu

Paul Newton
Univ Southern California
Dept of Aerospace Engineering
newton@spock.usc.edu

CP20

Essentially Asymptotically Stable Homoclinic Networks

In [Melourne, An example of a nonasymptotically stable attractor, 1991] Melbourne discusses an example of a robust heteroclinic network that is not asymptotically stable but which has the strong attracting property called essential asymptotic stability. We establish that this phenomenon is possible for homoclinic networks, where all equilibria are symmetry related. Moreover, we study a transverse bifurcation from an asymptotically stable to an essentially asymptotically stable homoclinic network. The essentially asymptotically stable homoclinic network turns out to attract all nearby points except those on a codimension-one stable manifold of equilibria outside the homoclinic network.

Ramon Driesse, Ale Jan Homburg
University of Amsterdam
r.driesse@uva.nl, a.j.homburg@uva.nl

CP20

Destruction of Anderson Localization in Nonlinear Disordered Lattices

We demonstrate, using two setups, that nonlinearity destroys Anderson localization in one-dimensional disordered lattices, using the discrete nonlinear Schrödinger equation as the basic model. First, we show that an initially localized wave packet in the presence of nonlinearity spreads sub-diffusively on a long time scale. Second, we study a transmission through a disordered nonlinear layer as a statistical bifurcation problem and demonstrate the destruction of localization via self-induced transparency.

Arkady Pikovsky
Department of Physics
University of Potsdam, Germany
pikovsky@uni-potsdam.de

CP21

Dynamics of Models of Intracellular Calcium

Calcium is important in cells, regulating many aspects of cell physiology. Experiments show that intracellular calcium dynamics typically evolves over two or more timescales, and mathematical models of calcium dynamics are constructed to reflect this. This talk will describe recent progress in the analysis of a range of models of intracellular calcium, focussing on some novel features of the observed global bifurcations, including some that result from the existence of multiple time-scales in the model equations.

Vivien Kirk
University of Auckland
v.kirk@auckland.ac.nz

CP21

Simulation of Feedback Control for the Suppression of Epileptic Seizures

It has been shown that a mesoscale cortical model can support waves quantitatively similar to epileptic seizures. By supplementing this PDE model with equations representing an electrode measurement and the application of an ex-

ternal electric field, we can simulate suppression of seizure activity via closed-loop feedback control. We can visualize this result using the full PDE model, and reduction to an ODE allows us to examine the behavior of seizure-causing bifurcations as control is applied.

Beth A. Lopour
University of California - Berkeley
bethlopour@berkeley.edu

Andrew J. Szeri
University of California at Berkeley
Department of Mechanical Engineering
aszeri@me.berkeley.edu

CP21

Isochron Portrait Analysis of Phase Response in Bursting Neural Models

Models of bursting neurons often have significantly different phase response curves than models of spiking neurons. Bursters may exhibit a high degree of phase sensitivity to synaptic input associated with intraburst spike timing and spike addition/deletion. We use isochron portraits and multiple time-scale analyses to relate corresponding PRC features to the geometry and bifurcation structure of the fast subsystems of biophysically realistic model bursters, and we compare burster PRCs with those of spikers. We also present a practical method for calculating isochrons, a task that is easy in theory but difficult in practice due to numerical issues.

William E. Sherwood
Center for Biodynamics
Boston University
wesher@bu.edu

John Guckenheimer
Cornell University
jmg16@cornell.edu

CP22

Modeling Extended Systems: Synchronization of Organ Pipes by Acoustical Interaction

The modeling of extended systems is highly involved as soon as nonlinearities come into play. For some pattern forming systems analytical descriptions can be found by the help of perturbation theory; for others heuristic equations are given; a third possibility is the numerically assisted modeling when some idea about the dynamics of the system already exists. The problem of synchronizing organ pipes lingers since more than a century, qualitative understanding has been developed, whereas quantitative descriptions are not yet given. We have performed a very precise measurement of the synchronization of an organ pipe by an external sound source thereby finding an Arnold Tongue over 3 decades (the deepest ever measured). The description in terms of compressible fluid dynamics is straightforward, but hard to solve, on the other hand is an oscillator model typical for synchronization. We find an appropriate model by numerical analysis with excellent coincidence of experiment and model. The focus of this talk is on the power of this ansatz for extended systems in general.

Markus Abel
University of Potsdam
markus.abel@physik.uni-potsdam.de

Karsten Ahnert
University of Potsdam
Institute of Physics and Astronomy
karsten@stat.physik.uni-potsdam.de

CP22

Stochastic Resonance in Unforced Cyclically Coupled Systems

We investigate Stochastic Resonance (SR) in the absence of oscillatory forcing, as it applies to nonlinear sensor devices built to detect dc external signals. We show the existence of SR effects and extension of the work to limit cycles that evolve from heteroclinic cycles. As test medium we use a model system characterizing the mean-field dynamics of a novel class of Electric Field Sensors currently being developed.

John L. Aven
San Diego State University
Department of Mathematics
chaotic_aven@yahoo.com

Antonio Palacios
San Diego State University
Dept. of Mathematics/Computational Science Research Center
palacios@sciences.sdsu.edu

Visarath In
SPAWAR Systems Center, San Diego
visarath@spawar.navy.mil

CP22

Epidemiological Network Analysis for the Network of Livestock Movements in the UK

In this talk, I will discuss the time scale interaction of more line defects (involving source and contact defects) that appear at the onset of the period-doubling for 2D spiral waves.

Adela N. Comanici
University of Glasgow
adela.comanici@gmail.com

CP23

Canards and Mixed-Mode Oscillations in a Forest Pest Model

Several forest pests have a pattern of showing up in outbreaks at more or less regular intervals. In between outbreaks, the population declines to close to zero. In the light of a changing climate, there is a challenge in predicting how such a pattern might change. By considering a simple ODE model, we show that canard explosions, describing a change from outbreak dynamics to small variations around an equilibrium, and mixed mode oscillations are possible.

Rune Kaasen, Morten Brøns
Technical University Denmark
kaasen@mat.dtu.dk, brons@mat.dtu.dk

CP23

New Dynamics in Cerebellar Purkinje Cells: Torus

Canards

We describe a transition from bursting to rapid spiking in a reduced mathematical model of a cerebellar Purkinje cell. We perform a slow-fast analysis of the system and find that — after a saddle node bifurcation of limit cycles — the full model dynamics follow temporarily a repelling branch of limit cycles. We propose that the system exhibits a dynamical phenomenon new to realistic, biophysical applications: torus canards.

Mark Kramer
Center for BioDynamics
Boston University
mak@bu.edu

Roger Traub
IBM
rtraub@us.ibm.com

Nancy J. Kopell
Boston University
Department of Mathematics
nk@math.bu.edu

CP24
Low Dimensional Description of Optimal Streaks

Streaky perturbations play an essential role in the destabilization of boundary layers, especially in the presence of free-stream turbulence. These perturbations are calculated in terms of a streamwise evolving parabolic problem. Using the asymptotic behaviour of the solutions near the leading edge singularity, we obtain a low-dimensional modal description of the streaks in the case of a boundary layer attached to a flat plate. Comparison with optimal streaks obtained via the adjoint gradient (Luchini, JFM 2000), seems to indicate that the development of the instability may be understood on the basis of appropriate amplitude equations giving the streamwise evolution of the amplitudes of the relevant modes.

Maria Higuera
E. T. S. I. Aeronauticos
Univ. Politecnica de Madrid
maria@fmetsia.upm.es

Jose Vega
E. T. S. I. Aeronáuticos
Universidad Politécnica de Madrid
josemanuel.vega@upm.es

CP24
Rossby Waves in the Artic Ocean

A number of co-existing oceanographic and atmospheric systems interact with quite different timescales in the evolution of the global climate. It has been suggested that the approximatly circular artic ocean might support a century-timescale, ocean-layer Rossby (planetary) wave, which could interact with the north atlantic circulation. We investigate the dynamics and spectrum of such a wave.

Poul G. Hjorth
Technical Univ of Denmark
Department of Mathematics
p.g.hjorth@mat.dtu.dk

Torben Schmith
Danish Meteorological Institute
ts@dmi.dk

Mette Petersen
Technical University of Denmark
Department of Mathematics
mette.h.petersen@gmail.com

CP24
Propulsion through Diffusion

We have discovered a remarkable new physical effect: the spontaneous propulsion of asymmetric objects in density-stratified fluids. Density-stratified environments, such as oceans and lakes, are commonly assumed to be gravitationally stable when increasing density is aligned with gravity. In the presence of sloping side walls, however, these systems are actually gravitationally unstable, due to diffusion-driven flow. This was discovered within the contexts of salt transport in rock fissures and ocean boundary mixing; although the related phenomena of valley and glacier winds was recognized much earlier. We have discovered that this effect can be exploited to produce a previously unrecognized mechanism for propulsion. The effect, which only works for asymmetric objects, produces remarkably complex dynamics, and may have widespread application to geophysical and environmental systems. We demonstrate the effect in a series of laboratory experiments and present details of a supporting mathematical model and numerical simulations.

Tom Peacock
MIT
tomp@mit.edu

CP25
Nonstandard Finite Difference Equations That Are Dynamically Consistent with Differential Equations

A class of difference equations and systems which are derived using nonstandard finite difference schemes (NSFD) from one-dimensional differential equations and two-dimensional Lotka-Volterra biological systems are presented. The difference equations are dynamically consistent with their continuous counterparts. That is, the positivity of solutions, monotonicity of solutions, and local stability of equilibria are all preserved. For the Lotka-Volterra system, we generalize Liu and Elaydi's discrete-time Lotka-Volterra model [Journal of Computational Analysis and Applications, 3: 53–73, 2001]. They showed only one particular finite difference competition system that is dynamically consistent. The global properties of the finite difference systems can be proved using the phase plane analysis as it is done in the continuous-time Lotka-Volterra system. We will show that similar schemes can be applied to other types of differential equations.

Lih-Ing Roeger
Texas Tech University
Department of Mathematics and Statistics
lih-ing.roeger@ttu.edu

CP25
Time Averaged Properties along Unstable Periodic Orbits in Some Systems of Ordinary Differential

Equations

It is recently found in some fluid dynamics models that only a few unstable periodic orbits(UPOs) with low periods can capture important statistical properties of turbulence. Motivated by this amazing fact we collected many UPOs in some ODE systems and found that the variance of the distribution of a time average of a dynamical variable along UPOs is small in contrast with that along segments of chaotic orbits if the orbit-lengths are short.

Yoshitaka Saiki
Research Institute for Mathematical Sciences,
Kyoto University
saiki@kurims.kyoto-u.ac.jp

Michio Yamada
Reseach Institute for Mathematical Sciences,
Kyoto University
yamada@kurims.kyoto-u.ac.jp

CP25

Stickiness and Recurrence Time Statistics in Planar Billiards

We study the dynamics of billiards with dispersing, neutral and focusing boundary components, such as the elliptical mushroom billiard. We show examples of billiards where there is no hierarchy of KAM islands but just one island of regular motion that can still produce stickiness in some trajectories. We study the implications of stickiness in recurrence time statistics.

Luz V. Vela-Arevalo
Georgia Institute of Technology
luzvela@math.gatech.edu

CP26

Localized Oscillations in a Nonvariational Swift-Hohenberg Equation

Stationary spatially localized states occur in many systems of physical interest, and are often organized in a so-called 'snakes-and-ladders' structure. In recent years the Swift-Hohenberg equation has garnered much attention as the standard model exhibiting this behavior. In this talk I consider a generalized version of the Swift-Hohenberg equation and show that it exhibits, in addition to the usual stationary localized states, both oscillating localized states and traveling pulses.

John Burke
Boston University
jb@math.bu.edu

CP26

Formation of Bound States in the Generalized Kuramoto-Sivashinsky Equation

The generalized Kuramoto-Sivashinsky (gKS) equation is a simple prototype for active media with energy supply, dissipation, dispersion and nonlinearity. A particular case of such a medium is that of a liquid film falling down a planar substrate. We consider the interaction of coherent structures in the film by using the gKS equation as a model system. We develop a coherent structures theory for solitary pulses of the gKS equation by writing the solution as a superposition of the pulses and an overlap function. The spectrum of the linearized operator governing the interaction has both a discrete and an essential part. By projecting the dynamics of the overlap function onto the discrete part we obtain a dynamical system for the location of the pulses. We examine the influence of dispersion onto the separation distance of equilibrium pulses and we contrast the theoretical predictions with the numerical solution of the full system.

Serafim Kalliadasis, Dmitri Tseluiko, Sergey Saprykin
Department of Chemical Engineering
Imperial College London
s.kalliadasis@imperial.ac.uk, d.tseluiko@imperial.ac.uk, s.saprykin@imperial.ac.uk

CP26

Multipulse Solutions in the Swift-Hohenberg Equation

The one-dimensional Swift-Hohenberg equation supports a multitude of localised solutions that can be seen as periodic solutions subjected to a localised amplitude modulation. Such solutions exist on homoclinic snaking curves, along which infinitely many fold bifurcations occur, with the corresponding solutions developing more and more oscillations about their center. We will discuss the existence of multipulse solutions of this type, combining numerical studies and a recently developed analytical approach.

Thomas Wagenknecht
University of Leeds
thomas@maths.leeds.ac.uk

CP27

Wavespeed in Reaction-Diffusion Systems: Applications to Chemotaxis and Population Pressure

A theory is developed to quantify the wavespeed modification in reaction-diffusion systems due to perturbative effects. The unperturbed system must have a well-defined wavespeed, as occurs in the Nagumo equation. The perturbation may depend on first and second derivatives of the density. The development uses a non-standard application of Melnikov's method. Explicit analytical results are obtained for examples modelling chemotaxis (bacteria/cells moving towards a chemical attractant) and population pressure.

Sanjeeva Balasuriya
Connecticut College
Department of Mathematics
sanjeeva.balasuriya@conncoll.edu

Georg A. Gottwald
School of Mathematics and Statistics
University of Sydney
gottwald@maths.usyd.edu.au

CP27

A Universal Separatrix Map for Weak Interactions of Solitary Waves in Generalized Nonlinear Schrodinger Equations

The dynamics of weak interactions of two solitary waves in generalized nonlinear Schrodinger (NLS) equations is governed by an ODE system. We analyze this dynamical system comprehensively. Using asymptotic methods along separatrix orbit, a map is derived. We show the map has the same fractal-scattering dependence on initial conditions as both the ODE system and the NLS. This is joint work with Yi Zhu (Colorado) and Jianke Yang (Vermont).

Richard Haberman
Southern Methodist University
Department of Mathematics
rhaberma@mail.smu.edu

CP27
Exponential Localization of Singular Vectors in Spatiotemporal Chaos

In a dynamical system the singular vector (SV) indicates which perturbation will exhibit maximal growth after a time interval τ. We show that in systems with spatiotemporal chaos, and under a suitable transformation, the SV scales as the solution of the Kardar-Parisi-Zhang equation with periodic noise. A scaling argument allows us to deduce a universal power law $\tau^{-\gamma}$ for the localization of the SV and the finite-τ deviation of the Lyapunov exponent.

Diego Pazo
Instituto de Fisica de Cantabria, IFCA
pazo@ifca.unican.es

Juan M. Lopez
Instituto de Fisica de Cantabria (IFCA), CSIC-UC
lopez@ifca.unican.es

Miguel Rodriguez
Instituto de Fisica de Cantabria, IFCA (CSIC-UC)
Santander, Spain
rodrigma@ifca.unican.es

CP28
Application of Resonance for Manipulation of Micro/Nano Particles

Nonlinear dynamics is substantial in nano and micro technology and physics. However, the nonlinearity has not been positively accepted in the investigation of new science and technology. The resonance in nonlinear lattice structure shows the interesting vibratory dissociation of particles under external vibration. We discuss the possibility of applications of resonance in the nonlinear system for manipulation of micro and nano particles bonding to material surface by van der Waals force towards to actuations.

Takashi Hikihara
Kyoto University
Department of Electrical Engineering
hikihara@kuee.kyoto-u.ac.jp

CP28
Parabolic Resonance: A Route to Hamiltonian Spatio-Temporal Chaos

We show that initial data near an unperturbed *stable* plane wave can evolve into a regime of spatio-temporal chaos in the slightly forced conservative periodic one-dimensional nonlinear Schrödinger equation. Statistical measures show that this spatio-temporal chaos is intermittent: there are windows in time for which the solution gains spatial coherence. The parameters and initial profiles that lead to such intermittency are predicted by utilizing a novel geometrical description of the integrable unforced equation.

Eli Shlizerman
The Weizmann Institute of Science
Department of Computer Science and Applied Mathematics
eli.shlizerman@weizmann.ac.il

Vered Rom-Kedar
The Weizmann Institute
Applied Math & Computer Sci
vered.rom-kedar@weizmann.ac.il

CP28
Resonances in a Piecewise-Smooth System

Resonance in smooth dynamical systems is a typical phenomenon leading to Arnol'd tongues in a two-parameter bifurcation diagram. Numerical observations show that for piecewise-smooth systems the resonance tongues look like strings of connected sausages. We explain this for the normal form of the Poincare map derived at a grazing-sliding bifurcation. Since in most models of physical systems non-smoothness is a simplifying approximation, we also relate our results to regularised systems.

Robert Szalai
University of Bristol
r.szalai@bristol.ac.uk

Hinke M. Osinga
University of Bristol
Engineering Mathematics
H.M.Osinga@bristol.ac.uk

CP29
Normally Stable and Unstable Subsets of Invariant Manifolds

We derive an analytic formula for the location of transverse instabilities along a general invariant manifold of a multi-dimensional dynamical system. Our formula requires an appropriately defined normal infinitesimal Lyapunov exponent (NILE) to be positive over regions of transverse instability. Unlike classic Lyapunov-type numbers in the theory of normally hyperbolic invariant manifold, NILE can be computed analytically. To illustrate our results, we determine intermittent instabilities in the oscillations of predator-prey interactions and soft-stiff structural systems.

Themistoklis Sapsis
Massachusetts Institute of Technology
sapsis@mit.edu

George Haller
Massachusetts Institute of Technology
Department of Mechanical Engineering
ghaller@mit.edu

CP29
Holes, Escape Rates, and Almost-Invariant Sets

Consider a dynamical system $T : X \to X$, and let $H \subset X$ be a "hole' such that almost every point eventually enters the hole. Such systems were first studied by Yorke and Pianigiani in 1979. An important quantity associated with these open systems is the "escape rate': how fast, asymptotically, do points enter the hole. In some cases, escape rates can be related to conditionally invariant measures as well as to eigenvalues of the Perron-Frobenius operator. In this talk I will give a brief review of escape rates and possible applications in detection of "almost invariant' sets.

Ognjen Stancevic
University of New South Wales
o.stancevic@student.unsw.edu.au

CP29

Invariant Manifolds without Perturbation

Consider a positively invariant set Γ of a C^r system of ODEs. When the partial derivatives of the system satisfy a set of simple inequalities, we establish the C^k $(1 \leq k \leq r)$ smoothness of Γ. Compared to results of Fenichel and Hirsch, Pugh, and Shub, we make no assumption about the existence of unperturbed *smooth* invariant manifolds. We use examples from physical applications to show this result manifests invariant manifolds that are not attainable with classical theory.

Guang Yang
Department of Mathematics, Cornell University
gy26@cornell.edu

CP30

State Dependent Delay and Advanced-Delay Bvps

Although not widely considered in the literature, several problems, including travelling waves on lattices, naturally give rise to advanced-delay boundary value problems. Since there is very little theory to underpin these problems, numerical results are needed to provide intuition, but are themselves difficult to obtain. Problems are compounded by state-dependency of the delay terms, which may even cause the character of the solution/equation to change between delayed and advanced-delayed. We highlight ongoing work in this area, illustrating the issues using a Bando discrete car-following model with reaction time delay, and some model problems with one or more linearly state-dependent delays which may be delayed or advanced-delayed.

Tony R. Humphries
McGill University
Mathematics & Statistics
Tony.Humphries@mcgill.ca

CP30

Delay-Induced Transient Dynamics in Artificial Operons - a Mathematical and Experimental Study

A generic feature in intracellular biochemical processes is the time required to complete the whole sequence of reactions to yield any observable quantity. This widespread phenomenon indicates the importance of time delay in biological functions. We show, theoretically and experimentally, that delayed repression induces transient increase and heterogeneity in gene expression before the gain of stability effected by the negative feedback. This design, therefore, is suitable for conferring both stability and variability in cells required for adaptive response to noisy environments.

Somdatta Sinha
Scientist
Centre for Cellular & Molecular Biology
sinha@ccmb.res.in

Maithreye R., Ram Rup SARKAR
CCMB
Uppal Road, Hyderabad
maithreye@yahoo.com, ramrup@ccmb.res.in

CP31

Approximate Parametrization of the Ergodic Partition Using Time-averages of Observables

Time averages (TA) of observables on the phase space of measure-preserving dynamical systems can be used to study the ergodic partition of the phase space. Reconstructing the ergodic partition from points in TA space is performed by parametrizing structures in TA space using eigenfunctions of a Laplace-like operator, a framework known as "diffusion maps". An application of the method is demonstrated through a simulation example.

Marko Budisic
Department of Mechanical Engineering
University of California at Santa Barbara
mbudisic@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

CP31

Snapshot-Based Balanced Truncation for Time-Periodic Systems

We introduce an algorithm for obtaining low-dimensional linear time-periodic models from very high-dimensional nonlinear system that has an asymptotically stable periodic orbit. Based on the method of snapshots, this algorithm computes approximate balanced truncations for linear time-periodic systems. We illustrate this method by developing reduced-order models for a complex Ginzburg-Landau equation, and for a periodic vortex shedding problem. Future work includes using these low-order models to design feedback controllers for the full nonlinear systems.

Zhanhua Ma
Department of Mechanical and Aerospace Engineering
Princeton University
zma@princeton.edu

Clarence Rowley
Princeton University
Department of Mechanical and Aerospace Engineering
cwrowley@princeton.edu

Gilead Tadmor
Northeastern University
tadmor@ece.neu.edu

CP31

Loss of Stability of Slow Motions in a Stiff Oscillatory System

We consider the dynamics of a double spring pendulum with very stiff springs. Contrary to a single spring pendulum numerical simulations show an unexpected large influence of the fast longitudinal oscillations on the slow pendulum oscillations even for extremely large values of the stiffness.

In order to understand the transition from the regular quasiperiodic motion to the apparantly chaotic behaviour we investigate the dynamics of the simplified Normal Form equations.

Alois Steindl
Vienna University of Technology
Institute of Mechanics and Mechatronics
Alois.Steindl@tuwien.ac.at

CP32

Mathematical Modeling of Maintenance of Stem Cell Numbers in the Shoot Apical Meristem

We model how plant stem cells in the shoot are maintained in a homeostatic manner, through their interactions with other differentiated cell populations. We develop deterministic and stochastic population models with transitions from one cell type to the other occurring through signaling interactions. This is then converted to a spatial model, which tracks individual cell transitions taking into account the geometry of the stem cell niche. The model provides interesting insights about stem cell control.

Vijay S. Chickarmane, Sean Gordon, Paul Tarr
California Institute of Technology
vchickar@caltech.edu, seang@caltech.edu,
paultarr@caltech.edu

Henrik Jonsson
Lund University, Sweden
henrik@thep.lu.se

Eric Mjolsness
Information and Computer Science
University of California, Irvine
emj@uci.edu

Elliot Meyerowitz
Division of Biology
California Institute of Technology
meyerow@its.caltech.edu

CP32

Single-celled Organisms Anticipate Periodic Events

The plasmodium of the true slime mold Physarum exposed to unfavourable conditions, presented in three consecutive pulses at constant intervals, reduced their locomotive speed in response to each episode. When subsequently subjected to favourable conditions, the plasmodia spontaneously reduced their locomotive speed at the time point when the next unfavourable episode would have occurred. This implied anticipation of impending environmental change. We explored the mechanisms underlying these behaviours from a dynamical systems perspective.

Toshiyuki Nakagaki
RIES
Hokkaido University
nakagaki@es.hokudai.ac.jp

Tetsu Saigusa
Creative Research Initiative Sousei
Hokkaido University
saigusa@cris.hokudai.ac.jp

Atsushi Tero
School of Engineering
Hokkaido University
tero@topology.coe.hokudai.ac.jp

Yoshiki Kuramoto
Kyoto University
kuramoto@kurims.kyoto-u.ac.jp

CP32

Modeling Synthetic Gene Regulatory Networks

In order to carry out an in silico study of a synthetic gene regulatory network, a mathematical model of the interacting mRNAs and proteins is essential. Several candidate models can be constructed for a given network, based on different assumptions (for example, steady state mRNA concentrations or use of step functions rather than Hill functions). We show how different assumptions lead to conflicting conclusions concerning the existence and stability of equilibria and stable oscillations.

Athanasios Polynikis
University of Bristol
Th.Polynikis@bristol.ac.uk

Stephen J. Hogan
University of Bristol
Dept of Engineering Math
s.j.hogan@bristol.ac.uk

Mario Di Bernardo
University of Bristol
Dept of Engineering Mathematic
m.dibernardo@bristol.ac.uk

CP32

Near-Perfect Adaptation in the *E. Coli* Chemotaxis Signal Transduction Network

Precise adaptation is an important property of many signaling networks,allowing compensation for continued stimulation without saturation. In the context of *E. coli* chemotaxis signal transduction network, we present a new computational scheme that explores surfaces in the space of total protein concentrations and reaction rates on which (near-)perfect adaptation holds and then provide the numerical ranges of parameters not known from experiments. We generalize the applicability of this scheme to other signaling networks.

Yang Yang
Indiana University
yangy@indiana.edu

Sima Setayeshgar
Indiana University Bloomington
simas@indiana.edu

CP33

Active Model Selection of Biochemical Dynamical Systems

We propose a novel approach to experimental design that enables biochemical model selection. The resulting active intervention maximizes the expected relative entropy of state estimates for nonlinear dynamical systems in extended state-spaces. The method identifies and stimulates the specific mechanisms of the system that maximally di-

versify the dynamics produced by alternative model hypotheses. This strategy proves useful with complex dynamical behaviours and uncertain models. Its effectiveness is demonstrated with competing models of the circadian clock.

Alberto G. Busetto, Joachim M. Buhmann
ETH Zurich
Departement Informatik and CC-SPMD
busettoa@inf.ethz.ch, jbuhmann@inf.ethz.ch

CP33

Homoclinic Chaos in Some Kinetic Model of Heterogeneous Catalytic Reaction

We consider a kinetic model of catalytic hydrogen oxidation, which is described by a systems of nonlinear ODEs with fast, intermediate and slow variables. We investigate the transition to chaos and the appearance of a strange attractor. Some topological characteristics (Lyapunov dimension, topology of unstable periodic orbits, etc.) of strange attractor and weakly-stable dynamics are investigated.

Gennadii A. Chumakov
Sobolev Institute of Mathematics
Siberian Branch of Russian Academy of Sciences
chumakov@math.nsc.ru

Natalia Chumakova
Boreskov Institute of Catalysis, Novosibirsk, Russia
chumakova001@gmail.com

Lyubov Chumakova
Courant Institute of Mathematics
New York University
lyubov@cims.nyu.edu

CP33

Stimulus-driven Traveling Wave Solutions in Neural Field Models

We examine the existence of traveling wave solutions to a continuum neuronal network modeled by integro-differential equations. First, we consider a scalar field model with a general firing rate function and a spatio-temporally varying stimulus. We show the existence of a traveling front locked to the stimulus. Next, we add a slow adaptation equation and perform a singular perturbation construction of a traveling pulse and obtain a formula for the wave speed.

Jozsi Z. Jalics
Department of Mathematics and Statistics
Youngstown State Univeristy
jalics@math.ysu.edu

Bard Ermentrout
University of Pittsburgh
bard@pitt.edu

Jonathan E. Rubin
University of Pittsburgh
Department of Mathematics
rubin@math.pitt.edu

CP33

Application of a Mechanistically Based, Time-Delay Model of Protein Translation to Gene Networks

Mechanistic models of gene networks are difficult to analyze due to the amount of details incorporated. From a mechanistic model for protein translation, a reduced time-delay model is obtained, which captures essential mechanistic details of the process. The reduced model applied to a simple gene network reveals complex dynamic behavior not observed with commonly used heuristic models and which would be difficult to infer from the original mechanistic model, due to its complexity.

Luis Mier-Y-Teran-R
Physics and Astronomy Department, Northwestern University
luis.miery@epfl.ch

CP34

Model Reduction for Rotating Boussinesq Equations

The proper orthogonal decomposition is a useful tool in identifying coherent structures in fluids that can be used to generate reduced-order models. A limitation of this approach is that the models that are generated quickly lose accuracy in parametric studies. We partially address this limitation by including additional basis functions in the low-order model that incorporate the derivative of the coherent structures with respect to the parameter of interest (the Rayleigh number in the rotating Boussinesq equations). We will also discuss our current progress in utilizing the structure of turbulence to account for the discarded structures in the low-dimensional dynamical system.

Jeff Borggaard
Virginia Tech
Department of Mathematics
jborggaard@vt.edu

Traian Iliescu
Virginia Tech.
iliescu@vt.edu

Imran Akhtar
Virginia Tech
akhtar@vt.edu

CP34

Pattern Selection in Surface Waves Excited by Nonuniform Parametric Forcing

We investigate the dynamics and pattern formation properties of a fluid interface subjected to spatially nonuniform parametric forcing. This is explored experimentally, by horizontally vibrating a container of fluid to create an effective parametric forcing mechanism localized near the endwalls, and theoretically, using appropriate model equations. Experimental results demonstrate the prevalence of so-called subharmonic cross-waves and reveal several new and interesting properties, including a preferred orientation other than 90° and a tendency to form domains of distinct patterns. Some theoretical explanation for these properties is provided and the importance of resonant interactions made clear.

Jeff Porter, Ignacio Tinao, Ana Laveron-Simavilla
Universidad Politecnica de Madrid
jeff.porter@upm.es, itinao@eusoc.upm.es,

ana.laveron@upm.es

CP34
Turbulent Thermal Convection

Thermal plumes appear in turbulent convection as a means of heat transport. In addition, a large-scale circulation (LSC) has been found in experiments, which sweeps the thermal plumes along like leaves in a wind. The orientation of this LSC exhibits diffusive meandering in addition to chaotic, abrupt switches. We present the results from our numerical simulations of three-dimensional, fully turbulent Rayleigh-Benard convection and compare to experiments and theoretical stochastic models. We also investigate the scaling of heat transport and thermal boundary layers with Rayleigh number.

Janet Scheel
Occidental College
jscheel@oxy.edu

Katelyn White
California Lutheran University
krwhite@callutheran.edu

CP34
Nested Invariant 3-Tori in a Quasiperiodic Fluid Flow

Nested invariant 3-tori surrounding a torus braid of elliptic type are found to exist in a fluid flow model with quasiperiodic forcing. The system is suspended in a four-dimensional phase space. To analyze this system we define two three-dimensional, global, Poincaré sections of the flow. The coherent structures are found to have a fractal dimensional of two, in each Poincaré cross-section. This framework has applications to tidal and other mixing problems of geophysical interest.

Hope L. Weiss, Andrew Szeri
University of California, Berkeley
hope@me.berkeley.edu, andrew.szeri@berkeley.edu

CP35
Noise Induced Chaos and Calculation of Noisy Lyapunov Exponent in Complex Systems

We describe investigations of random perturbations of various dissipative dynamical systems, and in particular the 'passive walker' model, which is described by a four dimensional continuous-discrete hybrid system. In the parameter regime where a saddle is present along with periodic points on the 2-D Poincar section of flow, we argue that in presence of noise above a certain threshold, the flow is chaotic, and shows positive leading Lyapunov exponent. We discuss the mechanism of noise induced chaos for parameters which are away from the regime of the usual period-doubling route to chaos. Several issues related to calculations of Lyapunov exponents are also discussed.

Piyush Grover, Shane D. Ross
Virginia Tech
Engineering Science and Mechanics
groverp@vt.edu, sdross@vt.edu

CP35
Shrinking Point Bifurcations of Resonance Tongues for Piecewise-Smooth, Continuous Maps

Resonance tongues are mode-locking regions of parameter space in which stable periodic solutions occur. For piecewise-smooth, continuous maps these tongues typically have a distinctive lens-chain (or sausage) shape in two-parameter bifurcation diagrams. This talk describes an unfolding of the codimension-two shrinking point bifurcation (where tongues have zero width) by assuming associated periodic solutions have a symbolic representation that is "rotational'.

David J. Simpson
University of Colorado at Boulder
simpson@colorado.edu

CP35
A Novel Approach for Solving the Bloch Equation

The Bloch equations are transferred to an excitation dependent rotating frame in order to find an analytic description of the dynamics of a spin system. The resultant equations are solved by first order averaging. An error analysis based on Gronwall lemma demonstrates that the error of the approximate analytic solution is negligible. Therefore, this solution can be used to solve excitation pattern design problems in magnetic resonance imaging, nuclear magnetic resonance, and optical resonance problems.

Bahman Tahayori
PhD Student of Electrical Engineerin University of Melbourne
and NICTA Victoria Research Laboratory
b.tahayori@ee.unimelb.edu.au

Leigh Johnston, Iven Mareels, Peter Farrell
EEE Department, The University of Melbourne
NICTA Victoria Research Laboratory
leigh.johnston@florey.edu.au, i.mareels@unimelb.edu.au, pfarrell@unimelb.edu.au

CP35
On Automated Computer-Assisted Proofs in Dynamical Systems

Numerical and methods have been successful in uncovering chaotic behavior in dynamical systems. We present a unified approach that combines non-rigorous numerical methods with recent results in automated, rigorous computer-assisted techniques. We first find hyperbolic invariant objects whose existence we are interested in proving, then use an automated computational technique based on the discrete Conley index to find a semi-conjugacy between the given dynamical system and a symbolic dynamical system. Using the symbolics, we prove the existence of chaotic dynamics in the original system. We will illustrate these ideas with concrete examples and rigorous results.

Rodrigo Trevino
The University of Maryland, College Park
rodrigo@math.umd.edu

Rafael Frongillo
The University of California at Berkeley
raf@cs.berkeley.edu

CP36

Simple Waves Do Not Avoid Eigenvalue Crossings

During the early days of quantum mechanics, physicists discovered "avoidance of crossing", namely that an $n \times n$ matrix $A(t)$, $t \in R$, is not likely to have multiple eigenvalues for any t. We found that, if the one-dimensional curve of matrices $A(t)$ is chosen to correspond to the phase space representation of a simple wave, the eigenvalues of $A(t)$ do cross with non-zero probability. The points where the matrix is degenerate are attractors for the simple wave dynamics in phase space.

Lyubov Chumakova
Courant Institute of Mathematical Sciences
New York University
lyubov@cims.nyu.edu

Esteban G. Tabak
Courant Institute
New York Universityb
tabak@cims.nyu.edu

CP36

Wavenumber Locking and Pattern Formation in Spatially Forced Systems

We will describe wavenumber locking resulting from spatially periodic one-dimensional forcing of two-dimensional pattern-forming systems. When the forcing wavenumber is approximately twice the pattern wavenumber of the unforced system, the forcing selects or stabilizes resonant stripe solutions or creates new resonant solutions. When the wavenumber mismatch is high the wave-vector component of the pattern in the direction of the forcing still locks at half the forcing wavenumber, but a wave-vector component in the orthogonal direction develops to compensate, and two-dimensional rectangular and oblique patterns form.

Aric Hagberg
Los Alamos National Laboratory
hagberg@lanl.gov

Rotem Manor
Physics Department
Ben-Gurion University
manorr@bgu.ac.il

Ehud Meron
Ben-Gurion University
ehud@bgu.ac.il

CP36

Pattern Forming System in the Presence of Different Symmetry-Breaking Mechanisms

We report experiments on spatially forced inclined layer convection, where the combined effect of the intrinsic symmetry breaking due to a gravity-induced shear flow and a spatially periodic 1D forcing is studied. We observed pattern selection processes resulting in stabilization of spatiotemporal chaos and the emergence of novel two-dimensional states. Phase diagrams depicting the different observed states for typical forcing scenarios are presented. Convection in the weakly nonlinear regime is compared with theory and a good agreement is found.

Gabriel Seiden, Stephan Weiss
Max Planck Institute for Dynamics & Self-Organization
gabriel.seiden@ds.mpg.de, stephan.weiss@ds.mpg.de

Jonathan McCoy
Cornell University
jhm28@cornell.edu

Werner Pesch
Bayreuth University, Bayreuth, Germany
btp406@uni-bayreuth.de

Eberhard Bodenschatz
Max Planck Institute for Dynamics & Self-Organization
eberhard.bodenschatz.ds.mpg.de

CP36

Towards Nonlinear Selection of Reaction-Diffusion Patterns in Presence of Advection: A Spatial Dynamics Approach

We present a theoretical study of nonlinear pattern selection mechanisms in a case model of bounded reaction-diffusion-advection system. The model describes an activator-inhibitor type dynamics in presence of a differential flow and a single diffusion; the latter excludes any finite wave number instability in the absence of advection. The focus is on three types of different behaviors and the respective sensitivity to boundary conditions: traveling waves, stationary periodic states, and excitable pulses. The theoretical methodology centers on the spatial dynamics approach, i.e. bifurcation theory of nonuniform solutions. These solutions coexist in overlapping parameter regimes, and multiple solutions of each type may be simultaneously stable. The results provide an efficient understanding of the pattern selection mechanisms that operate under realistic boundary conditions.

Arik Yochelis, Moshe Sheintuch
Department of Chemical Engineering
Technion - Israel Institute of Technology
yochelis@technion.ac.il, cermsll@technion.ac.il

CP37

Resonances and Long-Time Transport in a Cellular Flow

We present a quantitative theory of long-time transport induced by resonant mixing in time-dependent volume-preserving 3D flows using a model cellular flow introduced in Solomon and Mezic, (2003). We compute the fraction of the mixed volume and a rate of mixing as functions of the frequency of the perturbation. We illustrate how the transport properties can be described using the evolution of the probability distribution function in the space of adiabatic invariants.

Sahand Hariri Akbari, Dmitri Vainchtein
Dept. of Mechanical Engineering
Temple University, USA
sahand@temple.edu, dmitri@temple.edu

Roman Grigoriev
Georgia Tech
romgrig@gatech.edu

CP37

Parametrization Method for Lagrangian Long-

Range Interactions

We study Lagrangian systems in discrete time. We define the Euler-Lagrange equations for sequences of points on a manifold, based on a discrete Lagrangian or generating function. In particular, we are interested in the so called long-range interactions. The motivation of this approach is to avoid the Hamiltonian formalism that has been extensively used in the past for the study of twist maps. In other words, we try to avoid the necessity of global dynamics and favor the Lagrangian point of view. We use a modification of the so called *parametrization method* to show the existence of a Lagrangian stable manifold.

Hector Lomeli
Instituto Tecnológico Autónomo De México (ITAM)
lomeli@itam.mx

Rafael de La Llave
University of Texas
Department of Mathematics
llave@math.utexas.edu

CP37

Particle Trajectories in An Oscillatory Rotating Flow

Equations of motion are derived for a spherical particle in a fluid-filled container that undergoes oscillatory rigid-body rotation. At high frequencies when inertia is significant, particles denser than the fluid are seen to migrate toward the rotation axis while lighter particles migrate away. This is opposite to the behavior in ordinary centrifugation. The effect is explained qualitatively as a parametric forcing of the radial motion by the periodic component of the angular motion.

Ali Nadim
Claremont Graduate University
Department of Mathematics
ali.nadim@cgu.edu

CP37

Chaotic Motions of a Forced Droplet-Droplet Oscillator

The motion of two coupled spherical-cap droplets subject to periodic forcing is studied. Steady states of the inviscid unforced system are parameterized by the volume of the two droplet caps. A classical pitchfork bifurcation occurs, where a single symmetric steady state bifurcates into two asymmetric states. The forced damped extension is investigated for chaotic dynamics using Melnikov's method and by calculating Lyapunov exponents. Observations are compared qualitatively to experimental results, confirming the existence of chaos.

David M. Slater
Cornell University
dms236@cornell.edu

Paul Steen
School of Chemical Engineering
Cornell University
phs7@cornell.edu

CP38

Strong Positive Invariance of Disturbed Control Dynamical Systems

It is well known that a traditional discrete-time control dynamical system can be reduced to an iterative dynamical system of one endomorphism. The purpose of this paper is to study a similar reduction in the presence of disturbance. We show that a non-linear discrete-time control dynamical system with deterministic disturbance can be expressed as an iterative dynamical system of one multiple valued endomorphism. This reduction yields an intriguing problem in invariant set theory, because it is possible to consider two different types of positive invariance for multiple valued iterative dynamics. In this talk, we concentrate on the easier half, the strong positive invariance. We prove that the maximal positively strong invariant set of a multiple valued iterative dynamical system is countably controllable, and discuss its implication to the corresponding disturbed control dynamical system. Time permitting, preliminary results on weak positive invariance will be also discussed.

Byungik Kahng
University of Minnesota at Morris
kahng@morris.umn.edu

CP38

Moderation Incentives in Optimal Control

When something needs to be done as quickly as possible, the bounds on the possible are crucial in determining the optimal strategy. Moderation incentives—control-dependent cost function modifications rewarding avoidance of the admissible control region boundary and equaling zero on that boundary—can be used to construct smooth solutions of constrained optimal control problems. Subtracting a control-dependent moderation incentive scaled by a moderation parameter from a purely state-dependent cost term generates a one-parameter family of cost functions.

Debra Lewis
Department of Mathematics
University of California at Santa Cruz
lewis@math.ucsc.edu

CP38

Charge Balanced Optimal Inputs for Phase Models of Spiking Neurons

The optimal input current for reduced neuron models and a specific target spiking time is obtained. The objective of optimization is to minimize the total input power of the system subject to a zero net input integral over the time horizon. This "charge-balance constraint' ensures that no net external charge is injected into to the neuron. The results are compared to optimal currents for which the charge-balance constraint is not imposed. Also, the effect of replacing the optimal current with a simpler characterization is investigated.

Ali Nabi
UCSB
nabi@engineering.ucsb.edu

Jeffrey Moehlis
Dept. of Mech. Engineering
U. of California, St. Barbara
moehlis@engineering.ucsb.edu

CP38

Time-Delay Feedback Control of Long-Period Periodic Orbits

The Pyragas method of feedback control has attracted much interest as a method of stabilising unstable periodic orbits. I use a time-delayed feedback control, similar to the Pyragas method, to stabilise periodic orbits with arbitrarily large period, specifically those resulting from a resonant bifurcation of a heteroclinic cycle. The analysis reduces the infinite-dimensional delay-equation describing the system with feedback to a three-dimensional map, by making certain assumptions about the form of the solutions.

Claire M. Postlethwaite
University of Auckland
c.postlethwaite@math.auckland.ac.nz

CP39

Leonov's Approach for Calculation of Bifurcation Curves in Piecwise-Linear Maps

50 years ago (1959) in a series of works by Leonov a detailed study of piecwise-linear scalar discontinuous maps was presented. The results obtained by Leonov were barely known for a long time, although they allow the analytical calculation of border-collision bifurcation subspaces in an elegant and much more efficient way than it is usually done. We extend this approach for calculation of several crisis bifurcations and for bifurcations in 2D piecwise-linear maps.

Viktor Avrutin, Michael Schanz
Institute of Parallel and Distributed Systems (IPVS)
University of Stuttgart
viktor.avrutin@informatik.uni-stuttgart.de,
Michael.Schanz@informatik.uni-stuttgart.de

CP39

Simulation in Non-Smooth Dynamical Systems

We present the numerical analysis of sliding dynamics on the discontinuity boundary of three-dimensional Filippov systems using an integration-free method called Singular Point Tracking. Sliding dynamics due to nonsmooth phenomena such as friction, hysteresis or switchings are inherent to these systems. Bifurcation diagrams are computed through a new developed software by the authors. The discontinuity boundary is characterized using geometric criteria based on angular evaluations. Eighteen points are distinguished and eight basic scenarios are defined.

Gerard Olivar, Fabiola Angulo
Department of Electrical and Electronics Engineering
Universidad Nacional de Colombia, sede Manizales
golivart@unal.edu.co, fangulog@unal.edu.co

Ivan Dario Arango
Department of Mechanics
EAFIT University
iarango@eafit.edu.co

John Alexander Taborda
Department of Electrical and Electronics Engineering
Universidad Nacional de Colombia, sede Manizales
yatabordag@unal.edu.co

CP39

Organizing Centers of Higher Codimension in Piecewise Linear Maps

An approximation of the piecewise nonlinear Poincaré return map of a class of impact oscillators leads to a piecewise linear map defined on three partitions in state space. The detection of organizing centers of codimension two and three in the parameter space of this map is an important step towards the understanding of the dynamic behavior of the piecewise nonlinear map and hence the class of impact oscillators in extended regions of their parameter space.

Michael Schanz
Institute of Parallel and Distributed Systems (IPVS)
University of Stuttgart
Michael.Schanz@informatik.uni-stuttgart.de

Viktor Avrutin
IPVS
University of Stuttgart
viktor.avrutin@ipvs.uni-stuttgart.de

CP39

Classification of Non-Smooth Bifurcations for a Friction Oscillator

In "Y. Kuznetsov, S. Rinaldi, and A. Gragnani, One-parameter bifurcations in planar Filippov systems, Int. J. Bifurcation and Chaos, 13, 8 (2003) 2157–2188", for planar piece-wise smooth systems a complete classification is given of all Codimension 1 bifurcations. We investigate which of these bifurcations occur for a friction oscillator, which belongs to the class of planar Filippov systems. Further Stribeck's friction law is stipulated, which depends on three parameters and is in better agreement with experiments than Coulomb's law.

Hans Troger
Vienna University of Technology
Technische Universitaet Wien
hans.troger@tuwien.ac.at

Andreas Teufel
Vienna University of Technology
Institute of Mechanics and Mechatronics
andreas.teufel@tuwien.ac.at

Alois Steindl
Technische Universitat Vienna
Institute for Technical Mechanics
Alois.Steindl@tuwien.ac.at

CP40

Bifurcation Analysis on Nonsmooth Torus Destruction Scenario of Delayed-Pwm Switched Buck Converter

In this presentation, we propose a qualitative and quantitative dynamical study about the evolution of nonsmooth torus in a Digital Delayed Pulse-Width Modulator (PWM) switched buck converter. We explain the birth and destruction of the torus by successive discontinuity induced bifurcations (DIBs). Under variation of k_s, the system gets closer to a codimension-two bifurcation point, where two simultaneous border-collision bifurcations (BC) meet. The system leaves the high-order periodic behavior and a high-

order band torus appears.

Gerard Olivar, Fabiola Angulo
Department of Electrical and Electronics Engineering
Universidad Nacional de Colombia, sede Manizales
golivart@unal.edu.co, fangulog@unal.edu.co

John Taborda
Universidad Nacional de Colombia, sede Manizales
yatabordag@unal.edu.co

CP40

Optimal Gain Parameters for the Time-delayed Feedback Control of Subcritical Limit Cycles

Pyragas-type, time-delayed feedback control, added to the Hopf normal form, can stabilize subcritical periodic orbits. Near the subcritical Hopf bifurcation in the Lorenz equations, the feedback threshold for stabilization is determined via three methods with identical results: (i) converting the system without delay into normal form before adding feedback, (ii) rigorous center manifold reduction of the delay equations, and (iii) numerically. We also show that a rotationally symmetric gain matrix is "optimal" under Frobenius norm.

Genevieve Brown
Northwestern University
Genevieve-brown@northwestern.edu

Mary C. Silber
Northwestern University
Dept. of Engineering Sciences and Applied Mathematics
m-silber@northwestern.edu

Claire M. Postlethwaite
University of Auckland
c.postlethwaite@math.auckland.ac.nz

CP40

Video Target Tracking: Uncertain Associations, Dynamical Models, and State Estimation

Multi-target tracking algorithms for exploiting low frame rate video of urban traffic must contend with a combinatorial number of possible associations between objects detected in successive frames. While the mapping of sequences of non-invertible stochastic measurements to state sequences is familiar to the dynamical systems community, the combinatorial association aspect of this application may not be. I use analogies to ideas the dynamical systems community have long considered to explain current algorithms.

Andrew M. Fraser
Los Alamos National Laboratory
andy@fraserphysics.com

CP40

Virtual Orbits and Two-Parameter Bifurcation Analysis in Power Electronic Converters

Numerical simulation results on the control parameter space of a DC/DC buck converter with ZAD strategy differ from the ones obtained analytically. Using the concept of feasible orbits, existence conditions for saturated 2-periodic orbits are given and one dimensional bifurcation diagrams, already presented by Seara et al. in Snowbird 2007, are discussed. Finally, the mentioned differences are explained proving that the saddle node structure is destroyed under small perturbations of the ZAD condition.

Albert Granados
IPVS, University of Stuttgart
albert.granados@ipvs.uni-stuttgart.de

Enric Fossas
Inst. Industrial & Control Engineering
Univ. Politecnica de Catalunya
enric.fossas@upc.edu

Viktor Avrutin
IPVS
University of Stuttgart
viktor.avrutin@ipvs.uni-stuttgart.de

Michael Schanz
Institute of Parallel and Distributed Systems (IPVS)
University of Stuttgart
Michael.Schanz@informatik.uni-stuttgart.de

CP41

Brachistochrone on a Curved Surface

The brachistochrone problem that considers a body traversing on an inclined plane from one point to another in minimum-time and its solution are well-known. Using a state-space formulation, extension to the case of a curved surface was considered and this optimal control problem was solved as a 2-point boundary-value problem with the body yaw rate serving as the control input. Simulation results are presented including checking the Legendre-Clebsch necessary condition.

Michael P. Hennessey
School of Engineering
University of St. Thomas
mphennessey@stthomas.edu

CP41

Particle Filters: Using Statistics and Dynmical Systems to Find Hindden States

I will describe data assimilation techniques applied to point-vortex fluid models. With small dimensionality and complex nonlinear (Lagrangian) dynamics, vortex models are a natural paradigm for the investigation of systems with Lagrangian observations that commonly arise in oceanography. The objective is to estimate hidden states of a nonlinear, stochastic dynamical system by combining model predictions and noisy partial system observations. Sequential Monte-Carlo techniques can approximate distributions of hidden states without assumptions of linearity or Gaussianity.

Elaine Spiller
Marquette University
elaine.spiller@marquette.edu

CP41

Linked Twist Maps and Applications: Decay of Correlations and Rates of Fluid Mixing

Linked-twist maps are established as good models for a large class of fluid mixer design. We present new results on their ergodic mixing properties. In particular, we describe

new techniques to obtain accurate estimates on the rate of mixing via decay of correlations for examples of interest. In doing so we obtain important insights into dynamical features of the model which can lead to optimization of mixing performance.

James Springham, Rob Sturman
University of Leeds
j.springham@leeds.ac.uk, rsturman@maths.leeds.ac.uk

CP41

Linked Twist Maps and Applications: Optimizing the Rate of Mixing in a Dna Microarray

A pulsed source-sink mixing device used in DNA hybridization chambers is an example of a microfluidic device which can be modelled as a linked twist map. We show how new rigorous results on the ergodic properties of these maps relate to practical considerations for microfluidic mixing and DNA hybridization.

Rob Sturman, James Springham
University of Leeds
rsturman@maths.leeds.ac.uk, j.springham@leeds.ac.uk

CP42

Programmable Potentials for Self-Assembly

We study the problem of self assembly of entities into a prescribed configuration using only a potential interaction between them. We define a new class of programmable potentials that dictate the interaction between particles and hence define the system evolution via Newtons law. In this process, logic rules are transcribed into physical potentials that execute these rules and achieve the goal configuration. We give numerous examples that stem from this formalism. Specifically, we give examples from signal transduction, pathway selection and self-assembly of fifteen north-eastern states of the United States starting from initial disordered configuration.

Gunjan Singh Thakur
UCSB
gunjan@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

MS1

Mutually Delay-coupled Oscillators in Multi-strain and Spatial Disease Dynamics

We consider oscillations resulting from delayed-global coupling between strains of a multi-strain disease, and delayed-local coupling in a spatially spreading disease. Delayed-global coupling leads to oscillations that may be be synchronous or asynchronous, which will have consequences on field measurements of the disease prevalence. In the case of delayed-local coupling neighboring oscillators can either excite or inhibit oscillations at a specific spatial point. Analytical and numerical results describe the conditions for and the characteristics of the oscillatory solutions.

Thomas Carr
Southern Methodist University
tcarr@smu.edu

Michael Taylor
Department of Mathematics
Southern Methodist University
mltaylor@smu.edu

MS1

Synchronization in Complex Networks of Delay Systems

The emergence of collective and synchronized dynamics of complex networks have been extensively investigated since the last decade in an effort to understand the dynamics of wide variety of natural networks. In this connection, more realistic modeling of real-world networks with nonlocal interaction inevitably requires connection delays to be taken into account. It is also important to consider the individual dynamical unit of networks as a delay dynamical system to mimic most of the real-world network along with their inherent dynamical behavior. In this work, we will present some of interesting results on synchronization and clustering dynamics of network of delay systems, with and without delay coupling, with specific examples.

Senthilkumar Dharmapuri Vijayan
Interdisciplinary Centre for Dynamics of Complex Systems
University of Potsdam, 14469 Potsdam, Germany
skumarusnld@gmail.com

Juergen Kurths
Potsdam Institute for Climate Impact Research
Humboldt University Berlin, Germany
kurths@pik-potsdam.de

MS1

Coding by Switching: Heteroclinic Bifurcation in Spiking Neural Networks

Networks of spiking neurons may often exhibit saddle periodic orbits that are heteroclinically connected among each other. For fast interaction responses, these systems may show heteroclinically connected **unstable attractors** ([1] Phys. Rev. Lett. 89:154105 (2002); [2] Nonlinearity 18:2035?2060 (2005); [3] Nature 436:36-37 (2005).; [4] http://arxiv.org/abs/0709.3432v1 Phys. Rev. E (2008). Here we show that pulse-coupled (spiking) systems exhibit an analog of heteroclinic bifurcation that has both discrete and continuous parts. On this basis, we demonstrate how input signals may be coded by spiking neural network in a novel way.

Fabio Schittler-Neves
Network Dynamics Group
Max-Planck Institute for Dynamics
neves@nld.ds.mpg.de

Andreas Sorge, Christoph Kirst
Network Dynamics Group
Max-Planck Institute for Dynamics and Self-Organization
andreas.sorge@ds.mpg.de, ckirst@nld.ds.mpg.de

Marc Timme
Network Dynamics Group, Max-Planck Institute for Dynamics
and Self-Organization, Gottingen, Germany
timme@nld.ds.mpg.de

MS1

Some Novel States of Time Delay Coupled Nonlocal Systems

The collective states of a system of identical limit cycle oscillators that are coupled in a non-local and time delayed fashion are explored through numerical and analytical investigations of a generalized complex Ginzburg-Landau type equation. The existence and stability conditions of phase-locked states and some novel states like *clustered chimera states* and their two dimensional analogues are presented and their potential applications to chemical and biological systems discussed.

Abhijit Sen
Institute for Plasma Research
abhijit@ipr.res.in

Gautam C. Sethia
Institute for Plasma Research
Nonlinear Physics Division
gautam.sethia@gmail.com

Fatihcan Atay
Max Planck Institute for Mathematics in the Sciences, Leipzi
fcanatay@gmail.com

George Johnston
EduTron Corp.
gljohnston@gmail.com

MS2

Influence of Noise and Bifurcation Structure on Subthreshold Oscillations in Mixed Mode Oscillations

Mixed mode oscillations are observed in different classes of neurons. Various mathematical models have been proposed to describe this dynamical behavior, in particular a detailed conductance-based model and a simpler FitzHugh-Nagumo-type model. We compare these different models, focusing on the fundamentally different underlying bifurcation structures and the effect noise has on the dynamics. The goal is to present measures for closer comparison of the models with experimental data that help identifying the underlying mechanism.

Peter Borowski
The University of British Columbia
Department of Mathematics
borowski@math.ubc.ca

Na Yu
UBC Math
nayu@iam.ubc.ca

Juan Luis Cabrera
Centro de Fsica, IVIC, Caracas
Dept. of Math., UBC
juluisca@gmail.com

Yue-Xian Li
University of British Columbia
Department of Mathematics
yxli@math.ubc.ca

Rachel Kuske
University of British Columbia
rachel@math.ubc.ca

MS2

The Impact of Correlation on Stimulus Estimation in Feedforward Networks of Spiking Neurons

Correlated activity across a population of neurons performing an estimation task typically limits performance. In contrast, correlated activity boosts the propagation strength in feedforward networks, enhancing the signal to noise ratio in downstream populations. We show how when firing rate and correlation co-vary with one another the information throughput across a two layer network is maximized at a nonzero value of correlation.

Brent Doiron
Dept. of Mathematics
Univ. of Pittsburgh
bdoiron@pitt.edu

Jaime de la Rocha
Center for Neural Science
New York University
rocha@cns.nyu.edu

Eric Shea-Brown
Department of Applied Mathematics
University of Washington
etsb@amath.washington.edu

Kresimir Josic
University of Houston
Department of Mathematics
josic@math.uh.edu

Alex Reyes
Center for Neural Science
New York University
reyes@cns.nyu.edu

MS2

Fidelity of Neuronal Responses in Electrically Coupled Ensembles

Electrically coupled deterministic models of spiking neurons tend to synchronize and generate the same firing patterns as the models of individual neurons. Small noise can introduce pronounced differences in the behaviors of the single neuron models and electrically coupled networks. We elucidate the sources of such differences by analyzing certain conductance-based and integrate-and-fire neuron models and electrically coupled networks in the presence of noise. Our results suggest that electrical coupling promotes fidelity of neuronal responses.

Georgi S. Medvedev
Drexel University
Department of Mathematics
medvedev@drexel.edu

MS2

Correlation Propagation in Feedforward Networks of Integrate-and-Fire Neurons

It has been shown that correlations between the spiking activity of neurons can be used to encode information about a stimulus. However, experimental and theoretical data also suggests that excess correlations can accumulate in

feedforward networks and lead to pathological spiking behaviors. We will discuss correlation transfer properties of analytically tractable neuron models and implications on the behavior of feedforward networks.

Robert Rosenbaum
University of Houston
Dept. of Mathematics
robertr@math.uh.edu

Kresimir Josic
University of Houston
Department of Mathematics
josic@math.uh.edu

MS3
Detecting Topology in Dynamical Networks

Given a general physical network and measurements of node dynamics, methods are proposed for reconstructing the network topology. We focus on networks whose connections are sparse and where data are limited. Under these conditions, common in many biological networks, constrained optimization techniques based on the L1 vector norm are found to be superior for inference of the network connections.

Domenico Napoletani
Dept. of Mathematics
George Mason University
dnapolet@gmu.edu

Tim Sauer
Department of Mathematics
George Mason University
tsauer@gmu.edu

MS3
Dynamical Changes in Epilepsy

Epileptic seizures are thought to be caused by a change in neuronal synchrony. Using phase response curves we have predicted network synchrony under different amounts of current drive. We demonstrate that at the peak of the seizure, the neurons are firing at such a high rate that the anti-phase solution is stable resulting in splay state. As the network drive decreases the in-phase solution becomes stable and the network immediately synchronizes.

Theoden I. Netoff
University of Minnesota
Department of Biomedical Engineering
tnetoff@umn.edu

MS3
Spatially Extended Systems with Long-Range Interaction Links

We consider spatially extended systems with superimposed network structures describing long lange connections (or links) between different (remote) locations of the system. Such links occur in natural systems (heart, brain) and with some (feedback) control methods for spatiotemporal dynamics. We shall investigate the dynamical impact of additional long-range connections (including possible time delays), applications in controlling chaos and methods for identifying the corresponding coupling networks (e.g., from time series).

Ulrich Parlitz
Third Physical Institute, University of Goettingen,
Friedrich-Hund-Platz 1, 37077 Goettingen, Germany
parlitz@dpi.physik.uni-goettingen.de

MS3
Networks Underlying Tremor in Parkinsonian Disease

Networks of dynamical nonlinear processes are ubiquitous in many fields of research. We will address a network which underlies the common neurological disorder of Parkinsonian disease. To this aim, neurons of the human brain structure subthalamic nucleus are related to tremor muscle activity. We will present methodologies to investigate the network structure. The abilities and limitations will be discussed with particular emphasis on future development.

Bjoern Schelter
Center for Data Analysis and Modeling
University of Freiburg, Germany
schelter@fdm.uni-freiburg.de

Kathrin Henschel
Freiburg Center for Data Analysis and Modeling (FDM)
University of Freiburg
kathrinh@fdm.uni-freiburg.de

Linda Spindeler
Center for Data Analysis and Modeling
University of Freiburg, Germany
spindeler@fdm.uni-freiburg.de

Jens Timmer
University of Freiburg
Department of Physics
jeti@fdm.uni-freiburg.de

MS4
A Stochastic Approach to Fractional Diffusion

Fractional diffusion models replace the integer order derivatives in the classical diffusion model by their fractional analogues. Stable stochastic processes can be used for particle tracking, like a Gaussian process is used for classical diffusion. Fractional derivatives in space relate to long particle jumps, in one or more dimensions. Fractional time derivatives relate to long waiting times between jumps. Particle tracking uses a non-Markovian inverse stable subordinator. If waiting times and subsequent particle jumps are correlated, the subordinator is no longer independent of the outer process. This talk reviews the essential theoretical ideas, particle tracking codes, and applications to biology, finance, geophysics, and medicine.

Mark Meerschaert
Dept. of Statistics and Probability
Michigan State University, USA
mcubed@stt.msu.edu

MS4
Front Propagation in Cellular Stirred Flows

We experimentally address the propagation of chemical reaction fronts in a chain of vortices. The resulting succession of fast and slow transport in and across vortices induces anomalous diffusion and noticeable enhancement of the effective front velocity. This enhancement is quantitatively recovered by showing that the front follows the quickest possible path, in a way reminiscent of Fermat's principle in heterogeneous media. Extension to 3d flows and to more complex cellular flows are considered.

Alain Pocheau
IRPHE, Universite Aix-Marseille I
Marseille, France
alain.pocheau@irphe.univ-mrs.fr

Simona Bodea
IRPHE, Universite Aix-Marseille I
simona.bodea@irphe.univ-mrs.fr

MS4
Experimental Studies on Front Propagation with Chaotic Mixing and Superdiffusion

We describe experiments on the effects of chaotic fluid mixing on the motion of chemical fronts in vortex-dominated flows. In flows with enhanced, normal diffusion, moving vortices tend to pin and drag reaction fronts, resulting in mode-locked fronts for time-periodic flows. We are extending these studies to consider front propagation in vortex flows with jet regions that produce Lévy flights and superdiffusion. We also consider weakly turbulent vortex flows.

Tom Solomon
Dept. of Physics and Astronomy
Bucknell University, Lewisburg, PA, USA
tom.solomon@bucknell.edu

Garrett O'Malley
Department of Physics & Astronomy
Bucknell University
gmo003@bucknell.edu

Justin Winokur
Carnegie-Mellon University
jwinokur@andrew.cmu.edu

MS4
Chaotic Synchronization of Spatially Extended Systems with Power-law Interactions: An Analogy to Levy Flight Spreading of Epidemics

Spatially extended chaotic systems with power-law decaying interactions are considered. Two coupled replicas of such systems synchronize to a common spatio-temporal chaotic state above a certain coupling strength. The synchronization transition is studied as a nonequilibrium phase transition and its critical properties analyzed at varying the range of interaction. Strong numerical evidences indicate that the transition belongs to the *anomalous directed percolation* family of universality classes found for Lévy-flight spreading of epidemic processes.

Alessandro Torcini
Istituto dei Sistemi Complessi - CNR
Florence, Italy
alessandro.torcini@isc.cnr.il

Massimo Cencini
INFM-CNR, Center for Statistical Mechanics and Complexity
Rome (Italy)
massimo.cencini@roma1.infn.it

Claudio Juan Tessone
Chair of Systems Design ETH Zurich
KPL F 31.1, Kreuzplatz 5, CH-8032 Zurich
tessonec@ethz.ch

MS5
Detection of Diffusing Orbits in Hamiltonian Systems

We consider the spatial circular restricted three-body problem. We parametrize the center manifold near one of the libration points by action-angle coordinates. We use the method of correctly aligned windows to show numerically the existence of orbits that exhibit a substantial change in their action coordinate. As an application, one can design fuel-efficient maneuvers that change a horizontal orbit of a spacecraft parked near a libration point into a vertical orbit.

Marian Gidea
Dept. of Mathematics
Northeastern Illinois University
M-Gidea@neiu.edu

Pablo Roldan
Departament de Matematica Aplicada I
Universitat Politecnica de Catalunya, Barcelona, Spain
pablo.roldan@upc.edu

MS5
Arnold Diffusion in a Priori Unstable Hamiltonian Systems by Means of Geometric Methods

In this talk we consider the case of a general perturbation regular enough of an a priori unstable Hamiltonian system of 2 1/2 degrees of freedom, and we provide explicit conditions on it, which turn out to be generic and are verifiable in concrete examples, which guarantee the existence of Arnold diffusion. This is a generalization of the result in Delshams et al., [Mem. Amer. Math. Soc., 2006], where it was considered the case of a perturbation with a finite number of harmonics in the angular variables. The method of proof is based on a careful analysis of the resonant domains and it contains a deep quantitative description of the invariant objects generated by the resonances therein. The scattering map is used as an essential tool to construct transition chains of objects of different topology.

Gemma Huguet
Centre de Recerca Matematica
Gemma.huguet@upc.edu

Amadeu Delshams
Universitat Politecnica de Catalunya
amadeu.delshams@upc.edu

MS5
Breakup of Tori in Volume Preserving Mappings

Volume preserving maps have many similarities to Hamiltonian systems, including resonances, heteroclinic tangles and families of invariant tori. A saddle-center-Neimark-Sacker bifurcation creates a pair of saddle-foci whose stable and unstable manifolds bound a "vortex-bubble' containing an elliptic invariant circle surrounded by a Cantor family of tori. We study the bifurcations of these circles and

tori, classifying them by their resonances. One bifurcation gives rise to a *string of pearls* creating multiple copies of the original bubble.

James D. Meiss
University of Colorado
Dept of Applied Mathematics
jdm@colorado.edu

Holger R. Dullin
Mathematics
Univ. of Sydney
dullin@maths.usyd.edu.au

MS5

The Parabolic Resonance Instability - Theory and Applications

The parabolic resonance instability, which emerges in diverse applications and was shown to appear persistently in near integrable n degrees of freedom Hamiltonian families depending on p parameters provided $n + p \geq 3$, is analyzed in the simplest ($n = 2, p = 1$) symmetric case. The structure and the phase space volume of the parabolic-resonant instability zones are found for the six emerging normal forms. While the extent in action of these zones is similar to those appearing at elliptic resonances, their structure is very different and their phase-space volume is dramatically increased: they are not exponentially thin. In fact, their volume scales as a power law in the perturbation parameter.

Vered Rom-Kedar
The Weizmann Institute
Applied Math & Computer Sci
vered.rom-kedar@weizmann.ac.il

Dmitry Turaev
Ben Gurion University
Mathematics
turaev@cs.bgu.ac.il

MS6

Comparison of Uncertainty Propagation in Large Scale Dynamical Systems by Polynomial Chaos, Dynamical Sampling, Response Surfaces and Monte Carlo

Four uncertainty propagation approaches, Polynomial Chaos, Response Surfaces based on kernel eigenvectors (RS), Monte Carlo (MC), and a quasi MC type Dynamical System Sampling approach, are compared on a phase change temperature estimation problem for a large scale Molecular Dynamic system (Krypton on Graphite). The efficiency of the proposed RS approach is illustrated, and its advantages and disadvantages are discussed.

Ronald Coifman
YALE
coifman@plainsight.com

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

Vladimir Fonoberov
Chief Scientist
AIMdyn, Inc
vfonoberov@aimdyn.com

Tuhin Sahai
United Technologies
sahait@utrc.utc.com

Marco Arienti, Jose Miguel Pasini
UTRC
arientm@utrc.utc.com, pasinijm@utrc.utc.com

George Karniadakis
Brown University
George_Karniadakis@brown.edu

Sean Meyn
UIUC
meyn@control.csl.uiuc.edu

Sorin Costiner
Research Scientist
United Technologies Research Center
CostinS@utrc.utc.com

MS6

Multi-Scale Fusion of Information for Uncertainty Quantification and Management in Large-Scale Simulations

This talk will give an overview of AFOSR efforts in developing efficient and accurate analytical and computational tools that can be combined with experimental data to identify and synthesize uncertainties from various sources. The goal is to make uncertainty prediction a fundamental part of high-fidelity predictive tools for complex multiscale continuum systems of importance to Air Force. Current areas of importance include, heterogeneous material systems, roughness and scattering in electromagnetics and acoustics, and fluid-structure interaction.

Fariba Fahroo
Air Force Office of Scientific Research
fariba.fahroo@afosr.af.mil

MS6

Polynomial Chaos in High Dimensions

We propose a variant of the multi-element probabilistic collocation method (MEPCM) utilizing an ANOVA-type decomposition for dealing with problems of high random dimension. We first numerically investigated the dependence of the convergence of this method on the decomposition parameters and subsequently we present examples for up to 600 dimensions.

George Karniadakis
Brown University
George_Karniadakis@brown.edu

MS6

Numerical Computation of Head-Tail Ordering Phase Transitions in CO Ar mixtures on graphite in the presence of Uncertainty

Experimental studies of $(\mathrm{CO})_x(\mathrm{Ar})_{1-x}$ mixtures physisorbed on graphite have discovered low temperature phase transitions of the CO monolayer from Head-Tail to orientationally ordered commensurate herringbone phase. In this work we use a 2D Ising model that accurately captures this phase transition. The phase transitions are studied in the presence of uncertainty using Monte Carlo (MC) and Probabilistic Collocation Methods (PCM). We find that PCM computes the phase transition curve over 2000 times faster than MC.

Tuhin Sahai
United Technologies
sahait@utrc.utc.com

Vladimir Fonoberov
Chief Scientist
AIMdyn, Inc
vfonoberov@aimdyn.com

Sophie Loire
University of California Santa Barbara
AIMdyn Inc
sloire@engineering.ucsb.edu

MS7

Reduced-order Balanced POD Modeling and Control of Transitional Channel Flows

Reduced-order models obtained using balanced proper orthogonal decomposition (BPOD) are used for feedback control of transitional channel flow. The models are developed for linearized flow and the controllers designed for the models are then applied to full DNS simulations. Blowing and suction is used as actuation, and the control input is computed based on a low-order estimator. In addition, we evaluate the performance of models with different weighting on capturing of actuation and disturbances, and we investigate the performance of nonlinear reduced-order models obtained using Galerkin projection of the full Navier-Stokes equations onto the BPOD modes for linearized flow.

Milos Ilak
Princeton University
milak@princeton.edu

Clarence Rowley
Princeton University
Department of Mechanical and Aerospace Engineering
cwrowley@princeton.edu

MS7

Vortex Models for Flow Control Problems

In the first part of this presentation we review the recent progress regarding application modern control theory to stabilization of hydrodynamic instabilities based on point vortex models. We focus on the control of cylinder wake flows modeled by the Föppl point vortex system. It is demonstrated how such models can be stabilized using the Linear-Quadratic-Gaussian (LQG) approach. We prove the existence of a center manifold in the Föppl system with the closed-loop control and discuss how it affects the effectiveness of the control. We also show how properties of such reduced-order models for flow control can be improved by constructing a family of higher-order Föppl systems. In the second part of the presentation we discuss an extension of these techniques to flows involving finite-area vortex patches such as the Prandtl-Batchelor flows. The presentation will combine elements of rigorous mathematical analysis with results of numerical computations.

Bartosz Protas
Dept of Mathematics and Statistics
McMaster University
bprotas@mcmaster.ca

MS7

A Unifying Low Order Flow Modeling Framework Covers Statistical, Deterministic and Mean Field Effects

A finite-time thermodynamics (FTT) formalism (Noack et al.2008) accounts for the nonequilibrium modal energy flow in Galerkin systems. We highlight the essential role of FTT in deriving Galerkin models for shear flows, ranging from simple oscillations to very complex flows. The new frameworks integrates mean-field theory and sub-grid representations, compensating for neglected, small and large scales. Intriguingly, both can lead to a similar, nonlinear damping term for fluctuation energy as described by Landaus model.

Gilead Tadmor
Northeastern University
tadmor@ece.neu.edu

Bernd R. Noack
Berlin Institute of Technology
bernd.r.noack@tu-berlin.de

Michael Schlegel
Berlin Institute of Technology
Berlin, Germany
schlegel@pi.tu-berlin.de

Marek Morzynski
Poznan University of Technology
morzynski@stanton.ice.put.poznan.pl

MS7

Low-Dimensional Modeling of Shear Layers

Proper Orthogonal Decomposition/Galerkin Projection method has been successfully used in Reduced-Order Modeling efforts for many fluid mechanics problems. Even further model-reduction capability can be achieved if we combine it with other symmetry reduction techniques. In this work, by allowing a free variable to describe the shear layer growth, we can apply POD/Galerkin projection in a new space with mean-flow growth being factored out. As a result, only a few (2 or more) modes are needed to represent some basic dynamics. In this talk, we will discuss the application of this modified POD/Galerkin projection method to both temporal and spatial shear layers.

Mingjun Wei
Mechanical and Aerospace Engineering
New Mexico State University
mjwei@nmsu.edu

MS8

Swimming in a Vortex Street

Recent studies showed that a trout swimming in a cylinder wake can save energy by "slaloming" through a vortex street. We present a simple model using a flexible body with vortex sheets, and find swimming shapes which maximize output power and efficiency. We find analytic solutions and compare the optimal swimming phase between the body and vortices with previous experiments and numerics.

Silas Alben
Georgia Institute of Technology
School of Mathematics
alben@math.gatech.edu

MS8
Optimal Vortex Formation in a Bio-inspired Underwater Vehicle

We demonstrate and evaluate a propeller-driven underwater vehicle that is modified to generate a vortex ring wake similar to that observed in swimming fish. We show that by mimicking the vortex wake dynamics of swimming animals, the vehicle efficiency is substantially improved relative to a conventional underwater vehicle. This is accomplished without mimicking fish morphology or swimming kinematics. Optimal configurations of the vortex wake are explored in theory and experiments.

John O. Dabiri
Graduate Aeronautical Laboratories and Bioengineering
California Institute of Technology
jodabiri@caltech.edu

Lydia Ruiz
Mechanical Engineering
trevino@caltech.edu

MS8
Collective Locomotion at Low Reynolds Number: Multiscale Analysis

Concentrated suspensions of swimming micro-organisms display complex spatio-temporal structures, sometimes referred to as "bacterial turbulence". Hydrodynamic interactions between cells are suspected to be at the origin of such phenomenon. We study here a dilute system of swimming micro-organsisms, in the generic case where the individual cells move with circular trajectories. Using a multi-scale analysis in time, we derive the general dynamical system governing the averaged motion of the cells, characterize the stability of fixed points, and provide insight into the nonlinear dynamics of the system using numerical computations.

Eric Lauga, Sebastien Michelin
University of California, San Diego
Dept of Mechanical and Aerospace Engineering
elauga@ucsd.edu, michelin@turbulence.ucsd.edu

MS8
Bio-inspired Underwater Coordinated Control: Theory and Experiments

Natural fish schools demonstrate coordinated capabilities beyond those currently possible for engineered systems. For natural fish schools, communication and control are intimately connected. One approach to studying these capabilities is through the use of discretized Kuramoto oscillator systems with communication at the discretization intervals. This presentation will address stability properties of such systems for choices of dynamic communication patterns and weighted coupling between the agents. Results will be demonstrated in simulation and in experiment.

Kristi Morgansen
Dept. of Aeronautics and Astronautics
U. of Washington
morgansen@aa.washington.edu

MS9
Rigorous Monodromy Computation and its Application to the Pruning Front Theory

The focus of this talk is the interplay between two distinct areas of dynamical systems: one is the monodromy theory of complex polynomial maps, and the other is the so-called "pruning front" theory of real dynamical systems. We see that the dynamics of a real polynomial map is completely determined by the monodromy of the same map extended to complex variables, provided some hyperbolicity conditions which can be proved by a rigorous computational algorithm.

Zin Arai
Hokkaido University
arai@cris.hokudai.ac.jp

MS9
Dimension Reduction and Topological Analysis of Attractors

In this talk we will present some computational topological methods to approximate a chaotic attractor and corresponding symbolic dynamics from a time series of data. We give some initial results for numerically simulated data and indicate how these techniques may be applied to dimension reduction and ultimately experimental data.

Bill Kalies
Florida Atlantic University
Department of Mathematical Sciences
wkalies@fau.edu

MS9
Rigorous Path-Following Techniques for Periodic Solutions of Delay Equations

Periodic solutions are objects of fundamental importance in the study of nonlinear functional delay equations, and a wide range of analytic and topological tools have been used and developed to prove results concerning their existence. Among those tools are fixed point theorems, global bifurcation theorems, the Fuller index, ideas related to the Conley index theory and equivariant degree theory. However, in practice, it is extremely difficult to answer specific questions about a given nonlinear delay equations. In this talk, we introduce a computational approach that combines topological methods, a priori analytic estimates and classical numerical analysis techniques in order to compute rigorously global branches of periodic solutions of delay equations.

Jean-Philippe Lessard
VU University Amsterdam
jlessard@few.vu.nl

MS9
Building Databases for Nonlinear Dynamical Systems

Many applications involve nonlinear models, but specific parameters are unknown or not directly measurable (this is particularly true for mathematical models in biology). Since the actual dynamics can vary dramatically depending upon the parameters, it is important to be able to identify whether and at what parameter values specific dynamical behavior occurs. Further complicating the issue is that nonlinear systems can both exhibit chaotic dynamics and be structurally unstable for large sets of parameter values. To deal with these issues we are developing techniques to construct databases of the dynamics exhibited by specific multi-parameter systems. The basic idea is to identify and classify crude dynamical structures using graph theoretic and computational topological and algebraic topological techniques that are robust with respect to perturbations induced by numerical and parametrical approximations.

Konstantin Mischaikow
Department of Mathematics
Rutgers, The State University of New Jersey
mischaik@math.rutgers.edu

MS10
Local Ensemble Kalman Filtering in the Presence of Model Error

Data assimilation requires a model that includes both time evolution equations and a relation between the model state and available observations of the system being modeled. Model error, the inevitable discrepancy between the model and the true system dynamics, is a major obstacle to overcome in complex systems. I will describe some approaches we have developed and tested at the University of Maryland to detect and correct for model biases in atmospheric systems using an ensemble Kalman filter. Similar approaches can be used for other systems and other data assimilations methods.

Brian R. Hunt
University of Maryland
bhunt@ipst.umd.edu

MS10
Data Assimilation in Networks: The Consensus Set

A method is introduced for tracking heterogeneous networks of oscillators in a nonstationary environment, using a homogeneous model network to reconstruct parameters and unobserved variables. An implementation using ensemble Kalman filtering is demonstrated on simulated data and experimental data.

Tim Sauer
Department of Mathematics
George Mason University
tsauer@gmu.edu

MS10
Tracking and Control of Brain Network Dynamics with Nonlinear Kalman Filtering

Since the 1950s, we have developed mature theories of modern control theory and computational neuroscience with almost no interaction between these disciplines. With the advent of computationally efficient nonlinear Kalman filtering techniques, along with improved neuroscience models which provide increasingly accurate reconstruction of dynamics in a variety of important normal and disease states in the brain, the prospects for a synergistic interaction between these fields are now strong. I will show recent examples of the use of nonlinear control theory for the assimilation and control of cortical oscillatory wave dynamics, as well as a framework for the assimilation and control of Parkinsonian dynamics.

Steven J. Schiff
Penn State University
Center for Neural Engineering
sjs49@engr.psu.edu

Tim Sauer
Department of Mathematics
George Mason University
tsauer@gmu.edu

Ghanim Ullah
Center for Neural Engineering
Pennsylvania State University
gxu1@psu.edu

Brian R. Hunt
University of Maryland
bhunt@ipst.umd.edu

MS10
Tracking and Control of Neuronal Hodgkin-Huxley Dynamics

Nonlinear ensemble Kalman filtering state estimation offers a paradigm shifting improvement in our ability to observe, predict, and control the state of spiking neuronal systems. We use an unscented Kalman filter to predict hidden states and future trajectories in the Hodgkin-Huxley equations, reconstruct ion dynamics that modulate excitability, control neuronal activity through a variety of control variables including a novel strategy for dynamic conductance clamping, and show the feasibility of controlling pathological states like seizures.

Ghanim Ullah
Center for Neural Engineering
Pennsylvania State University
gxu1@psu.edu

Steven J. Schiff
Penn State University
Center for Neural Engineering
sjs49@engr.psu.edu

MS11
Nonlinear Dynamics in Biomedical Engineering: Estimating the Quality of Mechanical Non Invasive Ventilation

PNoninvasive mechanical ventilation helps patients to breath with respiratory failures. The most physiological ventilatory mode is the so-called pressure support ventilation since it allows the patient to keep a control over his respiratory rate. Unfortunately, some patient do not accept it due to some asynchronisms. The nonlinear dynamics underlying patient-ventilator interactions is investigated using tools borrowed to the nonlinear dynamical systems theory as phase portrait, first-return maps, Shannon entropies, Markov matrices, etc.

Christophe Letellier
Coria
Université de Rouen
letellier@coria.fr

Herinaina Rabarimanantsoa, Ubiratan Freitas

CORIA UMR 6614 - Rouen University
rabari@coria.fr, freitas@coria.fr

MS11

Chaotic Synchronization and Communication for a Satellite Formation Flight

A satellite formation flight is a group of satellites that fly within close range of each other. This system operates as a virtual satellite with a very large capability that would require a huge, complex and expensive monolithic satellite. In this work, we propose and analyze a chaotic based communication system tailored to be used on a satellite formation flight scenario. This system is based on collective chaotic synchronization among the communication systems installed in the satellites. It presents an outstanding performance and stability as well as a good tolerance to the presence of noise.

Elbert E. Macau
INPE - Brazilian National Institute for Space Research
LAC - Laboratory for Computing and Applied Mathematics
elbert@lac.inpe.br

Jose Grzybowski
Sao Jose dos Campos, SP, Brazil
zzmariovic@yahoo.com.br

MS11

Multiple Synchronous States in Static Delay-free Mutually-connected PLL Networks

In many engineering applications, the time coordination of geographically separated events is of fundamental importance, as in digital telecommunications and integrated digital circuits. For the last few decades, the synchronization networks for the purpose of time coordination in these systems has been implemented mainly by using the Master-Slave (MS) architecture. However, mutually-connected (MC) networks are very good candidates for some new types of application, such as wireless sensor networks, for which the MS technique does not present good performance. This paper presents a study on the behavior of MC networks of digital phase-locked loops (DPLLs) concerning the existence and achievability of synchronous states for the network. The major contribution is to verify that, even for static networks without delays, multiple synchronous states can be achieved. This is important in the neural computation context, as in this case, in which each synchronous state may be associated to a different memory information. The lower and upper bounds for the number of such states is obtained, allowing the design of artificial intelligence devices by using DPLLs.

José Piqueira
Escola Politécnica
Universidade de So Paulo - USP
piqueira@lac.usp.br

MS11

Controlling Complex Dynamics by Using Phase Control

The phase control technique is applied in this paper for open dynamical systems and excitable systems. For open dynamical systems, we use as a prototype model the Helmholtz oscillator, which is the simplest nonlinear oscillator with escapes. For some parameter values, this oscillator presents a critical value for which all particles escape from its single well. By using the phase control technique, weakly changing the shape of the potential via a periodic perturbation of suitable phase, avoiding escapes is achieved. We provide numerical evidence, heuristic arguments and an experimental implementation in an electronic circuit of this phenomenon. We also study how to control the dynamics of excitable systems by using this technique. We use the periodically driven FitzHugh-Nagumo (FHN) model, which displays both spiking and non-spiking behaviors in chaotic or periodic regimes. We compare our numerical results with experimental measurements performed on an electronic circuit with a good agreement between them. This is based on joint work with Jesus M. Seoane (Spain), Samuel Zambrano (Spain), Ines P. Marino (Spain), Stefano Euzzor(Italy), Riccardo Meucci (Italy) and Fortunato T. Arecchi (Italy).

Miguel Sanjuan
Department of Physics
Universidad Rey Juan Carlos, Madrid (Spain)
miguel.sanjuan@urjc.es

MS12

Composite-cavity Approach to Model Two side-to-side Coupled Lasers

In the composite cavity approach the spatiotemporal optical field is decomposed into spatial eigenmodes of the entire coupled laser device. Nonlinear interaction between eigenmodes is approximated by coupled ODEs with S1-symmetry and additional algebraic constraints from the laser geometry. After reducing the S1-symmetry we use numerical continuation to study the dynamics of the system. In particular, we study codimension-two bifurcations, which organise dynamics of the system, with dependence on three laser parameters.

Hartmut Erzgraber, Sebastian M. Wieczorek
University of Exeter
Mathematics Research Institute
h.erzgraber@exeter.ac.uk, s.m.wieczorek@exeter.ac.uk

Bernd Krauskopf
University of Bristol
Department of Engineering Mathematics
b.krauskopf@bristol.ac.uk

MS12

Time-delayed Feedback Control of Coupled Lasers

We study time-delayed feedback control of semiconductor lasers with the aim to stabilize unstable states. In particular we consider chaos synchronization of two lasers which are delay-coupled via a relay. We show that bubbling (noise induced desynchronization) is present in the system and that it is related to the transverse instability of some of the effective laser's external cavity modes. This work is in collaboration with I. Fischer, O. D'Huys, J. Danckaert, C. Mirasso

Valentin Flunkert, Eckehard Schöll
Technische Universität Berlin
Institut für Theoretische Physik
flunkert@itp.physik.tu-berlin.de,
schoell@physik.tu-berlin.de

MS12

Bifurcations of a Semiconductor Laser with Feedback from Two External Filters

In some applications two external filters are used to stabilize the output of a semiconductor laser. However, this laser system may show a wealth of other behavior due to possible interference between the two filter fields. We analyze the structure and stability of basic continuous wave solutions, which we represent in the form of surfaces in dependence on different filter parameters.

Piotr Slowinski, Bernd Krauskopf
University of Bristol
Department of Engineering Mathematics
Piotr.Slowinski@bristol.ac.uk, b.krauskopf@bristol.ac.uk

Sebastian M. Wieczorek
University of Exeter
Mathematics Research Institute
s.m.wieczorek@exeter.ac.uk

MS12

Topology of the Asymptotic Two-dimensional Phase Space of a Semiconductor Ring Laser

An asymptotic two-dimensional phase-space description of the dynamical behavior of semiconductor ring lasers is obtained. This reveals that semiconductor ring lasers are an optical prototype of nonlinear Z2-symmetric systems. Using the particular topology of the phase-space, we discover two different classes of stochastic switching events between the two counter-propagating lasing modes of a semiconductor ring laser. Novel deterministic switching mechanisms exploiting the phase-space structure are proposed. The predictions are confirmed by numerical simulations and experiments.

Guy Van der Sande
Vrije Universiteit Brussel
Department of Applied Physics and Photonics
guy.van.der.sande@vub.ac.be

Lendert Gelens
TONA, Vrije Universiteit Brussel
B-1050 Brussels, Belgium
lendert.gelens@vub.ac.be

Stefano Beri, Jan Danckaert
Vrije Universiteit Brussel
Department of Applied Physics and Photonics
stefano.beri@vub.ac.be, jandan@vub.ac.be

MS13

Distributed Control and Coordination Algorithms

The minitutorial consists of two parts. First, we provide a present a coherent introduction to distributed algorithms, briefly covering results in graph theory, synchronous networks, and averaging algorithms. We also put forth a model for robotic networks that helps formalize and analyze coordination algorithms. In the second part, we present various algorithms for coordination tasks such as rendezvous, connectivity maintenance, deployment, and boundary estimation. A freely-available online manuscript (with corresponding tutorial slides) is available at http://coordinationbook.info.

Francesco Bullo
Mechanical & Environmental Engineering
University of California at Santa Barbara
bullo@engineering.ucsb.edu

Jorge Cortés
University of California, San Diego
cortes@ucsd.edu

MS14

Analyzing Brain Networks with Granger Causality

Multielectrode neurophysiological recording and functional neuroimaging produce massive quantities of data. Multivariate time series analysis provides the basic framework for analyzing the patterns of neural interactions in these data. It has long been recognized that neural interactions are directional. Being able to assess the directionality of neuronal interactions is thus a highly desired capability for understanding the cooperative nature of neural processing. Research over the last few years has shown that Granger causality is a key technique to furnish this capability. In this talk, I will discuss the concept of Granger causality and present results from applications of this technique to multichannel LFP and EEG recordings from monkeys and humans performing cognitive tasks.

Mingzhou Ding
Department of Biomedical Engineering
University of Florida
mingzhou.ding@bme.ufl.edu

MS14

Active Probing - Subthreshold Stimulation for Probing Dynamic Networks in Freely Behaving Animals

Over the past decade, we've developed polarizing low-frequency electrical field (PLEF) modulation as a mode of input to brain, first in brain slices, and now in chronically implanted animals. Advantages of PLEF include that it modulates the response of the affected neurons to their input, the modulation is proportional and signed, and when instrumented correctly, allows artifact free recording during stimulation. I'll review our current work using PLEF to probe dynamic neural connectivity as an extension to other methods outlined in this session.

Bruce Gluckman
Center for Neural Engineering
Penn State Univeristy
bjg18@psu.edu

MS14

Estimating Causal Dependencies in Networks of Non-Linear Stochastic Dynamical Systems

We discuss the interference of causal interaction structures in multivariate systems by partial directed coherence. Analyzing non-linear systems using partial directed coherence requires high model orders of the underlying vector-autoregressive process. We propose a method to deal with the consequences of high model orders including a significance level. The performance of this approach is illustrated by means of model systems and in an application to neurological data.

Jens Timmer
Freiburger Zentrum für Datenanalyse und Modellbildung

(FDM)
University of Freiburg, Germany
jeti @ fdm.uni-freiburg.de

Linda Spindeler
Center for Data Analysis and Modeling
University of Freiburg, Germany
spindeler@fdm.uni-freiburg.de

Jachan Michael, Kathrin Henschel
Freiburger Zentrum für Datenanalyse und Modellbildung (FDM)
mj@fdm.uni-freiburg.de,
kathrin.henschel@fdm.uni-freiburg.de

Björn Schelter
Freiburg Center for Data Analysis and Modeling
University of Freiburg
schelter@fdm.uni-freiburg.de

MS15
From Target Search to Travel Bugs: Scale Free Motion in Biology

Numerous physical, biological and social systems exhibit anomalous diffusion, i.e particles or mobile agents perform stochastic motion that violates the key features of ordinary Brownian motion. Superdiffusion is typically a consequence of a lack of scale in the spatial increments, the distribution of which follows an inverse power-law with divergent second moment. For these processes the term Lvy flight has been coined and the utilisation fractional diffusion equations turns out to be a key theoretical framework to describe these systems. Lvy flights exhibit particulary interesting behavior when they evolve in heterogeneous environments and when superdiffusion is a consequence of the topological complexity of the system. I will give an overview of recent discoveries of this type of topological superdiffusion and similar processes in a variety of biological systems ranging from facilitated target location of proteins on folding heteropolymers, optimal saccadic scanpaths in human eye-movements, the geographic trajectories of banknotes to current research on the dispersal of travel bugs. These are tagged items that are part of geocaching, a worldwide kind of GPS treature hunt. I will allude to similarities between these systems, discuss their differences and provide a general theoretical framework for the description of topologically superdiffusive systems.

Dirk Brockmann
Dept. of ESAM, Northwestern University
Evanston, IL, USA
brockmann@northwestern.edu

MS15
Front Propagation and Memory Effects

The theory of anomalous diffusion is well-established and leads to the integral equations or the alternative fractional diffusion equations for number densities. Despite the progress in understanding the anomalous transport most work has been concentrated on the passive density of the particles, and comparatively little is known about the interaction of non-standard transport with chemical reactions. This work is intended to address this issue by utilizing the random walk techniques in order to model the wave propagation in disordered media with anomalous diffusion and reactions.

Sergei Fedotov
School of Mathematics
University of Manchester, UK
Sergei.Fedotov@manchester.ac.uk

MS15
Phase Boundaries in Systems with Anomalous Diffusion

Super-diffusive front dynamics are analysed via a fractional analogue of Allen-Cahn equation. One dimensional kink shape and such characteristics as slope at origin and domain wall dynamics are computed numerically and satisfactorily approximated by variational techniques for a set of anomaly exponents. The dynamics of a two dimensional curved front is considered. Also, the time dependence of coarsening rates during the various evolution stages is analysed in one and two spatial dimensions.

Yana Nec
Technion - Israel Institute of Technology
cranberryana@gmail.com

Alexander Golovin
Department of ESAM
Northwestern University
sasha@esam.northwestern.edu

Alexander Nepomnyashchy
Technion
Israel Institute of Technology
nepom@math.technion.ac.il

MS15
Exact Traveling Wave Solutions of Reaction-superdiffusion Equations

We consider reaction-superdiffusion equations and systems of equations, in which the reaction term is a discontinuous piecewise linear function. Applying the Fourier transform, we find traveling fronts and pulses, and discuss the effect of superdiffusion on the solutions. Specific problems that we consider include FitzHugh-Nagumo equations, domain wall pinning, systems of waves and others.

Yana Nec
Technion - Israel Institute of Technology
cranberryana@gmail.com

Alexander Nepomnyashchy
Technion
Israel Institute of Technology
nepom@math.technion.ac.il

Vladimir A. Volpert
Northwestern University
v-volpert@northwestern.edu

MS16
A Unified View to Strong Interactions in Dissipative Systems

Dissipative solitons (or particle patterns) mean any spatially localized structures such as chemical blob, discharge pattern, and binary convection cell. A challenge is to understand the dynamics when they interact strongly with

other objects such as collision with finite speed and dynamics in heterogeneous media. We present a new approach to clarify a backbone structure behind those complicated transient process with large deformation. A key ingredient lies in a hidden network of unstable patterns called scattors which play a crucial role to understand the relation of two dynamics before and after the event.

Yasumasa Nishiura
RIES, Hokkaido University
Japan
nishiura@aurora.es.hokudai.ac.jp

MS16

Dynamics of 2D Spots in Three-component Systems

The drift instability implies a deformation from circular to comma-shape, and the peanut one from circular to peanut shape. Those instabilities are detected in a class of three-component system and PDE dynamics can be reduced to a finite dimensional one. Such a reduced dynamics is able to capture rotational motion of traveling spots observed in the original PDE system. The spot dynamics in hetergeneous media is also studied.

Takashi Teramoto
Chitose Institute of Science and Technology
teraponn@mac.com

Xiaohui Yuan, Yasumasa Nishiura
Hokkaido University
yuan@nsc.es.hokudai.ac.jp, nishiura@nsc.es.hokudai.ac.jp

MS16

Collision Dynamics of Spatially Localized Convection Cells for the Rayleigh-Benard Convection

We study the collision processes of spatially localized moving convection cells (pulses) in a binary fluid mixture by direct numerical simulations. Kolodner et al. reported a variety of input-output outcomes through the collision process by laboratory experiments. Iima and Nishiura used an amplitude equation proposed by Riecke, and has succeeded in reproducing the qualitative results of such collisions. However, the detailed collision process has not been clarified so far. In this presentation, we will report the collision dynamics by applying the two-dimensional direct numerical simulation to the Navier-Stokes equations coupled with temperature and concentration fields with the aid of the spectral method. Binary-fluid is subject to periodic boundary conditions at side walls and no-slip conditions on the top and bottom, and Fourier decomposition in the x-direction and Chebyshev-tau decomposition in the y-direction are used here. The detailed collision mechanism and the comparison among the present results, laboratory experiment results, and the result obtained by the amplitude-equation will be discussed.

Kazutaka Toyabe
Dep.of Math. Hokkaido University
toyabe@nsc.es.hokudai.ac.jp

Makoto Iima
Research Institute for Electronic Science
Hokkaido University
makoto@nsc.es.hokudai.ac.jp

Yasumasa Nishiura
RIES, Hokkaido University
Japan
nishiura@aurora.es.hokudai.ac.jp

MS16

Velocity-dependent Posture Control in Bipedal Locomotion

In order to propose a bipedal walking model which can adapt to various types of perturbations, we performed numerical experiments near the unstable solution which separates the subsequent behavior into motion achievement and falling state. It is found that the instant walking speed is the most effective variable and that the system can improve the adaptability by modulating leg posture depending on it.

Kei-Ichi Ueda
RIMS, Kyoto University
ueda@kurims.kyoto-u.ac.jp

Kunishige Ohgane
Kyushu University
ohgane@math.kyushu-u.ac.jp

MS17

Uncertainty Quantification in Power Systems

We present a set of tools for uncertainty quantification in large interconnected systems. On example of a 25-state power system, we show that graph decomposition allows one to effectively reduce the dimension of the system. Several new uncertainty metrics, such as mean absolute deviation from the median are introduced and shown to be robust for all considered problems. Finally, a dynamical system sampling technique is introduced and shown to be far superior to Monte Carlo.

Vladimir Fonoberov
Chief Scientist
AIMdyn, Inc
vfonoberov@aimdyn.com

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

Sophie Loire
University of California Santa Barbara
sloire@engr.ucsb.edu

MS17

Developing "Industrial Strength" Tools for Uncertainty Quantification in Power Electronic Systems

Power electronic systems distribute electrical power from sources to electric powered devices. As electric devices become more ubiquitous in todays technology, complexity of power electronic systems increases dramatically. Consequently, it becomes more important to properly quantify uncertainty propagation in these systems to ensure they are robust enough to meet the demands of the industry. Here we discuss how to introduce state of the art uncertainty quantification methods to the standard work process in industry.

Slaven Peles
United Technologies Research Center

PelesS@utrc.utc.com

Teems Lovett
Hamilton Sundstrand
teems.lovett@hs.utc.com

MS17

Scalable Uncertainty Quantification in Complex Dynamic Networks

Many large scale systems are often composed of weakly interacting subsystems. We propose an iterative scheme that exploits such weak interconnections to overcome dimensionality curse associated with traditional uncertainty quantification (UQ) methods and accelerate uncertainty propagation in systems with large number of uncertain parameters. This approach relies on integrating graph theoretic methods and waveform relaxation with UQ techniques like probabilistic collocation. We analyze convergence properties of this scheme and illustrate it on a power network.

Amit Surana
System Dynamics and Optimization
United Tecnologies Research Center (UTRC)
suranaa@utrc.utc.com

Andrzej Banaszuk
United Technologies Research Center
banasza@utrc.utc.com

MS17

Transition Mechanism in the Stochastic Kuramoto-Sivashinsky Equation

We consider the transition process of the Kuramoto-Sivashinsky equation perturbed by the weak additive white noise. The transition occurs between a traveling wave and a fixed point. The most probable transition path, characterized by the minimizer of the Freidlin-Wentzell action functional, is discovered by the adaptive minimum action method. Certain invariant sets of saddle type, which play a key role in the transition process, will be identified and discussed.

Xiaoliang Wan
Postdoctoral Research Associate
Princeton University
xiaolian@math.princeton.edu

Xiang Zhou
Program in computational and applied mathematics
xiangz@math.princeton.edu

Weinan E
Program in computational and applied mathematics
and Department of Mathematics
weinan@math.princeton.edu

MS18

The Effects of Polymer Concentration on Elastic Instabilities in Cross-Flows

We investigate the flow of dilute and semi-dilute polymeric solutions in an extensional flow produced in a microchannel. The relatively small length scale and high deformation rates lead to significant stretching of flexible polymer molecules near the hyperbolic point. As the strain rate is varied at low Reynolds number, the stretching produces two flow instabilities, one in which the velocity field becomes strongly asymmetric, and a second in which it fluctuates in time. The frequency and amplitude of the velocity oscillations depends both on the Deborah number and on polymer concentration; oscillations are periodic in the semi-dilute regime and non-periodic in the dilute regime. In addition, we find strong hysteresis in both dilute and semi-dilute regime. These instabilities do not occur for semi-rigid polymer solutions or Newtonian fluids.

Paulo E. Arratia
Mechanical Engineering and Applied Mechanics
University of Pennsylvania, Philadelphia.
parratia@seas.upenn.edu

MS18

Transitions and Mixing in Viscoelastic Flows

Recent experiments have shown that, even at low Reynolds number, viscoelasticity of a fluid can drive symmetry breaking instabilities in cross-channel flows, and efficient mixing in yet more complex flow geometries. In joint work with B. Thomases, we study these phenomena with the Oldroyd-B model of a Boger fluid at low Reynolds number. We drive the flow by a simple body force that, if the fluid were Newtonian, would yield a four-roll mill flow with central stagnation point. We find that at low Weissenberg number the corresponding viscoelastic flow is slaved to the forcing and so preserves the four-roll mill flow. As the Weissenberg number is increased we see a series of transitions, beginning with a symmetry-breaking of the basic flow. At higher Weissenberg number the long-time flow is highly oscillatory and characterized by a single dominant vortex surrounded by a region of fluid that becomes well-mixed through the persistent destruction and reformation of smaller vortical structures. We believe that these transitions are related to appearance of nearly singular stress regions in the symmetric four-roll mill state that arise from a coil-stretch transition at the stagnation point, and whose dynamics were studied earlier by Thomases and Shelley (2007).

Mike Shelley
Courant Institute
New York University
shelley@cims.nyu.edu

MS18

Experiments on Parallel Visco-elastic Shear Flows: Is There a Nonlinear Instability?

We study the linear und nonlinear stability of flow of viscoelastic Polyacrylaamid solutions in straight channels. The channels are fabricated out of PDMS in standard micro fluidic technique and a variety of width to length ratios and different entry and exit flow geometries as well as perturbation methods have been tested. The high viscosity of the solutions leads to Reynolds numbers of the order of one whilst the Weisenberg number (Wi) the product of polymer relaxation time and shear rate was used as a control parameter in the range of 0.1 to 10. Without external distortions the flow remained laminar and stable in this range but above a certain critical Wi flow instabilities could be triggered by external distortions that were local in space and time. These instabilities lead to disordered flow profiles and they could be observed on a time scale that was several hundred times larger than any intrinsic time scale like the e.g. the polymer relaxation time. Nevertheless, finally the flow became stable and laminar again. However, the results depended strongly on the chosen geometries and for Wi above ten the entry flow became always unstable. Yet it was not possible to characterize the straight channel flow at higher flow rates. Experiments with smoother entry geometry are now underway.

Christian Wagner
Department of Physics
Universität Saarbrücken
c.wagner@mx.uni-saarland.de

MS18
Visco-elastic Flows: Singularities and Dynamical Instabilities

This talk serves as an introduction to the visco-elastic flow topics discussed at this symposium. After a brief introduction to the rheology of viso-elastic flows and the physics underlying it, and a discussion of the essence of low Reynolds number elastic instabilities, I will give an introduction to the topics covered by the other speakers at the symposium: visco-elastic symmetry bifurcations in cross-channel flows, the emergence of singular behavior in the stresses at stagnation points, and the issue whether low-Reynolds number visco-elastic flow in a straight channel exhibits a nonlinear instability.

Wim van Saarloos
Instituut-Lorentz
Leiden University
saarloos@lorentz.leidenuniv.nl

MS19
Localized Plankton Blooms in Mesoscale Hydrodynamic Vortices

The impact of horizontal mixing in the ocean on the growth of phytoplankton is discussed. In particular we study the dynamics of plankton in the wake of an island close to an upwelling region for nutrients. We consider a kinematic flow which mimics the von Karman vortex street as well as the Ekman flow perpendicular to it. We show that mesoscale vortices act as incubators for plankton growth leading to localized plankton blooms within vortices.

Ulrike Feudel
University of Oldenburg
ICBM, Theoretical Physics/Complex Systems
u.feudel@icbm.de

Mathias Sandulescu
University of Oldenburg, Germany
sandules@uni-oldenburg.de

Cristobal Lopez, Emilio Hernandez-Garcia
University of the Balearen Islands
Palma de Mallorca, Spain
clopez@ifisc.uib.es, emilio@ifisc.uib.es

MS19
Clustering of Phototactic Microorganisms in Turbulent Flow

We study the distribution of phototactic swimming microorganisms advected by a turbulent flow. It is shown that particles aggregate along an attractor with fractal measure whose dimension depends on the strength of the phototaxis. Using an effective diffusion approximation for the flow, we derive an analytic expression for the increase in light exposure over the aggregate and for the fractal dimension based on the properties of the advection and the statistics of the attracting field.

Zoltan Neufeld
University College Dublin
zoltan.neufeld@ucd.ie

MS19
Fluid Dynamics in Embryology: The Role of Cilia-induced Flows in the Development of the Left-right Asymmetry in Vertebrates

The problem of the body lateralization of vertebrates body plan at the embryonic stage and the history of the discovery of the role of cilia-induced flows in this process is reviewed. An intuitive and minimal fluid dynamical model is shown to have provided significant quantitative predictions which were accurately confirmed by experiments. Finally, some open questions involving the co-action of elasticity and hydrodynamics will be discussed.

Oreste Piro
University of the Balearen Islands
Palma de Mallorca, Spain
piro@ifisc.uib.es

MS19
Sinking Phytoplankton in Chaotic Flows

We study the effect of self-shading of light by phytoplankton individuals on the persistence of plankton blooms. The chaotic time-dependence of the flow is modelled by point vortices, and an individuum based simulation of the plankton component is carried out. If population is located in the upper layers initially, both weak and very intense vorticity favors phytoplankton bloom in deep waters. For populations below a critical level initially, an intermediate vorticity supports the bloom.

Tamas Tel
Institute for Theoretical Physics
Etovos University, Hungary
tel@general.elte.hu

M. Koch, I. Scheuring
Etovos University, Hungary
., n/a

MS20
Traveling Waves in a Model of a Fungal Disease over a Vineyard

We discuss traveling wave solutions of a model proposed for a fungal disease spreading in a vineyard. The model consists of two ODEs and a reaction-diffusion equation as well as a large parameter $\eta > 0$. Using a shooting argument, the geometric singular perturbation theory and the center manifold theory, we proved that there exists a $c_{min} > 0$ such that for each $c > c_{min}$ and sufficiently large $\eta > 0$, the model has a traveling wave solution with speed c.

Shangbing Ai
University of Alabama in Huntsville
ais@email.uah.edu

MS20

Birth of Canard Cycles

In the talk we consider singular perturbation problems occuring in planar slow-fast systems $\dot{x} = y - F(x,\lambda), \dot{y} = -\varepsilon G(x,\lambda))$ where F and G are smooth or even real analytic for some results, λ is a multiparameter and ε is a small parameter. We deal with turning points that are limiting situations of (generalized) Hopf bifurcations and that we call slow-fast Hopf points. We investigate the number of limit cycles that can appear near a slow-fast Hopf point and this under very general conditions. The talk is based on joint work with Robert Roussarie.

Freddy Dumortier
University of Hasselt
freddy.dumortier@uhasselt.be

MS20

Tent Structure for Stability-gain Turning Points

We will discuss some effects of stability-gain turning points for singularly perturbed systems. While the primary effect of stability-loss turning points is characterized by the delay-of-stability-loss which is sensitive to perturbations, the stability-gain turning points generally force a structure that is more robust to perturbations. Various extensions of this structure will also be discussed.

Weishi Liu
University of Kansas
wliu@math.ku.edu

MS20

Traveling Waves for a Thin Liquid Film with Surfactant on an Inclined Plane

We show the existence of traveling wave solutions for a lubrication model of surfactant-driven flow of a thin liquid film down an inclined plane in various parameter regimes via geometric singular perturbation theory.

Vahagn Manukian
University of Kansas
manukian@math.ku.edu

Stephen Schecter
North Carolina State University
Department of Mathematics
schecter@math.ncsu.edu

MS21

Dynamical Properies of Planar Point Vortex Clusters

Using a Hamiltonian formulation, we study the dynamic interactions of clusters of point vortices moving in an ideal fluid in the plane. Some interesting dynamical properties that we discovered using approximate asymptotic methods are proved and illustrated via simulation. Moreover, we describe some new types of cluster interactions that involve unusual exchange, capture and scattering phenomena.

Denis Blackmore
New Jersey Institute of Technology
Newark, NJ 07102, USA
deblac@m.njit.edu

MS21

Topology of the Vortex Wake of a Circular Cylinder

In the wake of a circular cylinder discrete vortices are formed and for a large range of the Reynolds number they are organized in a von Karman vortex street. We analyze how the topology of the flow fields change in the periodic domain and obtain a qualitative description of the vortex street. We consider both the velocity and the vorticity fields. For the latter, we find a novel bifurcation phenomenon, which we call Hilbert's hotel.

Morten Brons
Tech University of Denmark
Department of Mathematics
M.Brons@mat.dtu.dk

MS21

Vortices on Closed Surfaces

One hundred and fifty years after Helmholtz' "Wirbel' paper the study of vortices on surfaces is still in its infancy. It has been restricted basically to the sphere or surfaces of revolution. As far as we know an intrinsic Hamiltonian formulation for the motion of point vortices on a closed (compact, boundaryless, orientable) surface with riemannian metric is in order. We hope to fill this gap. For the full version of this note, arXiv:0802.4313v1 [math.SG].

Jair Koiller
FGV
Rio de Janeiro, Brazil
jkoiller@cds.caltech.edu

MS21

Topological and Structural Analysis of Vortical Flows

Creating a good visual representation of vortical flows is a challenging problem. Yet insightful and reliable visualizations are critical to the effective analysis of increasingly large and complex numerical simulations in a variety of engineering applications. The talk will provide an overview of recent approaches developed in scientific visualization research to characterize and display salient structural properties in vortical flows. These methods have in common the use of principles from the theory of dynamical systems.

Xavier Tricoche
Purdue University
West Lafayette, IN 4707-4348
xmt@cs.purdue.edu

MS22

Chaotic Advection and Activity in Blood Flow

Particles transported in blood are responsible for many vital processes of life. Abnormalities in blood flow alter the advection properties of these biologically active components, which can be important for the course of many illnesses. Atherosclerotic plaques or in-stent restenosis are such examples, where the interplay of chaotic advection, high shear initiated platelet activation, and their deposition in stagnant regions are expected to contribute to these diseases.

György Károlyi
Center for Applied Mathematics and Computational Physics

Budapest University of Technology and Economics
karolyi@tas.me.bme.hu

Adriane Schelin
Instituto de Fisica
Universidade de Sao Paulo
aschelin@gmail.com

Nuala Booth
Institute of Medical Sciences
University of Aberdeen
n.a.booth@abdn.ac.uk

Alessandro de Moura
Department of Physics
University of Aberdeen
a.moura@abdn.ac.uk

Celso Grebogi
King's College
University of Aberdeen
grebogi@abdn.ac.uk

MS22

Mode Locking and Generalized Synchronization in Mechanical Oscillators

We describe the relation between the complete, phase and generalized synchronization of the mechanical oscillators (response system) driven by the chaotic signal generated by the driven system. We identified the close dependence between the changes in the spectrum of Lyapunov exponents and a transition to different types of synchronization. The strict connection between the complete synchronization (imperfect complete synchronization) of response oscillators and their phase or generalized synchronization with the driving system (the (1:1) mode locking) is shown. We argue that the observed phenomena are generic in the parameter space and preserved in the presence of a small parameter mismatch.

Tomasz Kapitaniak
Technical University of Lodz
Division of Dynamics
tomaszka@p.lodz.pl

MS22

Synchronization of Dynamical Systems in Sense of Constraint Metric Functional

In this paper, a theory for synchronization of multiple dynamical systems under specific constraints is developed from a theory of discontinuous dynamical systems. The metric functionals based on specific constraints are proposed to describe the synchronicity of the two or more dynamical systems to such specific constraints. The synchronization, desynchronization and penetration of multiple dynamical systems to multiple specified constraints are discussed through such metric functionals, and the necessary and sufficient conditions for such synchronicity are developed. The synchronicity of two dynamical systems to a single specific constraint is presented, and the synchronicity of the two systems to multiple specific constraints is investigated as well. The paper provides a theoretic frame work in order to control slave systems which can be synchronized with master systems though specific constraints in a general sense.

Albert C. Luo
Southern Illinois University (SIUE)
aluo@siue.edu

MS22

Onset of Synchronization in Large Networks: Random Matrix Theory Approach

We use tools of random matrix theory to have compute of eigenvalues distribution of large complex networks. In particular, complex networks with node correlation. This allows us for an analytical estimation of the onset of synchronization in these complex networks and to analyze the role of the node correlations in the synchronization. This theory can be used to predict the onset of synchronization in neural networks.

Tiago Pereira
Instituto de Fsisca
USP - Universidade de So Paulo
tiagophysics@googlemail.com

MS23

Spontaneous Synchrony In Power Grids: The Network, The Dynamics, and The Stability Condition

The current resounding interest in network synchronization has been driven by the prospect that theoretical studies will help explain the behavior of real complex networks. In this talk, I will explore the power-grid system as a genuine complex network of broad significance that is amenable to theoretical modeling and whose dynamics can be simulated reliably. I will focus on the synchronization of power generators, a fascinating phenomenon that can occur spontaneously, that keeps all connected generators in pace, and whose failure constitutes one of the main sources of instabilities in power-grid systems. I will show that contrary to common wisdom, the network governing the synchronization dynamics is both qualitatively and quantitatively different from the physical network of transmission lines. Using simplifying approximations, I will derive a linear master stability condition for the synchronization of all generators in the network. I will use this condition to test hypotheses about the impact of heterogeneity and other factors on the stability of the system.

Adilson E. Motter
Northwestern University
motter@northwestern.edu

Seth Myers
Stanford University
samyers@stanford.edu

Marian Anghel
Los Alamos National Laboratory
manghel@lanl.gov

MS23

Synchronization with Arbitrary Network Structure: Stability Condition, Optimality, and Directionality

In this talk, I will briefly overview of the master stability framework for analyzing synchronization stability with arbitrary network structure, including various forms of generalization. In particular, I will discuss the extension to the class of directed and weighted networks and give a solution to the problem of optimizing the network structure for synchronization within that class. I will focus especially on the role of directionality in the connectivity patterns in enhancing the synchronizability.

Takashi Nishikawa
Clarkson University
tnishika@clarkson.edu

Adilson E. Motter
Northwestern University
motter@northwestern.edu

MS23
Rewiring Networks for Synchronization

We discuss the synchronization of identical oscillators diffusively coupled through a network and examine how adding, removing, and moving single edges affects the ability of the network to synchronize. We present algorithms which use methods based on node degrees and based on spectral properties of the network Laplacian for choosing edges that most impact synchronization. We show that rewiring based on the network Laplacian eigenvectors is more effective at enabling synchronization than methods based on node degree for many standard network models. We find an algebraic relationship between the eigenstructure before and after adding an edge and describe an efficient algorithm for computing Laplacian eigenvalues and eigenvectors that uses the network or its complement depending on which is more sparse.

Aric Hagberg
Los Alamos National Laboratory
hagberg@lanl.gov

Dan Schult
Colgate University
US
dschult@colgate.edu

MS23
Master Stability Functions for Coupled Near-Identical Oscillator Network

We derive a master stability function (MSF) for synchronization in networks of coupled non-identical oscillators with small but arbitrary parameter mismatch. Analogous to the MSF for identical systems, our generalized MSF simultaneously solves the linear stability problem for near-synchronous state (NSS) for all possible connectivity structures. Our analysis underlines the importance of the Laplacian eigenvectors in the synchronization of near-identical oscillators. Numerical examples including Lorenz oscillators on scale-free networks are presented.

Jie Sun, Erik Bollt, Takashi Nishikawa
Clarkson University
sunj@clarkson.edu, bolltem@clarkson.edu, tnishika@clarkson.edu

MS24
Boundary and Distributed Control for Suppression of Cardiac Alternans

In this work, the annihilation of cardiac alternans is explored by means of boundary and distributed placed actuation in the relevant cardiac tissue size. The boundary control input is associated with a pacing-based input, while the spatially-distributed actuation is associated with mechanically-based stimuli that modulate the internal calcium concentration of cells along the cable. Additionally, the controlled amplitude of alternans nonlinear parabolic PDE associated with cell cable model is explored and analyzed.

Stevan Dubljevic
David Geffen School of Medicine, UCLA
Cardiology Division
stevand@seas.ucla.edu

MS24
Low Energy Defibrillation

Defibrillation of cardiac arrhythmias currently requires large electric shocks that cause pain and tissue damage. In this talk, we will use optical mapping experiments and computer simulations to show a novel low-voltage method that uses pulsed electric fields to create virtual electrodes at sites of discontinuity in electrical conductivity. Larger electric fields affect larger discontinuities and thus recruit greater numbers of these sites. Our approach has the potential to become a safer defibrillation alternative.

Flavio Fenton
Cornell University
fhf3@cornell.edu

Stefan Luther
Max Planck Institute for Dynamics and Self-Organization
stefan.luther@ds.mpg.de

Elizabeth M. Cherry, Robert F. Gilmour, Jr.
Cornell University
emc58@cornell.edu, rfg2@cornell.edu

MS24
Model-based Control of Cardiac Dynamics in a Ring Geometry

In this talk we present our results on suppression, using different feedback control schemes, of arrhythmia in the Fenton-Karma model of cardiac tissue. Specifically, we compare non-model-based control (e.g., time-delay autosynchronization) with model-based control approaches in a one-dimensional ring geometry. In both cases, arrhythimic behavior can be eliminated by an appropriate current injected locally (e.g., through a microelectrode) into the tissue. However, model-based control achieves this goal faster and with a lower risk of tissue damage due to a much weaker control current.

Alejandro Garzon, Roman Grigoriev
Georgia Tech
gtg100n@mail.gatech.edu, romgrig@gatech.edu

MS24
Study of the Propagation of Point Perturbations on Action Potentials as a Basis for Cardiac Rhythm Control

This study attempts to shed light on the problem of controlling alternans (a dangerous alternation in cardiac action potential morphology) by examining the response to hypothetical electrical point stimuli. The characteristic scales and overall manner in which the response spreads, decays and/or is amplified as it interacts with action potential waves provide guidance as to what is and is not controllable by means of feedback-controlled electrical stimuli applied to a small number of locations.

Niels F. Otani
Department of Biomedical Science
Cornell University
nfo1@cornell.edu

MS25

Role of Neural Plasticity in Shaping Odor Codes

The olfactory system maps complex and high-dimensional olfactory stimuli into unique and reproducible ensembles of neuronal activity. Recent experimental work shows that several forms of neural plasticity contribute to the establishment and maintenance of odor codes. Drawing on results obtained with biophysical network models of the insect olfactory system, I will discuss how different forms of neural plasticity may improve and optimize odor encoding and decoding in the olfactory system.

Maxim Bazhenov
Department of Cell Biology and Neuroscience
University of California, Riverside
bazhenov@salk.edu

MS25

Dynamics of a Hippocampal Spiking Neural Model for Episodic-like Memory

While the anatomical division of the hippocampus into multiple subfields is well-known for years, how these circuits mediate episodic memory is poorly understood. Essentially, episodic memory refers to the association between objects and their locations in the environment. We construct an integrate-and-fire neural network for DG and CA3 hippocampal subfields and then investigate the role of DG in the orthogonalization of the CA3 activity patterns under object-place association task.

Rodica Curtu
University of Iowa
Department of Mathematics
rcurtu@math.uiowa.edu

MS25

Dynamics of Synaptic Connections in a Neural Network Model of Memory Consolidation and Reconsolidation

We use a connectionist model to investigate how dynamical changes in the synaptic connections among neurons involved in memory processes can account for both memory recovery or memory extinction. We hypothesize that when amenstic agents are present, the mismatch between stored memory patterns and new refining information leads to dynamical changes in the existing synaptic connections, which may disrupt the memory traces depending the timing of re-exposures to a learning context.

Remus Osan
Boston University
Department of Mathematics
osan@bu.edu

MS25

Local and Global Oscillations as a Means for Neocortico-hippocampal Communication

The most prominent dynamics that brain systems use to communicate is neuronal oscillations. We use large-scale recordings of LFP and multiple single units in rats to explore some of the mechanisms of information transfer between hippocampus and neocortex during different states. We show that neocortical slow and hippocampal theta oscillation are modulating each others local activity during respective states. Temporal coordination of the source dynamics by the receiver can be useful for information transfer.

Anton Sirota
Rutgers University, Newark Campus
Center for Molecular and Behavioral Neuroscience
sirota@andromeda.rutgers.edu

MS26

Localised Structures in Turing Instabilities with Conserved Quantities

I will discuss patterns and localised structures in two contrasting phenomenological amplitude equations, describing the formation of (1) oscillons in granular media and (2) large-scale atmospheric zonal jets driven by small-scale forcing. In both cases a Turing instability occurs in the presence of an additional long-wavelength mode that is (nearly) neutrally stable. Neither amplitude equation is the canonical Swift–Hohenberg equation. Perhaps surprisingly, case (2) is, however, variational and enables us to probe the relationship between localised structures and coarsening dynamics, for example as described by the Cahn–Hilliard equation.

Jonathan Dawes
University of Bath
J.H.P.Dawes@bath.ac.uk

MS26

Spectral Analysis and Coarsening Rates for the Cahn-Hilliard Equation

The Cahn-Hilliard equation is a standard model of spinodal decomposition, a phenomenon in which the rapid cooling of a homogeneously mixed binary alloy causes separation to occur, resolving the mixture into regions of different crystalline structure, separated by steep transition layers, in which one component concentration rises above its homogeneous concentration while the other component concentration falls below its homogeneous concentration. The rate at which this process proceeds is important in applications, and I will discuss one approach for approximating this rate. First, I'll review a method due to James Langer for relating coarsening rates to the eigenvalues associated with the linear operators obtained when the Cahn-Hilliard equation is linearized about certain distinguished stationary solutions, and then I'll discuss the calculation of these eigenvalues in certain cases.

Peter Howard
Department of Mathematics
Texas A&M University
phoward@math.tamu.edu

MS26

Spikes in the Presence of Conservation Laws — Stability and Instability

We will discuss stability and instability of spike-like solutions in systems which exhibit a pointwise conservation law. Examples include reaction-diffusion systems with stoichiometric constraints, fast-slow reactions in a singular limit, and chemotaxis. We will show results on both stability and instability of spikes in large and unbounded domains.

Alin Pogan
University of Minnesota
School of Mathematics
pogan@math.umn.edu

MS26

How Robust are Liesegang Patterns

Liesegang patterns are quite common stationary patterns in reaction-diffusion systems. They consist of precipitation spots that are spaced at geometrically increasing distances from the boundary. We will show that such patterns are untypical in generic reaction-diffusion systems, but robust in a class of systems with an irreversible chemical reaction. The main result gives necessary and sufficient conditions for the existence of Liesegang patterns. The proof involves the analysis of a degenerate reversible homoclinic orbit and an invariant manifold theorem for non-smooth Poincare maps.

Arnd Scheel
University of Minnesota
School of Mathematics
scheel@ima.umn.edu

MS27

Low-Dimensional Manifolds in the Spatial Dynamics of Steady One-Dimensional Premixed Flames

Spatial dynamics of steady one-dimensional flames are studied from a geometric perspective defined by motion on the stable manifold of a saddle fixed point. The geometry is studied via low-dimensional submanifolds that describe the longer spatial dynamics on the stable manifold. Two methods for generating the submanifolds are compared and the low-dimensional manifolds of the flame system are also compared to low-dimensional manifolds of chemical kinetic systems that have no transport.

Michael J. Davis
Argonne National Laboratory
Argonne, IL USA
davis@tcg.anl.gov

Alison S. Tomlin
University of Leeds, UK
fueast@leeds.ac.uk

MS27

Riemannian Geometry Concepts for Model Reduction in Chemical Kinetics via Minimal Curvature Trajectories

Many common model reduction approaches approximate the system dynamics by fully relaxing the fast modes. This often renders the reduced representation inaccurate and makes the solution of the reduction equations particularly difficult. We demonstrate that trajectory optimization approaches avoid such severe restrictions and present a novel model reduction framework based on geometric criteria characterizing the relaxation of chemical forces along reaction trajectories. Our approach exploits ideas from Riemmanian geometry and proves highly successful in applications.

Dirk Lebiedz
University of Freiburg
Center for Systems Biology
dirk.lebiedz@biologie.uni-freiburg.de

Volkmar Reinhardt
University of Heidelberg
volkmar.reinhardt@iwr.uni-heidelberg.de

Jochen Siehr
University of Heidelberg
Interdisciplinary Center for Scientific Computing
jochen.siehr@iwr.uni-heidelberg.de

MS27

Timescale and Stability Analysis with Finite-time Lyapunov Exponents and Vectors

Finite-time Lyapunov exponents (FTLEs) give exponential rates associated with the linear flow along a trajectory of a nonlinear dynamical system. The associated vectors (FTLVs) can be used to split the tangent space at a phase space point into either slow and fast, or stable and unstable, subspaces. The fast convergence of key subspaces means they are feasible for use in model reduction. Several applications will be discussed.

Kenneth Mease
University of California, Irvine
kmease@uci.edu

Erkut Aykutlug
University of California, Irvine
Department of Mechanical and Aerospace Engineering
erkut.aykutlug@gmail.com

MS27

Approximation and Convergence Properties of the Constrained Runs Algorithms

In this talk, we introduce the constrained runs family. These are iterative algorithms designed to locate low-dimensional, attracting, slow manifolds in systems of nonlinear, multiscale ODEs. We review the accuracy with which the fixed point (or, rather, manifold) of each algorithm approximates a slow manifold and demonstrate analytically how the system geometry and the fast dynamics determine the algorithms' stability regions. We conclude with a brief discussion on stabilization as applied to specific examples.

Antonios Zagaris
Centrum voor Wiskunde en Informatica
Amsterdam, the Netherlands
zagaris@cwi.nl

C.W. Gear
Princeton University
Department of Chemical Engineering
wgear@princeton.edu

Tasso J. Kaper
Boston University
Department of Mathematics
tasso@math.bu.edu

Ioannis Kevrekidis
Dept. of Chemical Engineering
Princeton University
yannis@princeton.edu

MS28

Dynamics and Bifurcations of Random Circle Diffeomorphisms

We discuss iterates of random circle diffeomorphisms with identically distributed noise, where the noise is bounded and absolutely continuous. We study bifurcations of stationary measures and relate this to bifurcations of random attracting periodic orbits.

Ale Jan Homburg
KdV Institute for Mathematics
University of Amsterdam
a.j.homburg@uva.nl

MS28

Stability Radii for Random Dynamical Systems and their Applications

Mathematical models of systems often contain parameters that determine the behavior of the system under varying conditions. In this presentation we study qualitative changes in parametrized families of systems for different classes of parameter variations, including

- one-dimensional families of the form $\dot{x} = X(x, \alpha)$, where $\alpha \in I \subset \mathbf{R}$ is a bifurcation parameter,
- perturbation families of the form $\dot{x} = X(x) + \sum_{i=1}^{m} u_i^\rho(t) X_i(x)$, where $u^\rho(t) \in U^\rho \subset \mathbf{R}^m$ and U^ρ is a (continuous) family of perturbation ranges depending on $\rho \geq 0$,
- stochastic families of the form $\dot{x} = X(x) + \sum_{i=1}^{m} \xi_i^\rho(t, \omega) X_i(x)$, where $\xi_i^\rho(t, \omega)$ is a stochastic (Markov) process with values in $U^\rho \subset \mathbf{R}^m$, with U^ρ a (continuous) family of stochastic perturbation ranges depending on $\rho \geq 0$.

We concentrate on the singular situation, in which the families have a common fixed point x^* for all values of the parameter. If x^* is stable for the nominal system with parameter $\alpha = 0$ (or $\rho = 0$), a key question in bifurcation theory (and in many applications in engineering) is: at which parameter values does x^* loose its stability? The smallest such value is called the stability radius of the system. This paper analyzes stability radii for the three classes of systems based on the concept of Lyapunov exponents for the systems linearized at the fixed point x^*. We present several results on the relationship between the different stability radii, studying the linear and nonlinear situations, as well as several examples that illuminate the theory. We point out connections to bifurcation theory, robust stability and stabilization in control theory, and stochastic bifurcation theory and stability indices.

Wolfgang Kliemann
Department of Mathematics
Iowa State University
kliemann@iastate.edu

MS28

Large Deviations for Billiards and Nonuniformly Hyperbolic Dynamical Systems

We present large deviation results for ergodic averages dynamical systems which are chaotic and admit a SRB measure but are not uniformly hyperbolic. For example our results cover the Sinai billiard (Lorentz Gas) as well as Henon maps and other nonuniformly hyperbolic dynamical systems. The analysis is based on a symbolic representation of these dynamical systems introduced by L.S. Young (the so-called Young towers). We also discuss some applications to steady states in nonequilibrium statistical mechanics and to fluctuations of entropy production in such systems. This a joint work with Lai-Sang Young (Courant Institute, NYU).

Luc Rey-Bellet
Department of Mathematics & Statistics
University of Massachusetts
luc@math.umass.edu

MS28

The Effects of Small Random Perturbations on Cell Cycle Dynamics and Clustering in Yeast

Biologists have long observed periodic-like oxygen consumption oscillations in yeast populations under certain conditions and several unsatisfactory explanations for this phenomenon have been proposed. We hypothesize that these oscillations could be caused by cell cycle synchronization or clustering. We develop some novel ordinary differential equation (ODE) models of the cell cycle. For these models, and for random and stochastic perturbations, we give both rigorous proofs and simulations showing that both positive and negative feedback can lead to clustering of populations within the cell cycle. It occurs for a variety of models and a broad selection of parameter values in those models. These results suggest that the clustering phenomenon is robust and is likely to be observed in nature. Since there are necessarily an integer number of clusters, clustering would lead to periodic-like behavior with periods that are nearly integer divisors of the period of the cell cycle. Related experiments have shown conclusively that cell cycle clustering occurs in some oscillating yeast cultures.

Erik Boczko
Department of Biomedical Informatics
Vanderbilt University Medical School
erik.m.boczko@vanderbilt.edu

Tomas Gedeon
Department of Mathematics
Montana State University
tgedeon@gmail.com

Chris Stowers
Dow Chemical
chris.c.stowers@vanderbilt.edu

Todd Young
Ohio University
Department of Mathematics
young@math.ohiou.edu

MS29

Globalized Newton-Krylov Solvers for Large-

scale Simulation of Navier-Stokes and Magnetohydrodynamic Systems

The robust and efficient solution of large-scale systems of nonlinear equations is a difficult task. Fully implicit Newton-Krylov solvers have been demonstrated with excellent scalability on a variety of problems. However, achieving robust execution is still an open issue. This presentation will discuss the application of globalized Newton-Krylov methods to Navier-Stokes and magnetohydrodynamic systems. We will present comparisons of line search, trust region, and homotopy algorithms applied to established benchmarks and important applications.

Roger Pawlowski
Sandia National Labs
rppawlo@sandia.gov

John Shadid
Sandia National Laboratories
Albuquerque, NM
jnshadi@sandia.gov

Chacon Luis
Oak Ridge National Lab
chaconl@ornl.gov

MS29

Multiple Shooting Continuation of Periodic Orbits in Large-Scale Dissipative Systems

We present a numerical algorithm for the continuation of periodic orbits of high-dimensional dissipative dynamical systems, using multiple shooting and parallelism. The equations of the multiple shooting are solved by Newton-Krylov methods. A direct application, with each partial shoot computed in a different processor does not provide any significant speedup. To achieve a linear speedup some kind of preconditioning for the linear systems must be used. It is shown how a preconditioner can be constructed from the information on the stability of nearby periodic orbits. The additional cost is small, and it can be computed on a different processor. Then, there is no interference with the computation of the periodic orbits. The method is applied to the thermal convection of a binary mixture in a rectangular geometry. Linear speedup by using up to 10 processors has been achieved.

Juan Sanchez
UPC Barcelona
Spain
sanchez@fa.upc.es

Marta Net
Departament Fsica Aplicada
Universitat Politècnica de Catalunya
marta@fa.upc.edu

MS29

A General Method Using a Spatial Filter to Obtain Spatially Localized UPO

In turbulence, spatially localized structures such as puffs and large scale motions have been observed. Some UPO corresponding to these structures were found by special methods. Here, we propose a general method to obtain such spatially localized UPO. A spatial filter is implemented to evolution equation directly in this method that is basically Newton iteration with a continuation of the filter amplitude to zero. This method has been applied to Kuramoto-Sivashinsky equation and we found a spatially localized UPO. We attempt to apply the method to Poiseuille flow.

Sadayoshi Toh
Kyoto University
toh@scphys.kyoto-u.ac.jp

Tomoaki Itano
Kansai University
itano@ipcku.kansai-u.ac.jp

MS29

Computing Unstable Manifolds in Turbulent Shear Flow with Multiple Shooting

Since the publication of a landmark paper by Kawahara and Kida on the relevance of unstable periodic orbits to shear flow, as lot of research has been focused on so called "edge states". Edge states are equilibria or periodic orbits that live on the boundary of the basin of attraction of laminar flow. It would seem that the (un)stable manifolds of these objects play an important role in subcritical transition and bursting. I will present a recently developed algorithm for the approximation of 2D unstable manifolds of periodic orbits and its application to shear flows, both in a toy model and in a full-scale simulation of turbulent Couette flow.

Lennaert van Veen
Department of Mathematics and Statistics
Concordia University
lvanveen@mathstat.concordia.ca

MS30

Derivation of Stochastic Partial Differential Equations for Structured Populations and for Reaction-diffusion Systems

Stochastic partial differential equations (SPDEs) for age- and size-structured populations are derived from basic principles. Discrete stochastic models of structured populations are constructed, carefully taking into account the randomness in births, deaths, and size changes. As the time, size, and age intervals decrease, SPDEs are derived for the structured populations. Similarly, SPDEs are derived for reaction-diffusion systems. Comparisons between the SPDEs and Monte Carlo calculations support the accuracy of the derivations.

Edward J. Allen
Texas Tech University
Department of Mathematics and Statistics
edward.allen@ttu.edu

Elife Dogan
Department of Mathematics and Statistics
Texas Tech University
elife.dogan@ttu.edu

MS30

Stochastic Fluctuations Close to Instability Boundaries: Relevance for Community Ecology and Infectious Diseases

Can we explain complex temporal and spatial patterns observed in nature in terms of simple non linear systems? Infectious diseases provide a great opportunity to study the effect of random and environmental fluctuations on the dynamics of these systems. Here, recent results on stochastic theory for the major dynamical transitions in epidemics are reviewed and the relevance of those results for ecological communities is discussed.

David Alonso
University of Groningen
Center for Ecological and Evolutionary Studies
d.alonso@rug.nl

MS30

Outbreak Prediction in Reduced Stochastic Epidemic Models

We use a stochastic normal form coordinate transform to reduce the dimension of a stochastic SEIR epidemiological model. The general procedure allows one to analytically derive both the stochastic center manifold and the reduced set of stochastic evolution equations. The transformation correctly projects both the dynamics and the noise onto the center manifold. The solution of this reduced stochastic dynamical system yields excellent agreement of disease outbreaks, both in amplitude and phase, with the solution of the original stochastic system.

Eric Forgoston
Naval Research Laboratory
eric.forgoston.ctr@nrl.navy.mil

Lora Billings
Montclair State University
Dept. of Mathematical Sciences
billingsl@mail.montclair.edu

Ira Schwartz
Naval Research Laboratory
Washington DC
ira.schwartz@nrl.navy.mil

MS30

Eat the Specialist - Some Results on the Stability of 35 Billion Food Webs

Foodwebs are networks of predative interactions that form the backbone of ecosystems. They are modeled by high dimensional, strongly nonlinear, highly stiff systems of differential equations containing thousands of parameters. Here we use the approach of generalized modeling to study these systems. The efficiency of generalized modeling allows us to extract meaningful biological information by analyzing a large ensemble of parameter sets. In particular we find a topological pattern that strongly promotes dynamical stability.

Thilo Gross
Max-Planck Institute for Physics of Complex Systems
gross@mpipks-dresden.mpg.de

MS31

Invariant Manifolds and Approximate Dynamics for the Two-body Problem with Finite Propagation Speed

The equations of motion for the two-body problem in a force field with finite propagation speed are functional differential equations; or, PDEs with dynamic boundary conditions. Effective equations of motion, ODEs in a singular limit, will be mentioned. Also, rigorous results on the existence of invariant manifolds will be formulated, and more recent results on a two-body problem (two opposing pistons at the ends of a gas filled tube) will be discussed.

Carmen Chicone
Department of Mathematics
University of Missouri, Columbia
carmen@math.missouri.edu

MS31

Smoothness of Transition Maps in Singular Perturbation Problems with One Fast Variable

We discuss the smoothness of the transition map between two sections transverse to the fast flow of a singularly perturbed vector field (one fast, multiple slow directions). Orbits connecting both sections are canard orbits, i.e. they first move rapidly towards the attracting part of a critical surface, then travel a distance near this critical surface, even beyond the point where the orbit enters the repelling part of the critical surface, and finally repel away from the surface. It is commonly believed that the transition map is smooth, and we give a proof for this fact. In a transcritical situation however, where orbits from an attracting part of one critical manifold follow the repelling part of another critical manifold, the smoothness of the transition map may be limited, due to resonance phenomena that are revealed by blowing up the turning point.

Peter De Maesschalck
Hasselt University
peter.demaesschalck@uhasselt.be

MS31

A Geometric Singular Perturbation Analysis of Signaling Networks

A fundamental part of cell signaling processes are enzyme-protein interactions. Michaelis-Menten type differential equations are therefore frequently used to model such processes. The applicability of these equations is dependent on the assumption of separation of timescales. We first revisit the derivation of these equations from the viewpoint of geometric singular perturbation theory. Interestingly, in certain limiting cases of biological interest, the steady states correspond mostly to high or low protein concentrations. Therefore, there is hope of approximating this continuous dynamics using a Boolean network. We use geometric singular perturbation techniques to study the behavior of Michaelis-Menten type equation near the singular values of these parameters.

Ajit Kumar
Department of Mathematics
University of Houston
ajitkmar@math.uh.edu

Kresimir Josic
University of Houston
Department of Mathematics
josic@math.uh.edu

Robert Azencott
Department of Mathematics
University of Houston
razencot@math.uh.edu

MS31

A General Exchange Lemma

Exchange lemmas are used in geometric singular perturbation theory to track ?ows near normally hyperbolic invariant manifolds. I shall describe a recently proved General Exchange Lemma, which implies previous exchange lemmas for recti?able slow ?ows (work of Jones, Kopell, Kaper, Tin, and Brunovsky) and loss-of-stability turning points (work of Liu). It also yields a new exchange lemma for gain-of-stability turning points (joint work with Szmolyan).

Stephen Schecter
North Carolina State University
Department of Mathematics
schecter@math.ncsu.edu

MS32

Turbulence in a Rayleigh-Benard Box

We investigate turbulence in a semi-periodic Rayleigh-Benard box, with no-slip boundary conditions on the velocity field in the vertical direction. The flow is driven by controlling the temperature on the boundary and the phenomenon is modeled by the Boussinesq approximation to the Navier-Stokes equations. We study a vertically averaged system in the framework of the mathematical theory of 2-D periodic flows and derive rigorous analogs of the fundamental relations between the standard statistical quantities of the theory of 2-D turbulence: cascade wavenumbers, Grashof number, enstrophy and enstrophy dissipation rate.

Nusret Balci
Indiana University
nubalci@indiana.edu

Ciprian Foias
Texas A&M University
na

Michael S. Jolly
Indiana University
Department of Mathematics
msjolly@indiana.edu

MS32

Regularity Criteria for the 3D Navier-Stokes Equations

The question of global regularity for the 3D Navier-Stokes equations is a major open problem in applied analysis. It is well-known that the existence and uniqueness of strong solutions could be obtain under suitable additional assumptions. In this talk I will review some old and new results about the sufficient conditions for the global regularity to the 3D Navier-Stokes equations.

Chongsheng Cao
Department of Mathematics
Florida International University
caoc@fiu.edu

Edriss Titi
Department of Mathematics
University of California, Irvine
etiti@math.uci.edu

MS32

On the Maximal Enstrophy Growth Rate for Solutions to the 3D Navier-Stokes Equations

Due to a supercritical nature of the 3D Navier-Stokes equations, the best known estimates on the enstrophy growth rate do not rule out the existence of finite time singularities. Recently Doering and Lu numerically showed that these estimates are sharp. I this talk I will present some analytical results in this direction as well as related regularity criteria in critical spaces.

Alexey Cheskidov
University of Illinois Chicago
acheskid@math.uic.edu

MS32

Stochastic Lagrangian Particle Systems for the Navier-Stokes and Burgers Equations

I introduce an exact stochastic representation for certain non-linear transport equations (e.g. 3D-Navier-Stokes, Burgers) based on noisy Lagrangian paths, and use this to construct a (stochastic) particle system for the Navier-Stokes equations. On any fixed time interval, this particle system converges to the Navier-Stokes equations as the number of particles goes to infinity. Curiously, a similar system for the (viscous) Burgers equations is shocks in finite time, and solutions can not be continued past these shocks using classical methods. I will describe a resetting procedure by which these shocks can (surprisingly!) be avoided, and thus obtain convergence to the viscous Burgers equations on long time intervals.

Gautam Iyer
Department of Mathematics
Stanford University
gautam@math.stanford.edu

Peter Constantin
Department of Mathematics
University of Chicago
const@cs.uchicago.edu

Jonathan C. Mattingly
Duke University
jonm@math.duke.edu

Alexei Novikov
Penn State University
Mathematics
anovikov@math.psu.edu

MS33

A Uniform Coverage Search Strategy

We present a spectral multiscale search algorithm for multiple searchers with realistic dynamics that uniformly samples a prior distribution from which the target position is drawn. We combine this with a Neyman-Pearson decision making algorithm that satisfies performance bounds on the probability of detection and false alarm. We show that our search strategy results in faster target detection and robustness under various uncertainties when compared with lawnmower and billiards-type searches.

Vladimir Fonoberov
Chief Scientist
AIMdyn, Inc

vfonoberov@aimdyn.com

George A. Mathew
University of California, Santa Barbara
gmathew@engineering.ucsb.edu

Alice Hubenko
UCSB
Department of Mechanical Engineering
hubenko@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

MS33

Global Information Search with Autonomous Vehicles Subject to Uncertainty

The talk is concerned with the computation of near globally optimal motions for agile autonomous vehicles gathering information under uncertainty. We consider the general problem of finding trajectories that satisfy the vehicle dynamics and maximise the information gained. The proposed solution is based on optimal control for precomputing a set of motion primitives and dynamic programming in a finite approximation of the space of system state probability distributions. Distributed search for multiple vehicles will also be discussed.

Marin Kobilarov
California Institute of Technology
1200 E. California Blvd, MC 107-81, Caltech, Pasadena, CA 91
marin@cds.caltech.edu

Sina Ober-Blöbaum
California Institute Of Technology
sinaob@cds.caltech.edu

Jerrold E. Marsden
California Institute Of Technology
1200 E. California Blvd, MC 107-81, Caltech, Pasadena, CA 91
jmarsden@caltech.edu

MS33

Designing Search Dynamics Robust Under Sensor Uncertainty

The subdivision properties of mixing transformations can be exploited in search scenarios where there is a hierarchy of target sizes. For stationary targets and certain classes of moving targets, it is shown that the mean search time with these mixing transformations goes as

$$c_1 \ln\left(\frac{1}{\delta}\right) + c_2, \qquad (1)$$

where the target size is distributed randomly in $[\delta, a)$, a is fixed, and $\delta \to 0$.

Ryan Mohr, Igor Mezic
University of California, Santa Barbara
mohrrm@engineering.ucsb.edu,
mezic@engineering.ucsb.edu

MS33

Search Strategies for Under-actuated Vehicles with Uncertain Measurements

We consider the problem of quickly detecting multiple stationary targets using a network of under-actuated sensors with uncertain measurements. We present sensor reassignment strategies based on the current Bayesian belief map for the targets and show how to exploit a classical result of Newton to optimally compute Bayesian updates. The use of dynamically generated trajectories ensures robust exploration of arbitrarily shaped regions. We demonstrate the improved efficiency of these methods over standard lawnmower type techniques.

Sujit Nair
California Institute of Technology
nair@cds.caltech.edu

Philip C. du Toit
Control and Dynamical Systems
California Institute of Technology
pdutoit@cds.caltech.edu

Konda Reddy
United Technologies Research Center
chevvakr@utrc.utc.com

Jerry Marsden
California Institute Of Technology
jmarsden@caltech.edu

Houman Owhadi
Applied Mathematics
Caltech
owhadi@caltech.edu

MS34

The Onset of Synchronization in Networks of Networks

We consider networks of interacting phase oscillators which are composed of several populations. The oscillators in a given population are heterogeneous in that their natural frequencies are drawn from a given distribution, and each population has its own such distribution. The coupling among the oscillators is global; however, we permit the coupling strengths between the members of different populations to be separately specified. We determine the critical condition for the onset of coherent collective behavior.

Ernest Barreto
George Mason University
Krasnow Institute
ebarreto@gmu.edu

Brian R. Hunt
University of Maryland
bhunt@ipst.umd.edu

Edward Ott
University of Maryland
Inst. for Plasma Research
edott@umd.edu

Paul So
George Mason University
The Krasnow Institute
paso@gmu.edu

MS34

Stability Diagram for the Forced Kuramoto Model

We analyze the periodically forced Kuramoto model. This system consists of an infinite population of phase oscillators with random intrinsic frequencies, global sinusoidal coupling, and external sinusoidal forcing. Previous work uncovered two main types of attractors but the details of the bifurcations between them were unclear. Here we present a complete bifurcation analysis of the model for a special case in which the infinite-dimensional dynamics collapse to a two-dimensional system.

Lauren M. Childs
Cornell University
Lmc74@cornell.edu

Steven Strogatz
Theoretical and Applied Mechanics
Cornell University
shs7@cornell.edu

MS34

Exact Solutions of the Bimodal Kuramoto Problem

We analyze a large system of globally coupled phase oscillators whose natural frequencies are bimodally distributed. The dynamics of this system has been the subject of longstanding interest. In 1984 Kuramoto proposed several conjectures about its behavior; ten years later, Crawford obtained the first analytical results by means of a local center manifold calculation. Nevertheless, many questions have remained open, especially about the possibility of global bifurcations. Here we derive the system's complete stability diagram for the special case where the bimodal distribution consists of two equally weighted Lorentzians. Using an ansatz recently discovered by Ott and Antonsen, we show that in this case the infinite-dimensional problem reduces exactly to a flow in four dimensions. Depending on the parameters and initial conditions, the long-term dynamics evolves to one of three states: incoherence, where all the oscillators are desynchronized; partial synchrony, where a macroscopic group of phase-locked oscillators coexists with a sea of desynchronized ones; and a standing wave state, where two counter-rotating groups of phase-locked oscillators emerge. Analytical results are presented for the bifurcation boundaries between these states. Similar results are also obtained for the case in which the bimodal distribution is given by the sum of two Gaussians.

Erik Martens
Department of Theoretical & Applied Mechanics
Cornell University
eam67@cornell.edu

MS34

Low Dimensional Behavior of Large Systems of Globally Coupled Oscillators

We show that, in the infinite-size limit, certain systems of globally-coupled phase oscillators display low-dimensional dynamics. We derive an explicit finite set of nonlinear ODEs for the macroscopic evolution of the systems considered. For example, an exact, closed-form solution for the nonlinear time evolution of the Kuramoto problem with a Lorentzian oscillator frequency distribution function is obtained. Low dimensional behavior is also demonstrated for extensions of the Kuramoto model, and time-delayed coupling is also considered.

Edward Ott
University of Maryland
Inst. for Plasma Research
edott@umd.edu

Thomas Antonsen
University of Maryland
antonsen@umd.edu

MS35

Investigating an Unfolded Border-Collision Bifurcation in Paced Cardiac Tissue

Bifurcations in the electrical response of cardiac tissue can destabilize electrochemical waves in the heart. Therefore, it is important to classify these bifurcations to understand the mechanisms that cause instabilities. We have determined that the period-doubling bifurcation in paced myocardium is of the unfolded border-collision type. Furthermore, we have studied the role of calcium in inducing this bifurcation based on voltage and calcium measurements in frog ventricle.

Carolyn Berger
Department of Physics
Duke University
cberger@phy.duke.edu

Xiaopeng Zhao
University of Tennessee
xzhao9@utk.edu

David G. Schaeffer
Department of Mathematics
Duke University
dgs@math.duke.edu

Wanda Krassowska
Duke University
wanda@eel-mail.bme.duke.edu

Daniel Gauthier
Departments of Physics and Biomedical Engineering
Duke University
gauthier@phy.duke.edu

MS35

Restitution Curve Splitting as a Mechanism for the Bifurcation to Alternans

Cardiac tissue displays a bifurcation in electrical response at rapid pacing rates. Traditionally, this bifurcation has been explained in terms of the slope of the restitution curve, a function that relates the response duration to the duration of the interval preceding it. However, we have recently observed that this curve is not a single-valued function under a wide range of physiological conditions. We will show examples of this restitution curve splitting and discuss the implications.

Elizabeth Cherry, Flavio Fenton, Robert F. Gilmour
Cornell University
emc58@cornell.edu, fhf3@cornell.edu, rfg2@cornell.edu

MS35
Role of Stochasticity in the Genesis of Cardiac Arrhythmia

Mutations in ion channels have been linked to sudden cardiac death. However, the precise sequence of events linking a channel mutation to a whole heart arrhythmia is not completely understood. We have applied mathematical modeling to study the role of ion channel stochasticity on the genesis of a cardiac arrhythmia. In particular we show that stochastic features of calcium signaling are essential to understand triggered activity in the heart.

Yohannes Shiferaw
California State University
Northridge
yshiferaw@csun.edu

MS35
Bifurcation Analysis of Spatially Discordant Alternans

We investigate spatially discordant alternans in a cardiac model, which accounts for interaction between voltage dynamics and intracellular calcium cycling. A detailed bifurcation analysis is carried out to show synchronization of spatial alternans due to electrotonic coupling.

Xiaopeng Zhao
University of Tennessee
xzhao9@utk.edu

MS36
Long Time Coming: Modeling Sound Emission from the Ear

Not only does the ear receive sound, but it emits it as well. These otoacoustic emissions are considered a by-product of the processes occurring inside the ear that give rise to its sharp tuning and remarkable sensitivity. The model described here, based upon an oscillator array for the lizard inner ear, provides an analytic foundation for the connection between the long emission phase delays observed empirically and the filter bandwidths of the underlying transducers.

Christopher Bergevin
University of Arizona
cbergevin@math.arizona.edu

Christopher A. Shera
Eaton-Peabody Laboratory
Harvard Medical School
shera@epl.meei.harvard.edu

MS36
Linking Transduction Mechanism and Auditory System Performance - A Physical Description of the Ear of a Fly

We present a comprehensive physical description of the ear of Drosophila melanogaster. We show that a simple dynamical system that consists of transduction modules and a simple harmonic oscillator quantitatively explains mechanical and electrical key properties of the flys ear. Linking molecular mechanisms and auditory system performance, our model can be used to study the consequences of genetic defects in hearing.

Martin Goepfert, Björn Nadrowski
University of Cologne
m.gopfert@uni-koeln.de, nadrowski@uni-koeln.de

MS36
Active and Adaptive Auditory Mechanics in Insects

The ears of insects are not as simple as they seem. Their sophistication relates to their high degree of miniaturisation and the complex, sometimes active, mechanisms subtending their sensitivity, adaptive tuning and capacity for spectral analysis. A variety of examples will be presented that illustrate the diversity of mechanisms at work in an effort to highlight to opportunities offered by insect auditory systems to study the biological solutions to the problem of acoustic detection.

Daniel Robert
University of Bristol
d.robert@bristol.ac.uk

MS36
The Active Process of the Mammalian Inner Ear

A nonlinear active process is thought to be responsible for the ear's large dynamic range, sensitivity and ability to emit sound spontaneously. We present a physical description of cochlear mechanics by examining the interaction between active hair bundle motion and electromotility(piezoelectric response) of the sensory outer hair cell. The system exhibits generic properties, resulting from the proximity of its operating point to a Hopf bifurcation, which account for the main characteristics of hearing. Specific features of this system are also discussed.

Dáibhid Maoiléidigh, Frank Jülicher
Max-Planck-Institut für Physik komplexer Systeme
dmelody@mpipks-dresden.mpg.de,
julicher@mpipks-dresden.mpg.de

MS37
The Evans Function, Computational Challenges and Recent Results

We briefly review and motivate the stability problem for traveling waves, specifically front and pulse stability in dissipative systems. We present an overview of both analytical and computational issues surrounding Evans function, and explore some of the competing methods for large-scale computation. We conclude by providing a run-down on our most recent results involving highly-oscillatory profiles, root location, and stiff systems. A software demonstration is also included.

Blake Barker, Samuel Dittmer, Jeffrey Humpherys,
Joshua Lytle
Brigham Young University
bhbarker@gmail.com, samuel_dittmer@hotmail.com,
jeffh@math.byu.edu, joshualy@sfcn.org

MS37
Spectral Mapping Theorems and Stability of Pulses

We will discuss various spectral methods and spectral mapping theorems for strongly continuous operator semigroups used to study the spectral and linear stability of pulses, in particular, for reaction diffusion systems with the degenerate diffusion matrix. This is a joint work with A. Ghazaryan, K. Makarov, S. Schecter, A. Sukhtaev.

Yuri Latushkin
University of Missouri
yuri@math.missouri.edu

MS37

Computing Exponential Dichotomies and Error Bounds for Evans Function Calculations

We outline an error analysis for stability spectra (Lyapunov exponents and Sacker-Sell spectrum) using continuous orthonormalization techniques in which the fundamental matrix solution of a time varying linear system is decomposed using a continuous QR factorization. We show how this type of error analysis can be employed to obtain rigorous error bounds on computations of some differential eigenvalue problems.

Erik Van Vleck
Department of Mathematics
University of Kansas
evanvleck@math.ku.edu

MS37

Stability of Strong Viscous Shock Layers in an Ideal Gas

By a combination of asymptotic ODE estimates and numerical Evans function computations, we examine the spectral stability of shock-wave solutions of the compressible Navier-Stokes equations (ideal gas), for arbitrary strength waves. We show that the Evans function (i) converges in the strong shock limit to the Evans function for a limiting shock profile of the same equations and (ii) has no unstable (positive real part) zeros outside a uniform ball. Numerical results are also presented.

Kevin Zumbrun
Indiana University
USA
kzumbrun@indiana.edu

Jeffrey Humpherys
Brigham Young University
jeffh@math.byu.edu

MS38

Exceptional Discretisations of the Sine-Gordon Equation

Recently, the method of one-dimensional maps was introduced as a means of generating exceptional discretisations of the ϕ^4-theories, i.e., discrete ϕ^4-models which support kinks centred at a continuous range of positions relative to the lattice. In this talk, we employ this method to obtain exceptional Frenkel-Kontorova chains. We also use one-dimensional maps to construct a discrete sine-Gordon equation supporting kinks moving with arbitrary velocities without emitting radiation.

Igor Barashenkov
University of Cape Town
Igor.Barashenkov@uct.ac.za

MS38

Stationary and Moving Localised Structures in Dissipitive Optical Lattices

A one-dimensional lattice equation is studied that models the light field in an system comprised of a periodic array of optical cavities pumped by a coherent source. In parameter regions where there is bistability between low-power and high-power spatially homogeneous steady states a myriad of different stable localised states are discovered, both bright and grey, that lie on so-called homoclinic snaking branches in as the pump strength is varied. Several different mechanisms are revealed by which the snakes can be created and destroyed as a second parameter is varied. By adding a phase gradient, the reversibility of the underlying mathematical model is broken. The snaking curves then break up into isolas, but unlike the continuum case, for this discrete system a finite amount of symmetry breaking is required before moving solitary structures are created. This is joint work with Alex Yulin.

Alan R. Champneys
University of Bristol
a.r.champneys@bristol.ac.uk

MS38

Applications of 1-D Highly Nonlinear Granular Systems

Highly nonlinear solitary waves in granular media have been receiving increasing attention in the last few years thanks to their tunable dynamical properties, compact support and the ease in their experimental observation. They offer an elegant platform to study numerically and analytically the interplay between discrete and continuum properties, and offer potential for a variety of different applications. This talk will give an overview of the current state-of-the-art analysis and will describe potential engineering applications.

Chiara Daraio
Aeronautics and Applied Physics
California Institute of Technology
daraio@caltech.edu

MS38

Nonlinear Excitations in Dusty Plasma (Debye) Crystals: An Overview of Recent Developments

Dust crystals are formed inside a plasma consisting of electrons, ions and massive charged mesoscopic-sized defects (dust). Electrostatic interactions and the plasma sheath on-site potential provide the ingredients to tailor-fit nonlinear wave theories. The nonlinear aspects of longitudinal and transverse/vertical dust motion in 1D and 2D (hexagonal) dust lattices are reviewed. Nonlinear modes occuring include kinks and symmetric/asymmetric envelope wavepackets, obtained via quasi-continuum soliton theories. Shock wave formation is modelled by an efficient Korteweg-de Vries/Burgers approach. Reference to discrete breathers and vortex modes found via discrete models is also made.

Ioannis Kourakis
Queen's University Belfast
Centre for Plasma Physics (CPP)
i.kourakis@qub.ac.uk

MS39

Slow Acceleration and De-acceleration Through a Hopf Bifurcation

From the periodicity of regional climate change to sustained oscillations in living cells, the transition between stationary and oscillatory behavior is often through a Hopf bifurcation. When a parameter slowly ramps through a Hopf bifurcation there is a delayed transition to sustained oscillations. Most theoretical studies assume constant ramp speeds. Here we generalize the problem to slow parameter acceleration and de-acceleration with application to nerve membrane accommodation, pacemaker formation in the Belousov-Zhabotinsky reaction, and elliptic bursting.

Steven M. Baer
Arizona State University
Dept. of Mathematics and Statistics
baer@math.la.asu.edu

MS39

Harmonically Forced Enclosed Swirling Flow

Harmonic modulations of steady enclosed swirling flows near Hopf bifurcations are investigated experimentally and numerically. For very low forcing frequency, the synchronous flow approaches quasi-static adjustment, and for very large forcing frequencies the oscillations are localized in boundary layers and the synchronous flow in the interior is driven to the underlying steady basic state. The third regime occurs for forcing frequencies in the neighborhoods of the most dangerous Hopf eigenfrequencies, with 1:1 resonance leading to greatly enhanced oscillation amplitudes localized near the axis.

Juan Lopez
Arizona State University
Department of Mathematics and Statistics
lopez@math.asu.edu

MS39

Noise Induced Mixed-mode Oscillations in a Relaxation Oscillator Near the Onset of a Limit Cycle

I will report a detailed asymptotic study of the effect of small Gaussian white noise on a relaxation oscillator undergoing a supercritical Hopf bifurcation, which reveals an intricate stochastic bifurcation leading to several kinds of noise-driven mixed-mode oscillations at different levels of amplitude of the noise. In the limit of strong time scale separation, five different scaling regimes for the noise amplitude are identified. As the noise amplitude is decreased, the dynamics of the system goes from the limit cycle due to self-induced stochastic resonance to the coherence resonance limit cycle, then to bursting relaxation oscillations, followed by rare clusters of several relaxation cycles (spikes), and finally to small-amplitude oscillations (or stable fixed point) with sporadic single spikes.

Cyrill B. Muratov
New Jersey Institute of Technology
Department of Mathematical Sciences
muratov@njit.edu

Eric Vanden-Eijnden
Courant Institute
New York University
eve2@cims.nyu.edu

MS39

Delay Induced Canard Cycles

We consider a model for machining chatter that is a nonlinear delay differential equation. For any fixed value of the delay, a large enough increase in the width of the cut results in a Hopf bifurcation from the steady state, the origin of chatter vibration. We show that for zero delay the Hopf bifurcation is degenerate and for small delay (high speed machining) this leads to a canard explosion. Our analysis relies on perturbation techniques and a small delay approximation due to Chicone.

Emily F. Stone
Dept. of Mathematical Sciences
The University of Montana
stone@mso.umt.edu

Sue Ann Campbell
University of Waterloo
Dept of Applied Mathematics
sacampbell@uwaterloo.ca

Thomas Erneux
Université Libre de Bruxelles
Optique Nonlinéaire Théorique
terneux@ulb.ac.be

MS40

The Decay of Turbulence in Taylor-Couette Flow

In shear flows, the transition to turbulence typically occurs through a subcritical bifurcation. Experiments have shown that the lifetime of the turbulent state is finite at moderate Reynolds numbers. Some experiments suggest that above some critical Reynolds number turbulence becomes sustained, whereas other experiments suggest the lifetime increases rapidly but diverges only at infinite Reynolds number. We present measurements over several orders of magnitude of lifetimes in the flow between concentric, rotating cylinders.

Daniel Borrero-Echeverry, Michael Schatz
Center for Nonlinear Science and School of Physics
Georgia Institute of Technology
dborrero@gatech.edu, mike.schatz@physics.gatech.edu

MS40

Confinement of Turbulence in Pipe Experiments in the Intermittent Flow Regime

We identify an instability mechanism transferring energy from the laminar to the turbulent flow. Of particular importance is the action of streamwise vortices in the near wall region which create strong gradients in the mean shear and inflection points in the velocity profile. Subsequently streamwise vortices are redistributed throughout the flow invigorating the turbulent motion. Having identified the active region of the flow we are able to apply a simple control mechanism to intercept this energy transfer. In experiments carried out at relatively low Reynolds numbers this simple control concept is sufficient to destroy the localized turbulent structures typical for this regime. When this procedure is applied continuously turbulence can be fully omitted downstream of the control point.

Alberto De Lozar
Max-Planck Institute for Dynamics and Self-Organization
adelozar@googlemail.com

MS40

Experimental Investigations of Coherent Flow States in Turbulentpipe and Couette Flow

Turbulent pipe and plane Couette flow are investigated in the transitional regime. The experimental techniques used allow to spatially and temporally fully resolve the velocity fields of localized turbulent structures (puffs and spots). The measurements are compared to the velocity fields of finite amplitude solutions known from numerical studies. Within the turbulent spots coherent patches of vorticity are identified which typically propagate at a velocity larger than the mean velocity of the turbulent spot. While we find overall good quantitative agreement for the propagation velocity, the wavelength and the streak vortex interaction, when compared to the exact coherent states there are also quantitative differences concerning velocity profiles and the wall shear stress.

Bjoern Hof
Max Planck Institute of Dynamics and Self Organization
bhof@gwdg.de

MS40

Experimental Observation of the Decay of Localized Turbulence in Pipe Flow

Transition to turbulence in pipe flow occurs as localized turbulent disturbances (puffs) that travel down the pipe. The lifetime of puffs increases with Reynolds number and according to numerous studies diverges for a finite Reynolds number. Results of previous experiments were based on the outflow of long pipes only, and no information was available about the intermediate states. In this experiment the life time of each puff has been measured quantitatively. We observed that the probability of puff existence has an exponential distribution, implying that the decay is a memoryless process. The turbulent state remained transient for all observed Reynold numbers.

Dirk Kuik
Laboratory for Aero and Hydrodynamics
Technische Universiteit Delft
d.j.kuik@tudelft.nl

MS41

Extinction of Metastable Stochastic Populations

We address extinction of a long-lived self-regulating stochastic population, caused by intrinsic noise. Typically, extinction occurs via one of two scenarios depending on whether the absorbing state n=0 is a repelling or attracting point of the deterministic rate equation. Starting from the master equation, we calculate analytically the quasi-stationary probability distribution and the (exponentially long) mean time to extinction for each of the two scenarios. Our theory holds for a general set of multiple-step processes when detailed balance is broken.

Michael Assaf, Baruch Meerson
Racah Institute of Physics
Hebrew University of Jerusalem
michael.assaf@mail.huji.ac.il, meerson@cc.huji.ac.il

MS41

The Effects of Recombination and Finite Population Size on Viral Evolution

We introduce generalizations of the parallel, or Crow-Kimura, and Eigen models of molecular evolution to represent the exchange of genetic information between individuals in a population. We present exact analytical formulas for the equilibrium mean fitness of the population, in terms of a maximum principle derived from an exact field theory, which are generally applicable to any permutation invariant replication rate function. These results prove that the mutational deterministic hypothesis holds for quasi-species models.

Michael W. Deem
Rice Unversity
Depts. Physics & Astronomy and Bioengineering
mwdeem@rice.edu

MS41

Stochastic Extinction of Epidemics and Vaccinations

Stochastic extinction of disease is investigated for large populations using an optimal escape path approach. A standard Langevin equation is used to model an SIS epidemic with random fluctuations produced by the probabilistic contact and recovery rates. The effect of vaccinations on stochastic extinction is also investigated.

Alexandra Landsman
James Madison University
landsman@alumni.princeton.edu

Ira Schwartz
Naval Research Laboratory
Washington DC
ira.schwartz@nrl.navy.mil

MS41

Controlling Epidemic Spread in Adaptive Networks Using Poisson Vaccination

We study an epidemic model for disease spread on an adaptive network where non-infected nodes rewire away from infected nodes. Poisson distributed vaccination of susceptibles is included. Effects of the vaccination frequency and amplitude are studied in the full system and compared to a derived mean field theory. Disease extinction rates using vaccination are found for both adaptive and static networks, and we quantify why vaccine control is more effective on adaptive than static networks.

Leah Shaw
The College of William & Mary
lbshaw@wm.edu

Ira Schwartz
Naval Research Laboratory
Washington DC
ira.schwartz@nrl.navy.mil

MS42

Discrete 3-Dimensional Stirring Models

We have developed discrete 3-dimensional stirring models which we believe mimic stirring in a cylindrical tank. We discuss experimental and rigorous results of our study of the models.

Judy Kennedy
Lamar University

kennedy@gmail.com

MS42

Stalking Trajectories in Higher-dimensional Systems

Predictions of any chaotic dynamical process, including weather and climate, require one to specify the probability associated with a given outcome. Suppose that C denotes a chaotic process and that M is a model of C. Even if C and M begin from comparable initial conditions, no solution of C remains close to a solution of M for all time. This talk addresses the question of how to identify trajectories of M, called *stalking* trajectories, that remain suitably close to trajectories of C for time scales of forecast interest in simplified atmospheric models with some realistic physical parametrizations.

Eric J. Kostelich
Arizona State University
Department of Mathematics
kostelich@asu.edu

Chris Danforth
Mathematics and Statistics
University of Vermont
chris.danforth@uvm.edu

MS42

From Limit Cycles to Shear-induced Chaos

We consider limit cycles of flows on finite-dimensional spaces. We show that if a computable quantity called the shear integral is sufficiently large, then the system can exhibit sustained, observable chaos when the system is forced by a time-periodic pulsatile drive. This is an example of shear-induced chaos: the presense of shear in the unforced flow can cause a strange attractor with strong stochastic properties to replace a stable dynamical structure when the system is forced with a periodic signal. We will discuss potential generalizations to flows defined by evolution partial differential equations.

William Ott
University of Houston
ott@math.uh.edu

Mikko Stenlund
Courant Institute of Mathematical Sciences
University of Helsinki
mikko@cims.nyu.edu

MS42

Understanding Transient Behavior of Systems of Partial Differential Equations via Numerical Bifurcation

This talk will describe dynamical results in materials science for three component alloys, modeled by the Morral-Cahn equation. We have computed the bifurcation structure in a particular parameter regime known as the nucleation regime. We used two-parameter continuation to find solutions. Though unstable, these solutions form as organizational centers which qualitatively match transient behavior seen in one- and two-dimensional simulations.

Evelyn Sander
George Mason University
esander@gmu.edu

MS43

Well-posedness Results for the Equations of Stochastic Fluid Dynamics with Multiplicative Noise

The addition of white noise driven terms to the fundamental equations of physics and engineering are used to model numerical and empirical uncertainties. In the context of fluid dynamics such forcing terms have been employed in the theory of turbulence. Although the study of well posedness for the Stochastic Navier-Stokes Equations goes back to the 1970's with the work of Bensoussan and Temam, many basic questions remain unaddressed. In this talk we discuss some recent work concerning the local and global existence of pathwise solutions with initial data in H1.

Nathan Glatt-Holtz
Indiana University
negh@indiana.edu

M. Ziane
Univ. of Southern California
ziane@amth.usc.edu

MS43

A 3D Computational Model of the Mammalian Cochlea

We seek to build a computational model for the simplified Mammalian Cochlea with the standard coupled fluid-plate equations as our base. Physiological data shows a clear wave nature in the response of the basillar membrane to stimulus. We seek to explain the presence of this wave nature and use it as inspiration for a 3D numerical solver. Such a solver can help in understanding nonlinear cochlear mechanics.

William Holmes
Indiana University
wrholmes@indiana.edu

MS43

Parameter Study of the Two-dimensional Navier-Stokes-Voight and Damped Navier-Stokes Equations in the Context of Image Inpainting

An approximate solution to the image inpainting problem is obtained by numerically approximating the steady state solution of the 2D NSE vorticity transport equation, and simultaneously solving the Poisson problem between the vorticity and stream function, in the region to be inpainted. This elegant approach allows one to produce an approximate solution to the image inpainting problem by using techniques from computational fluid dynamics. In this talk we present the use of the 2D Navier-Stokes-Voight sub-grid scale turbulence model and the 2D damped NSE in algorithms for the inpainting problem.

Evelyn Lunasin
University of California San Diego
elunasin@math.ucsd.edu

Moe Ebrahimi
University of California, San Diego
maebrahi@math.ucsd.edu

Michael J. Holst
Univ. of California, San Diego
Department of Mathematics
mholst@math.ucsd.edu

MS43

Statistical Properties of the Navier-Stokes-Voight Equations

We discuss the statistical properties of viscoelastic flows governed by the Navier-Stokes-Voight equations. For large values of a certain material parameter, compared to the Kolmogorov dissipative scale, shell model simulations exhibit multiscaling inertial range, and dissipation range with low intermittency. This fact leads to a reduction of the stiffness in Direct Numerical Simulations, and may shed light on the elusive question about the relation between finite time singularities and intermittency phenomena in turbulence.

Fabio Ramos
Weizmann Institute of Science
fabio.ramos@weizmann.ac.il

Edriss Titi
Department of Mathematics
University of California, Irvine
etiti@math.uci.edu

Boris Levant
Weizmann Institute of Science
boris.levant@weizmann.ac.il

MS44

Operational Parameter Study of Aircraft Ground Dynamics

The dynamics of passenger aircraft on the ground are influenced by nonlinear characteristics of components, especially aerodynamic surfaces and tyre properties. We perform a bifurcation analysis of a mid-size aircraft during high-speed turning in the parameters steering angle and centre of gravity position. Two-parameter bifurcation diagrams showing regions of qualitatively different behaviour allow us to draw conclusions on the robustness of ground operations under variation of additional parameters, such as aircraft mass and runway condition.

James Rankin
Dept of Engineering Mathematics
University of Bristol
J.Rankin@bristol.ac.uk

Bernd Krauskopf
University of Bristol
Department of Engineering Mathematics
b.krauskopf@bristol.ac.uk

Mark Lowenberg
Dept. of Aerospace Engineering
University of Bristol
m.lowenberg@bristol.ac.uk

Etienne Coetzee
Landing Gear Systems, Airbus
Bristol, UK
etienne.coetzee@airbus.com

MS44

Torsional Vibration Absorbers for Automotive Engines - An Application of Coupled Oscillators

This talk surveys the design of torsional vibration absorbers for automotive engines that employ cylinder deactivation to improve fuel economy. These consist of globally coupled, resonantly driven, weakly damped oscillators with potentially rich dynamics. The desired mode of operation, which extends well into the nonlinear range, consists of synchronous absorber motion, which can be achieved by judicious selection of linear and nonlinear tuning parameters. Modeling, analysis, and systematic experimentation are described.

Steven W. Shaw
Department of Mechanical Engineering
Michigan State University
shawsw@msu.edu

Alan Haddow
Dept of Mechanical Engineering
Michigan State University
haddow@egr.msu.edu

Brian Feeny, Ryan Monroe, Brendan Vidmar
Dept. of Mechanical Engineering
Michigan State University
feeny@egr.msu.edu, ———-, ———-

Bruce Geist
Chrysler Corporation
bg57@chrysler.com

MS44

Continuation in a Pendulum Experiment

We demonstrate with a vertically excited mechanical pendulum how one can apply pseudo-arclength continuation to track periodic orbits in a real experiment. The only requirement of our method is a stabilizing feedback control loop. In the pendulum experiment we start from a stable periodic orbit (the pendulum is rotating) and then vary the excitation amplitude to track the branch of periodic orbits through a fold to find its unstable part.

Jan Sieber
University of Portsmouth
Dept. of Mathematics
jan.sieber@port.ac.uk

Alicia Gonzalez-Buelga
Universitat Polytecnica de Catalunya
(Barcelona, Spain)
alicia.gonzalez.buelga@upc.edu

David Wagg, Simon Neild
Dept. of Mechanical Engineering
University of Bristol
david.wagg@bristol.ac.uk, simon.neild@bristol.ac.uk

Bernd Krauskopf
University of Bristol
Department of Engineering Mathematics
b.krauskopf@bristol.ac.uk

MS44

An Experimental Billiards-type Problem

This presentation will focus on a specific type of forced nonsmooth dynamical system in which a particle moves in free space until it encounters a sudden restoring force. The two physical examples of this type of system considered here are a point mass tethered by cables, and a rolling particle that contacts a surrounding wall. In both cases the mass experiences a sudden elastic rebound. These systems exhibit a variety of interesting nonlinear behavior, and the main thrust of the presentation is based on experimental results.

Lawrie N. Virgin
Department of Civil and Environmental Engineering
Duke University
l.virgin@duke.edu

Jonathan Nichols
US Naval Research Lab
——-

MS45

Fluctuations and stability due to finite-size effects in the Kuramoto model

The incoherent state of the Kuramoto model of coupled oscillators exhibits marginal modes in mean field theory. We demonstrate that corrections due to finite size effects render these modes stable. This demonstration is facilitated by the construction of a kinetic theory of coupled oscillators. We show that explicit computations can be made by truncating the resulting moment hierarchy of the kinetic theory or by re-expressing the problem in terms of a path-integral that can be solved perturbatively.

Carson C. Chow
Laboratory for Biological Modeling
NIDDK, NIH
carsonc@mail.nih.gov

MIchael Buice
LBM/NIDDK
National Institutes of Health
buicem@niddk.nih.gov

MS45

The Effects of Spread in the Distribution of Link Time Delays on the Dynamics of Coupled Oscillator Systems

Time delay exists in physical systems due to many reasons like finite propagation speeds of physical signals and finite system response times. We study in this paper the effects of a distribution of link-to-link coupling delays on a network of coupled oscillators. By reducing the system dynamics to an invariance manifold, we study the stability properties of the incoherent states and transition to the coherent states. Further, we calculate the coherent states and characterize their stability properties. We find that spread in the distribution of coupling delays can affect the system dynamics substantially.

Wai S. Lee
Institute for Research in Electronics and Applied Physics
University of Maryland
wslee@umd.edu

Edward Ott
University of Maryland
Inst. for Plasma Research
edott@umd.edu

Thomas Antonsen
University of Maryland
antonsen@umd.edu

MS45

Local adaptation in oscillator networks

Slow adaptation of oscillator networks Slow mechanisms of adaptation in Kuramoto oscillator networks will be discussed. First, a local adaptive mechanism will be presented by which a single oscillator slowly changes its frequency in response to the coherence of its neighbors. The effect of network structure and adaptation on synchronization will be discussed for this model. The method of solution will then be extended to more general cases, which include previously proposed adaptive rules.

Juan Restrepo
Department of Applied Mathematics
University of Colorado at Boulder
Juanga@Colorado.EDU

Edward Ott
University of Maryland
Inst. for Plasma Research
edott@umd.edu

MS45

Exploring the two population oscillator model beyond the Ott-Antonsen ansatz

We report on a novel set of time asymptotic solutions of the model system of two interacting populations of phase oscillators that consist of irregularly breathing chimera states. Our numerical findings suggest that the Ott-Antonsen ansatz cannot provide a complete dynamical description of the model and that there exist non-Poisson attractors in the system that can support a richer variety of equilibrium states.

Gautam C. Sethia
Institute for Plasma Research
Nonlinear Physics Division
gautam.sethia@gmail.com

Steven H. Strogatz
Department of Theoretical and Applied Mechanics
Cornell University, Ithaca, New York 14853, USA
strogatz@cornell.edu

Abhijit Sen
Institute for Plasma Research
Bhat, India
senabhijit@gmail.com

MS46

Far Field Pacing Supersedes Anti-tachycardia Pacing in a Generic Model of Excitable Media

The unpinning of vortices rotating around obstacles is a mechanism underlying low-energy termination of cardiac arrhythmias using electric far-field pacing (Pumir *et al.*, *Phys. Rev. Lett.* **99**, 208101 (2007); Fenton *et al.*, *Circ.*

(submitted)). We report on a parameter study of the unpinning mechanism, the vulnerable and unpinning window using the Barkley model (Bittihn *et al.*, *New J. Phys.* **10**, 103012 (2008); Bittihn *et al.*, *Phil. Trans. R. Soc.* (submitted)) and discuss implications for pacing strategies.

Philip Bittihn, Valentin Krinsky, Eberhard Bodenschatz
Max Planck Institute for Dynamics and Self-Organization
bittihn@physik3.gwdg.de, valentin.krinsky@ds.mpg.de, eberhard.bodenschatz@ds.mpg.de

Ulrich Parlitz
Drittes Physikalisches Institu
Universitaet Goettingen
parlitz@physik3.gwdg.de

Stefan Luther
Max Planck Institute for Dynamics and Self-Organization
stefan.luther@ds.mpg.de

MS46
A Normal Form for Excitable Media

We present a normal form for one-dimensional excitable media in form of a differential delay equation. The normal form allows to analyze bifurcations of pulses and wave trains. The parameters of the normal form are determined and its predictions are tested against numerical simulations of excitable media with good agreement. Using center manifold theory we find the Hopf bifurcation to be subcritical for all parameter values. This has interesting consequences for cardiac dynamics and so called alternans, which have so far been believed to be stable oscillations. We show that our normal form goes beyond the classical restitution hypothesis, in agreement with recent numerical studies.

Georg A. Gottwald
School of Mathematics and Statistics
University of Sydney
gottwald@maths.usyd.edu.au

MS46
Pacing-induced Arrhythmia Termination

Some potentially fatal cardiac arrhythmias may be terminated by a series of premature stimuli. We investigated mechanisms for termination of reentry using an ionic cardiac ring model. Termination requires conduction block, which we found to robustly manifest when the magnitude of the spatial gradient in recovery time exceeds a critical value. The sign of this necessary gradient determines whether an induced wave blocks in the direction of (negative) or opposite (positive) to the reentrant wave. We show analytically the necessary conditions for generating termination-prone gradients and introduce a new type of pacing protocol which increases the termination efficacy.

Trine Krogh-Madsen
Cornell University - Weill Medical College
trk2002@med.cornell.edu

David Christini
Cornell University - Weill Medical College
Division of Cardiology
dchristi@med.cornell.edu

MS46
Comparison of Microscopic and Bidomain Models of Anisotropic Conduction

In order to incorporate details like extracellular space distribution, gap-junction distribution, and myocyte shapes into the bidomain models for cardiac propagation, we created a tissue level model that incorporates these details. The resulting depolarization fronts from this model were subsequently compared with the continuous bidomain model, which is less computational intensive, in order to determine which averaged properties need to be used in the bidomain model to mimic the detailed model.

Rob McLeod, Jeroen Stinstra
University of Utah
macleod@cvrti.utah.edu, jeroen@sci.utah.edu

MS47
Neural Coding of Amplitude-Modulated Cochlear Implant Stimulation

Cochlear implants are neural prostheses that provide sound information to listeners by stimulating the auditory nerve with amplitude-modulated, constant-rate electrical pulse trains. We model the response of the auditory nerve to amplitude-modulated cochlear implant stimulation as a point process and relate simulation results to psychophysical data. In particular, we quantify the temporal encoding properties of the auditory nerve using an ideal observer analysis and then construct a decoding algorithm that can predict some qualitative features of observed psychophysical data.

Joshua H. Goldwyn
Department of Applied Mathematics
University of Washington
jgoldwyn@amath.washington.edu

MS47
Synaptic Dynamics in the Auditory Brainstem: Models and Mechanisms

The dynamic regulation of synaptic strength can have a profound impact on how information is transmitted across the synapse. Short-term synaptic plasticity at the synapses between the auditory nerve and auditory brainstem neurons shape the pathways that encode different aspects of sound. Recent experiments investigating the mechanisms of synaptic transmission in the cochlear nucleus suggest that vesicle depletion is a common mechanism responsible for short-term depression, but facilitation is differentially regulated. We also present a novel model that may explain the dynamics behind a rapid recovery from vesicle depletion and how it leads to an apparent activity-dependent acceleration in the recovery after high-frequency stimuli.

Katrina MacLeod
University of Maryland
macleod@umd.edu

MS47
Dynamics of Fast, Precise Neuronal Computing in the Auditory Brainstem

Neurons in the medial superior olive (MSO) perform extraordinarily fast and precise coincidence detection in the neuronal computation for sound localization. These MSO neurons are biophysically specialized with fast-gating, spatially-segregated ionic currents, bipolar dendrites - each driven by inputs from one side, a fast subthreshold-activated K+ current, synaptic excitation and inhibition, both fast. Our experimental and computational results provide insights into this definitive feedforward neuron and how interaural time difference (ITD) tuning is achieved.

John M. Rinzel
Courant Institute and Center for Neural Science
New York University
rinzel@cns.nyu.edu

MS47

Forced Hopf Oscillators and the Auditory System

We describe how a periodically forced system, tuned near a Hopf bifurcation point, of modeling auditory system can lead to more complicated responses than the description given in many models studied previously. We also discuss how the amplification of an input sound signal can be achieved by incorporating the Hopf oscillators stated as frequency detectors in the auditory system.

LieJune Shiau
University of Houston
shiau@uhcl.edu

Marty Golubitsky
Ohio State University
Mathematical Biosciences Institute
mg@mbi.ohio-state.edu

Claire M. Postlethwaite
University of Auckland
c.postlethwaite@math.auckland.ac.nz

Yanyan Zhang
Ohio State University
yzhang@math.osu.edu

MS48

Using Global Invariant Manifolds to Understand Metastability in Burgers Equation with Small Viscosity

In Burgers equation with small viscosity, it has been observed that solutions spend a long time near N-waves, the stable solutions for zero viscosity, before finally converging to self-similar diffusion waves, the stable solutions for nonzero viscosity. This is an example of metastability. We show that, by using similarity variables and working in an algebraically weighted L^2 space, it can be explained geometrically using global invariant manifolds.

Margaret Beck
Brown University
Margaret_Beck@brown.edu

C. Eugene Wayne
Boston University
Department of Mathematics
cew@math.bu.edu

MS48

Nonlinear Convective Stability of Traveling Fronts near Turing and Hopf Instabilities

We analyze the instability of fronts in reaction-diffusion systems when the instability is caused by the rest state behind the front undergoing a supercritical Turing or Hopf bifurcation. We use a technique based on interplay of norms with and without weight to show that in the frame that moves together with the front, the pattern is pushed away from the interface of the front, in other words, the instability is convective.

Margaret Beck
Brown University
Margaret_Beck@brown.edu

Anna Ghazaryan
University of Kansas
aghazaryan@math.ku.edu

Bjorn Sandstede
Brown University
bjorn_sandstede@brown.edu

MS48

Stability of Traveling Waves for Double Degenerate Fisher-Type

This talk is concerned with the asymptotic stability of traveling wave solutions for double degenerate Fisher-type equations. By detailed spectral analysis, each traveling front solution with non-critical speed is proved to be linearly exponentially stable in some exponentially weighted spaces. Further by Evans function method and detailed semi-group estimates, each traveling wave solution with non-critical speed is proved to be locally algebraically stable to perturbations in some appropriate polynomially weighted spaces.

Yi Li
University of Iowa
yi-li@uiowa.edu

Yaping Wu
Capital Normal University
Beijing, China
yaping_wu@hotmail.com

MS48

Solitary Waves in the Earth's Interior and their Stability

Solitary waves emerge in many physical problems, including water waves and optics. Such structures also appear in models for mantle convection and magma migration. Unfortunately, the equations of this geophysical setting lack tools such as an inverse scattering transform or a variational formulation. This necessitates a less elegant strategy for studying them. We prove asymptotic stability of the solitary waves and see the limitations of current techniques.

Gideon Simpson
University of Toronto
simpson@math.utoronto.ca

Michael I. Weinstein
Department of Applied Physics and Applied Mathematics
Columbia University
miw2103 at columbia dot edu

MS49

To Snake or Not to Snake in the Planar Swift-

Hohenberg Equation

We focus on the numerical continuation of fully localised solutions to the planar Swift-Hohenberg equation. Firstly, we deal with boundary-value problems, boundary and phase conditions, parallelisation. Secondly, we address homoclinic snaking: unlike the one-dimensional case, snaking and non-snaking patterns exist in the same region of parameter space and may belong to the same branch, or they may be indistinguishable. We will show continuation and stability computations of rolls, almost-planar rolls, worms, squares.

Daniele Avitabile
Department of Engineering Mathematics, University of Bristol
d.avitabile@bristol.ac.uk

David Lloyd
University of Surrey
d.j.lloyd@surrey.ac.uk

Bjorn Sandstede
Brown University
bjorn_sandstede@brown.edu

MS49
Loca and Other Trilinos Tools for Analysis of Large-Scale Dynamical Systems

This talk will describe LOCA, the Library of Continuation Algorithms, a package for continuation and bifurcation analysis of large-scale dynamical systems that is part of the Trilinos software collection. In particular we will discuss research on linear algebra methods for solving augmented systems of equations that are crucial for scalability and efficiency. We also describe several other Trilinos tools that LOCA can leverage enabling analysis of problems with billions of unknowns on thousands of processors.

Eric Phipps
Sandia National Laboratories
Optimization and Uncertainty Estimation Department
etphipp@sandia.gov

Andrew Salinger, Roger Pawlowski
Sandia National Labs
agsalin@sandia.gov, rppawlo@sandia.gov

MS49
Computing Phase Transitions of Confined Fluids using Bifurcation Analysis Techniques

Phase transitions are often the key to understanding, controlling, and eventually designing molecular fluid systems. Some examples include capillary condensation transitions of a fluid adsorped in a porous media, the self-assembly of block copolymer melts into patterns, and the formation (and destruction) of cell membranes. Computational bifurcation analysis tools for large-scale systems (LOCA), augmented by a phase transition tracking algorithm, drive a classical fluids Density Functional Theory code (Tramonto) to enable all these studies.

Andy Salinger
Sandia National Laboratories
agsalin@sandia.gov

Laura J. Dougla Frink
Colder Insights Corp
St. Paul, Minnesota
ljfrink@colderinsights.com

Michael A. Heroux, Amalie Frischknecht
Sandia National Laboratories
maherou@sandia.gov, alfrisc@sandia.gov

Eric Phipps
Sandia National Laboratories
Optimization and Uncertainty Estimation Department
etphipp@sandia.gov

MS49
Large Scale Simulations of Vortices in Coupled Ginzburg–Landau Equations

The focus of this talk will be on the numerical solution of the Ginzburg–Landau equations

$$\begin{aligned} 0 &= -(-\mathrm{i}\nabla - \mathbf{A})^{\mathbf{2}}\psi + \psi\left(\mathbf{1} - |\psi|^{\mathbf{2}}\right) \quad \text{on}\,\Omega \\ 0 &= \kappa^2\Delta\mathbf{A} + \frac{\mathbf{1}}{\mathbf{2}\mathrm{i}}\left(\overline{\psi}\nabla\psi - \psi\overline{\nabla\psi}\right) - |\psi|^{\mathbf{2}}\,\mathbf{A} \quad \text{on}\,\Omega \\ 0 &= \mathbf{n}\left(-\mathrm{i}\nabla - \mathbf{A}\right)\psi \quad \text{on}\,\Gamma \end{aligned}$$

which mathematically describe the phenomenon of superconductivity. Of particular interest are the nonlinearity of the problem and the strong coupling between the equations. By choosing the discretization to adhere to desired physical properties, more numerical obstacles arise. To properly apply numerical continuation methods for exploring the complex solution landscape (e.g., along κ), these issues need to be addressed.

Nico Schlömer
University of Antwerpen
Belgium
nico.schloemer@ua.ac.be

Wim Vanroose
Universiteit Antwerpen
vanroose@gmail.com

MS50
Linear Fluctuation-dissipation for Low Frequency Climate Response

Recently, the authors developed a new algorithm for predicting the climate response of a nonlinear chaotic forced-dissipative system to small changes in external forcing. Here we test the new method on the low frequency response for a T21 barotropic truncation on the sphere with realistic topography in two dynamical regimes corresponding to the mean climate behavior at 300 hPa and 500 hPa geopotential height. It is found that the blended response algorithm has significant skill beyond the classical quasi-Gaussian algorithm for the response of the climate mean state and its variance. Additionally, the predicted response of the T21 barotropic model in the low frequency regime for these functionals does not seem to be affected by the model's structural instability.

Rafail Abramov
Department of Mathematics, Statistics and Computer Science
University of Illinois at Chicago
abramov@math.uic.edu

Andrew Majda

Courant Institute NYU
jonjon@cims.nyu.edu

MS50
Reduced Stochastic Models of Climate Variability

The systematic development of reduced low-dimensional stochastic climate models from observations or comprehensive high-dimensional climate models is an important topic for atmospheric low-frequency variability, climate sensitivity, and improved extended range weather forecasting. Here we systematically derive normal forms for reduced stochastic climate models for low-frequency variables. The use of a few Empirical Orthogonal Functions (EOF) depending on observational data to span the low-frequency subspace requires the assessment of dyad interactions besides the more familiar triads in the interaction between the low- an high-frequency subspaces of the dynamics. It is shown that dyad and triad interactions combine with the climatological linear operator interactions to simultaneously produce both strong nonlinear dissipation and Correlated Additive and Multiplicative (CAM) stochastic noise. For a single low-frequency variable the dyad interactions and climatological linear operator alone produce a normal form with CAM noise from advection of the large-scales by the small scales and simultaneously strong cubic damping. This normal form should prove useful for developing systematic regression fitting strategies for stochastic models of climate data.

Christian Franzke
British Antarctic Survey
chan1@bas.ac.uk

MS50
Fokker-Planck Description for Noisy Neuronal Network Dynamics

Kinetic theory provides a coarse-grained alternative to the integrate-and-fire neuronal network description. In the limit of infinitely short conductance responses, a Boltzmann-type differential-difference equation can be derived for the probability density function (PDF) of the average network membrane potential. A Fokker-Planck and a mean-field equation can be derived in the limit of small and vanishing conductance fluctuations, respectively. This talk will present detailed solutions to the mean-field and Fokker-Planck equations. For the former, the solutions are exact, for the latter they are asymptotic using the size of the conductance fluctuations as the small parameter. Various sub-limits of the latter will be discussed, in which the solutions simplify dramatically.

Gregor Kovacic
Rensselaer Polytechnic Inst
Dept of Mathematical Sciences
kovacg@rpi.edu

Louis Tao
Department of Mathematical Sciences
New Jersey Institute of Technology
tao@njit.edu

Aaditya Rangan
Courant Institute of Mathematical Sciences
New York University
rangan@cims.nyu.edu

David Cai
Courant institute
New York Unvirsity
cai@cims.nyu.edu

MS50
Markov Chain Modeling of Effective Dynamics

Novel empirical approach for stochastic modeling of spatially extended deterministic systems is discussed. In this approach the right-hand side of the essential variables is modeled by a discrete-time Markov Chain. We demonstrate that the effective equation reproduces the major statistical properties of the full dynamics. Moreover, the optimal time-step in the effective stochastic model can be taken larger than in the original system making the effective system computationally more efficient. Dependence of the approach on the sampling time-step and number of states in the Markov Chain will also be discussed.

Kawin Nimsaila
UH
kawinsk@math.uh.edu

Ilya Timofeyev
Dept. of Mathematics
Univ. of Houston
ilya@math.uh.edu

Eric Vanden-Eijnden
Courant Institute
New York University
eve2@cims.nyu.edu

MS51
Localised States in Transitional Shear Flows

We investigate the spatial structure corresponding to phase-space trajectories on the laminar-turbulent boundary in the hydrodynamical context of pipe flow and also plane Couette flow, both typical examples of transition caused by finite-amplitude perturbations. Emphasis is now put on tackling large computational domains, which allow for spatially localised coherent structures commonly observed in real fluid experiments.

Yohann Duguet
Department of Mechanics, Royal Inst. of Technology (KTH)
SE-100 44 Stockholm, Sweden
duguet@mech.kth.se

MS51
Edge States for Plane Poiseuille Flow

Plane Poiseuille flow falls under the category of shear flows where turbulence can be triggered with large finite amplitude perturbations. We study the edge of chaos, the boundary which separates laminar and turbulent dynamics, and implement an iterative edge tracking algorithm in order to find solutions near this boundary, called edge-states. We study the edge-states for various channel sizes and compare their dynamics to those of edge-states for other shear flows.

Lina Kim
UC Santa Barbara
Dept. of Mechanical Engineering
lina@engineering.ucsb.edu

Jeff Moehlis
Dept. of Mechanical Engineering
University of California – Santa Barbara
moehlis@engineering.ucsb.edu

MS51

Pipe Flow Localised Transitional Dynamics

Pipe flow undergoes transition to turbulence despite the linear stability of its basic laminar solution. Simple solutions, taking the form of traveling waves, relative periodic orbits and chaotic saddles, have been found in the nonempty region of phase space separating the laminar from the turbulent basins of attraction in the case of short periodic pipes. Here we investigate how the scenario is modified when long pipes, where transition to intermittent localized structures occurs rather than to global turbulence, are considered.

Fernando Mellibovsky
Department of Applied Physics
Universitat Politecnica de Catalunya
fmellibovsky@fa.upc.edu

MS51

Edge of Chaos and the Turbulence Transition in Linearly Stable Flows

The edge of chaos generalizes the familiar concept of basin boundaries to situations with transient dynamics. Embedded in the edge are locally attracting dynamic objects wich can be computed using the iterated edge tracking algorithm. We will introduce the conceptional ideas, summarize different possible types of embedded attracting objects and discuss how these findings relate to the transition to turbulence in linarely stable flows.

Tobias M. Schneider
School of Engineering and Applied Science, Harvard Univ.
tschneid@seas.harvard.edu

MS52

An Integrative Approach Towards Completing Genome-scale Metabolic Networks

We propose a strategy that incorporates genomic sequence data and metabolite profiles into modeling approaches to arrive at improved gene annotations and more complete genome-scale metabolic networks. The core of our strategy is an algorithm that computes minimal sets of reactions by which a draft network has to be extended in order to be consistent with experimental observations. We evaluate our strategy on the well-studied metabolic network of Escherichia coli, demonstrating how the predictions can be improved by incorporating sequence data. Subsequently, we apply our method to the recently sequenced green alga Chlamydomonas reinhardtii. We propose particular reactions which should be added to the existing draft network, supporting our hypotheses with biological and computational evidence. Moreover, we suggest specific genes in the genome of Chlamydomonas which are the strongest candidates for coding the responsible enzymes.

Nils Christian
Max Planck Institute for Molecular Plant Physiology
Potsdam (Germany)
christian@mpimp-golm.mpg.de

Patrick May
Max Planck Institute for Molecular Plant Physiology
Potsdam (Germany)
may@mpimp-golm.mpg.de

Stefan Kempa
Max Planck Institute for Molecular Plant Physiology
Potsdam (Germany)
kempa@mpimp-golm.mpg.de

Thomas Handorf
Humboldt University
Berlin (Germany)
handorf@physik.hu-berlin.de

Oliver Ebenhoeh
Max Planck Institute for Molecular Plant Physiology
Potsdam (Germany)
ebenhoeh@mpimp-golm.mpg.de

MS52

Modeling of the Circadian Clock of Ostreococcus Tauri: A Minimal System for Circadian Biology?

The circadian clocks keeping time in most organisms consist of genetic networks which generate autonomous biochemical oscillations synchronized to the day/night cycle. We have studied the clock of a unicellular green alga using luminescent reporting of the activity of two key genes. A minimal two-gene model reproduces mRNA and protein profiles with unprecedented precision. The best adjusting model is a free-running oscillator, which suggests that coupling to the light/dark cycle occurs over short time intervals.

Florence Corellou
UMR CNRS/Paris 6 7628,
Observatoire océanologique de Banyuls/mer, France
florence.corellou@obs-banyuls.fr

Pierre-Emmanuel Morant
PhLAM/Université Lille 1
France
morant@phlam.univ-lille1.fr

Christian Schwartz
UMR CNRS/Paris 6 7628
Observatoire oc
'eanologique de Banyuls/ France
christian.schwartz@obs.banyuls.fr

Quentin Thommen
PhLAM/Universit
'e de Lille I
France
thommen@phlam.univ-lille1.fr

Constant Vandermoere
PhLAM/Université de Lille I
vander@phlam.univ-lille1.fr

Marc Lefranc
PhLAM/Université Lille I,
France
marc.lefranc@univ-lille1.fr

Franois-Yves Bouget
UMR CNRS/Paris 6 7628

Observatoire oc
'eanologique de Banyuls/mer, France
francois-yves.bouget@obs-banyuls.fr

MS52
Queuing Generated Phase Transitions in mRNA Translation

We propose a stochastic model for the description of the translation of mRNA molecules in eukaryotic cells. In particular, we focus on the effect that the configuration of rare codons has on the flow of ribosomes along the mRNA. We consider the relationship between the translation and the initiation rate and show that depending on the specific configuration of rare codons, there are two main qualitatively different types of behaviour. In the type-I mRNA sequences, we observe a phase transition of first order, whereas in the type-II mRNA sequences, we observe a smooth dependence of the flow with the initiation rate. Applying our model to experimental mRNA sequences of Saccharomyces Cerevisae, we also find two main types of behaviour: type-II are ribosomal proteins, whereas type-I are non-ribosomal ones. This result cleary indicates that the specific rare codon configuration in an mRNA sequence constitutes a regulatory mechanism for gene expression.

Maria C. Romano
Physics Department and Institute of Medical Sciences
University of Aberdeen
m.romano@abdn.ac.uk

MS52
Delay-induced Degrade-and-Fire Oscillations in Small Genetic Circuits

We describe an engineered genetic oscillator in *Escherichia coli* based on a pair of linked positive and negative feedback loops. Computational modeling of the remarkably robust oscillations observed experimentally reveals that the key mechanism is a time delay in the negative feedback loop. We use deterministic and stochastic modeling to investigate how a *small* time delay in such regulatory networks can lead to strongly nonlinear oscillations that can be characterized by "degrade and fire' dynamics.

William Mather, Matthew Bennett, Jeff Hasty,
Lev S. Tsimring
University of California, San Diego
wmather@ucsd.edu, mbennett@ucsd.edu,
jmhasty@ucsd.edu, ltsimring@ucsd.edu

MS53
Robust Invariant Tori in Nontwist Plasma Flows

A Hamiltonian is introduced to describe the chaotic particle transport by drift waves propagating in plasma edge tokamaks with poloidal zonal flow. The flow radial profile determines the transport barriers created by the non linear interaction between the flow and the resonant waves. The particle transport in nontwist plasma equilibria with reverse shear flows is reduced in the radial positions with robust tori. These results explain experiments on the transport reduction by a biased electrode.

Ibere L. Caldas
Institute of Physics
University of Sao Paulo
ibere@if.usp.br

F.A. Marcus
Institute of Physics
University of So Paulo
albertus.marcus@gmail.com

Z.O. Guimaraes-Filho
Institute of Physics
University of Sao Paulo
zwinglio@if.usp.br

P.J. Morrison
Department of Physics
The University of Texas at Austin
morrison@physics.utexas.edu

W. Horton
Institute for Fusion Studies
University of Texas at Austin
horton@physics.utexas.edu

MS53
Vanishing Twist near Resonant Hamiltonian Equilibria

I will review the relation between bifurcations of periodic orbits of area preserving maps and the vanishing of twist, and then describe new results that establish a similar connection for resonant equilibria, in particular the $1 : -1$ (Hamiltonian Hopf) and $1 : -2$ resonances. The main result is that the rotation number has a critical value when the quadratic part of the energy is positive and energy in higher order terms is vanishing. This once again shows that the vanishing of twist is generic in one-parameter families of Hamiltonian systems with two degrees of freedom.

Holger R. Dullin
University of Sydney
School of Mathematics and Statistics
hdullin@usyd.edu.au

MS53
Breakup of Shearless Invariant Tori in Nontwist Area-preserving Maps: Recent Results

Area-preserving nontwist maps are simple models for degenerate Hamiltonian systems. Of particular interest is the breakup of shearless invariant tori that often correspond to transport barriers in the physical systems modeled. An open question is the effect of symmetry on the details of the breakup. Using Greene's residue criterion as an indicator of torus breakup, I describe recent results on the breakup of noble shearless invariant tori in nontwist maps with different symmetry properties.

Alexander Wurm
Department of Physical & Biological Sciences
Western New England College
awurm@wnec.edu

Michael Martini
Department of Physics
Rochester Institute of Technology
howlingflute@gmail.com

MS53
Persistence of Non-twist Tori in Higher Dimen-

sions: Theory and Numerics

We study the problem of persistence of quasiperiodic motions in Hamiltonian systems with a degenerate normal form. We show that in families with enough parameters, we can find tori with prescribed singularities in the normal form (provided some non-degeneracy conditions). The method of proof is designed to work well with numerics. It can validate numerical calculations. It also leads to very fast algorithms.

Alejandra Gonzalez-Enriquez
Dept. of Mathematics
University of Exeter
m.a.gonzalez-enriquez@exeter.ac.uk.

alex Haro
Dept. of Mat. Apl. i Analisi
Univ. de Barcelona
alex@maia.ub.es

Rafael de La Llave
University of Texas
Department of Mathematics
llave@math.utexas.edu

MS54

Point Vortex Equilibria on the Sphere Via Brownian Ratchets

We describe a Brownian ratchet scheme which we use to calculate relative equilibrium configurations of N point vortices of mixed strength on the surface of a unit sphere. The problem is formulated as one in linear algebra where a 'configuration matrix' associated with the system of particles is first identified. A necessary condition that the particles form a relative equilibrium is that the matrix has a non-trivial nullspace, hence $det(A^T A) = 0$. To home in on a relative equilibrium from random initial conditions, we use a Brownian ratchet scheme with the smallest singular value of the matrix being the 'ratchet' which we drive to zero via random walks. The talk will discuss the notion of Shannon entropy associated with individual equilibria, as well as statistical averages.

Paul K. Newton
U Southern California
newton@usc.edu

MS54

Numerical Simulation of Falling Leaves Using Volume Penalization

Numerical modeling of solid bodies moving through viscous incompressible fluid is considered. The 2D Navier-Stokes equations, written in the vorticity-streamfunction formulation, are discretized using a Fourier pseudo-spectral scheme with adaptive time-stepping. Solid obstacles of arbitrary shape are taken into account using the volume penalization method. Time-dependent penalization is implemented, making the method capable of solving problems where the obstacle follows an arbitrary motion. Numerical simulations of falling leaves are performed, using the above model supplemented by the discretized ODEs describing the motion of a solid body subjected to external forces and moments. Various regimes of the free fall are explored, depending on the physical parameters and initial conditions. The influence of the Reynolds number on the transition between fluttering and tumbling is investigated, showing the stabilizing effect of viscosity. This work is joint work with Dmitry Kolomenskiy.

Kai Schneider
Universite de Provence, Aix-Marseille
Centre de Mathematiques et Informatique
kschneid@cmi.univ-mrs.fr

MS54

Dynamical Transition Theory and Mechanism of El Nino -Southern Oscillation

This talk addresses a dynamic transition theory for nonlinear dissipative systems. The main philosophy of the theory is to search for the full set of transition states, giving a complete characterization on stability and transition. The set of transition states is represented by a local attractor. Following this philosophy, the dynamic transition theory is developed to identify the transition states and to classify them both dynamically and physically. With this theory, many long standing phase transition problems are either solved or become more accessible. In particular, as an application of the theory, we present in this talk a new mechanism of the El Niño Southern Oscillation (ENSO), which appears to be in agreement with observations.

Tian Ma
Sichuan University
matian56@sina.com

Shouhong Wang
Department of Mathematics
Indiana University
showang@indiana.edu

MS55

Phase Space Methods for Signal Identification

Characterizing a complex system based on an output signal is a difficult problem, especially when the input signal is not available. Conventional behavioral modeling techniques depend on knowledge of the input, but in many situations, the input signal is not available. I have chosen in this work to study a simple cw transmitter. I use low frequency experimental simulations to show how phase space based techniques may identify which one of 3 transmitters generated the signal.

Thomas L. Carroll
Naval Reseach Laboratory
carroll@anvil.nrl.navy.mil

MS55

System Identification Using Chaos With Applications to Through-the-wall Radar

In this paper, we investigate the application of chaos modulation techniques for through-the-wall imaging. With its wideband nature, chaotic sequence has been found to be an ideal choice for system identification and radar modulation. By combining these two tasks, we develop novel high resolution through-the-wall imaging techniques for rooms with reverberations. We analyze the range Doppler resolution and side lobe suppression characters and compare it with conventional techniques.

Henry Leung, Ajeesh Kurian
University of Calgary
Department of Electrical and Computer Engineering

leungh@ucalgary.ca, ajeesh.kurian@ucalgary.ca

MS55

Target Recognition with Optimized Chaos Based Waveforms

Chaos based waveforms can be constructed and optimized to selectively enhance the cross correlation of the radar or sonar return from complex targets at particular orientations with respect to the source. We have employed several methods of complex waveform generation and optimization. We demonstrate our methods with computer simulations and experiments in an acoustic range. The technique is shown to be robust in the presence of clutter.

Frederic Rachford
Naval Reserach Laboratory
Material Science
rachford@anvil.nrl.navy.mil

Thomas L. Carroll
Naval Reseach Laboratory
carroll@anvil.nrl.navy.mil

MS55

Application of Chaotic Sequences to Underwater Telemetry

Transmission of acoustic signals through the non-stationary underwater environment requires dealing with multipath and Doppler effects. Chaotic sequences can be found that exhibit some tolerance to these effects. These sequences can then be used for transmitting information. This talk will define tolerance and discuss the optimization of chaotic sequences based on the ambiguity surface of the signal. The ambiguity surface is used to illustrate the application of the chaotic sequence to underwater telemetry.

Martin Renken
US Naval Underwater Warfare Center
martin.renken@navy.mil

MS56

Phase Models and Networks of Oscillators with Time Delayed Coupling

We consider a network of inherently oscillatory neurons with time delayed connections. We reduce the system of delay differential equations to a phase model representation and show how the time delay enters into the reduced model. For the case of two neurons, we show how the time delay may affect the stability of the periodic solution leading to stability switching between synchronous and antiphase solutions as the delay is increased. The results of the phase model analysis are compared with numerical bifurcation analysis of the full system of delay differential equations. Both type I and type II oscillators are considered.

Sue Ann Campbell
University of Waterloo
Dept of Applied Mathematics
sacampbell@uwaterloo.ca

Ilya Kobelevskiy, Andrew Smith
Dept of Applied Mathematics
University of Waterloo
ikobelevskiy@math.uwaterloo.ca, arsmith@math.uwaterloo.ca

MS56

Design of Dynamics Using Time Delays in Transcriptional Regulatory Networks

Recent experimental work in synthetic biology has demonstrated the ability to fabricate artificial transcriptional regulatory networks that implement basic logic functions and periodic oscillators. These circuits often demonstrate high variability and lack of robustness. In this talk we describe the use of time delays as a mechanism of improving the properties of these circuits, with an emphasis on oscillators.

Richard Murray
Control and Dynamical Systems
California Institute of Technology
murrayrm@cds.caltech.edu

MS56

Effects of Delay on the Functionality of Large-scale Networks

We consider what effect heterogeneous communication delays can have on the functionality of large-scale networked systems with nonlinear dynamics. We show that for some networked systems, functionality can be retained for arbitrary communication delays, even for switching topologies under certain connectivity conditions; whereas for others, loop gains have to be compensated for by the delay size. Consensus reaching in multi-agent systems and stability of network congestion control for the Internet are used as examples.

Antonis Papachristodoulou
University of Oxford
Department of Engineering Science
antonis@eng.ox.ac.uk

MS56

Delay Dynamics in Coupled Neural Systems

The influence of time delay in systems of two coupled excitable neural popoulations is studied in the framework of the FitzHugh-Nagumo model. Time delays can occur in the coupling between the neurons and in a self-feedback loop and can be used to control the dynamics. By appropriate choice of the delay times, synchronization can be either enhanced or suppressed, antiphase oscillations can be induced, and complex scenarios of synchronized in-phase or antiphase oscillations, bursting patterns, or amplitude death can be observed. This work is in collaboration with Markus Dahlem, Gerald Hiller, and Philipp Hövel

Eckehard Schöll
Technische Universität Berlin
Institut für Theoretische Physik
schoell@physik.tu-berlin.de

MS57

Overlapping CPGs for Leech Crawling and Swimming

Swimming and the whole body shortening reflex are two incompatible behaviors performed by the medicinal leech Hirudo medicinalis. We set out to examine the neuronal basis of the choice between these behaviors, taking advantage of the fact that the neuronal circuit underlying swimming is relatively well understood. The leech swim circuit is organized hierarchically and contains three interneuronal levels, including two upper levels of command-like neurons. We tested the responses of the swim circuit neurons to stimuli that produced shortening, using reduced preparations in which neurophysiological recording could be performed while behaviors were elicited. We found that the majority of the swim circuit neurons, including most of the command like cells and all of the cells at the highest hierarchical level of the circuit, were excited by stimuli that produced shortening as well as by stimuli that produced swimming. These results imply that the control of the choice between swimming and shortening is not exercised selectively at the higher levels of the swim circuit.

William B. Kristan
Neurobiology Section, Biological Sciences
UC San Diego
wkristan@ucsd.edu

MS57

Multiple Rhythmic States in a Model of Respirarory CPG

A model of the respiratory CPG has been developed. The model reproduces (and proposes explanation for) several oscillatory regimes observed in the respiratory system. These regimes in the model depend on specific network interactions and intrinsic cellular mechanisms and are controlled by external drives to particular network elements. The regimes and transitions between them have been mathematically analyzed. Results provide important insights for understanding the state-dependent mechanisms for respiratory rhythm and pattern generation.

Ilya A. Rybak
Drexel University College of Medicine
rybak@drexel.edu

MS57

Polyrhythmic Synchronization in Bursting Network Motifs

We study the emergence of polyrhythmic dynamics of motifs which are the building block for central pattern generators controlling various locomotive behaviors of animals. We discovered that the pacemaker determining the specific rhythm of such a network composed of realistic HodgkinHuxley-type neurons is identified through the order parameter, which is the ratio of the neurons burst durations or of duty cycles. We analyze different configurations of the motifs and describe the universal mechanisms for synergetics of the synchronous bursting patterns. We found that bursting motifs can have several attractors; this multistability of inhibitory networks results in polyrhythmicity in multi-functional central pattern generators.

Andrey Shilnikov
Neuroscience Institute and Department of Mathematics
Georgia State University
ashilnikov@gsu.edu

Rene Gordon
Department of Mathemarics
Georgia State University
neompterus@gmail.com

Igor Belykh
Department of Mathematics
Georgia State University
ibelykh@gmail.com

MS57

A Hierarchy of Multiple Rhythmogenic Mechanisms in Respiratory CPG Circuits

Recent experimental studies indicate that there are at least four hierarchically organized rhythmogenic mechanisms inherent in the spatial and functional architecture of brainstem respiratory circuits (Smith et al., J. Neurophysiol. 98: 3370-3387, 2007). Expression of different rhythmogenic states is controlled by afferent drives to the core circuitry. A fundamental design feature is that there are rhythmogenic capabilities at multiple levels of cellular and network organization, allowing flexible expression of different behaviorally important rhythmic respiratory patterns.

Jeffrey C. Smith
NINDS, NIH
jsmith@helix.nih.gov

MS58

A Mechanism for Circadian Pulsatile Prolactin Secretion Triggered by a Brief Mating Stimulus

Prolactin is a multi-functional hormone secreted from lactotroph cells in the pituitary gland. The mating stimulus triggers a long-lasting circadian rhythm of pulsatile prolactin secretion in female rats. This rhythm is functionally important, since premature termination of the rhythm aborts the pregnancy. We have developed a mathematical model that describes how pituitary lactotrophs can interact with hypothalamic neurons to produce this rhythm. We describe the model and its use as a tool for guiding experiments in our lab.

Richard Bertram
Department of Mathematics
Florida State University
bertram@mail.math.fsu.edu

MS58

Synchronization of Pancreatic Islets

ß-cells are cells located in the human pancreas and are known to produce electrical activity. When these cells are electrically active, they secrete a hormone necessary for maintaining glucose homeostasis in the blood called insulin. The ß-cells are located in the pancreas in small micro-organs called islets of Langerhans. There are thousands of islets in the pancreas which are known to produce oscillatory insulin secretion. Measurements of insulin have shown that oscillatory secretion also occurs in the blood. Since plasma insulin reflects the secretion from the entire islet population, oscillations in plasma insulin levels suggest that islet oscillations must be largely synchronized. Bertram et al. “Bio. Phys. Jour., 92, 1544-1555, 2007” has developed a mathematical model of the ß-cell which reproduces many of the measured electrical and calcium properties of the ß-cell. We use this model to investigate methods of synchronization of the islet population. The islet is known to be innervated by neurons, in ganglia, interspersed throughout the pancreas. In our recent publication, Zhang et al. “Bio. Phys. Jour., 95, 4676-4688, 2008” we demonstrated that pulses of carbachol, a muscarinic agonist, could synchronize a population of islets in vitro.

Using our model, we investigate the viability of islet synchronization by coordinated action of the intrapancreatic ganglia.

Bernard Fendler
Physics Department
Florida State University
bfendler@sb.fsu.edu

MS58
Synchrony and Rhythmogenesis in Endocrine Neurons

A circhoral rhythm of secretion by GnRH neurons is necessary for reproductive function. GnRH rhythmogenesis due to autocrine regulation has been modeled, assuming a well-stirred medium and voltage clamping. We extend a previous model to the case of regularly or randomly distributed GnRH neurons in a space the size of a hypothalamus, coupled by diffusion of GnRH without stirring. We study the effects of electrical activities and intracellular calcium dynamics on GnRH pulse generation.

Yue-Xian Li
Dept. of Mathematics
UBC
yxli@math.ubc.ca

Patrick A. Fletcher
Department of Mathematics
University of British Columbia, Vancouver, BC, Canada
fletcher@math.ubc.ca

Atsushi Yokoyama
Department of Bioscience and Bioinformatics,
Ritsumeikan University, Kusatsu Shiga, Japan
rs025010@se.ritsumei.ac.jp

MS58
Routes to Lactation via Homoclinic Bursting

Abstract not available at time of publication.

Peter Roper
Mathematics Department
University of Utah
roper@math.utah.edu

MS59
Traveling Wave Solutions to a Discrete Nagumo Equation with Negative Diffusion

We consider traveling wave solutions for a one-dimensional, spatially-discrete reaction-diffusion equation with a negative diffusive coupling and bistable nonlinearity. We present a physical model consisting of a chain of particles, each interacting with its nearest and next-to-nearest neighbors. The long-range interaction between next-to-nearest neighbors is assumed to be harmonic, while the nearest-neighbor interactions are nonlinear and bistable. By introducing new variables, we study the behavior of these traveling wave solutions analytically and computationally.

Maila Brucal
University of Kansas
mbrucal@math.ku.edu

MS59
Traveling Waves in a Class of Unidirectional Lattice Differential Equations

We prove the existence and uniqueness, for wave speeds sufficiently large, of monotone traveling wave solutions connecting 0 and 1 for a class of N-dimensional lattice differential equations with unidirectional coupling. The class of systems that we study includes as special cases the one-dimensional lattice equation

$$u_n' = -u_n + u_{n-1}^2$$

and the two-dimensional integer lattice equation

$$u_{n,m}' = -u_n + u_{n-1,m}^2 + u_{n,m-1}^2.$$

Our results extend those in a 2004 paper by Peletier and Rodriquez.

Benjamin Kennedy
Gettysburg College
Department of Mathematics
bkennedy@gettysburg.edu

MS59
Dynamics and Interactions of Dark Solitons in Continua and Lattices

Recent experiments in Bose-Einstein condensates, which can be accurately described by variants of the nonlinear Schrödinger equation, allow the construction of a controllable number of dark solitons in Bose-Einstein condensates. Motivated by the experimental findings, we examine the features of these multi-soliton states. Their interactions and their being subject to external potentials produces interesting dynamics for this "lattice of solitons'. We analyze the normal modes of such a lattice and connect them to the negative Krein signature modes of the PDE linearization. We also present a series of experimentally observable manifestations of such modes, including measurements of dark soliton frequency oscillations and instability-creating resonances with the normal modes of the background on which the solitons live. Finally, time permitting, we will speculate on future ramifications of these results, including the role of temperature and the possibility of examining transitions from dark soliton "crystals' to dark soliton "gases'.

Panos Kevrekidis
University of Massachussets
kevrekid@math.umass.edu

MS59
Shooting Manifolds in Lattice Systems

Many systems possess asymptotically stable traveling wave solutions which are, in some sense, spatially localized. Experiment, numerical simulation and intuition lead us to believe that there ought to be solutions of the original equation which are very nearly the linear superposition of multiple pulses. Constructing such solutions is a first step towards understanding collisions between pulses. We construct a two-dimensional manifold of such solutions (the two parameters should be thought of as the location of each of the pulses) and show that this manifold is dynamically stable. In particular, we discuss how our methods, initially developed for reaction-diffusion PDE, carry over to lattice systems.

J. Douglas Wright

Drexel University
Department of Mathematics
jdoug@math.drexel.edu

MS60

Renormalizations for Various Time-delay Systems

In this talk we propose renormalization methods for studying some weakly nonlinear delay differential equations. For systems with order-one delay, we show that the renormalization method leads to reduced systems without delay. For systems with order-one delay and long delay, we propose an extended renormalization method which leads to reduced systems with delay. In some examples, the validity of our perturbative results is confirmed analytically and numerically. We also compare our reduced equations with reduced equations obtained with another perturbation method.

Shin-itiro Goto
Lancaster University
shinitiro.goto@googlemail.com

MS60

Review of the RG Approach and Analytical Techniquesand Future Directions

In this seminar, I will review the early development of the RG and will make connections with recent analytical techniques for the determination of asymptotic solutions of differential equations characterized by multiple scales by use of the cumulants of the secular sequence [Phys. Rev. E 77, 011105 (2008), J. Math. Phys. 49, 073518 (2008)]

Eleftherios Kirkinis
University of Washington, Applied Mathematics
kirkinis@amath.washington.edu

MS60

An RG-derivation of Relativistic Hydrodynamic Equations for Viscous Fluids

Abstract not available at time of publication.

Teiji Kunihiro
Kyoto University
kunihiro@ruby.scphys.kyoto-u.ac.jp

MS61

Directed Intermittent Search for Hidden Targets

We analyze a stochastic model of directed intermittent search for a hidden target on a one-dimensional track. A particle injected at one end of the track randomly switches between a stationary search phase and a ballistic phase that is biased in the anterograde direction. There is a finite possibility that the particle fails to find the target due to an absorbing boundary at the other end of the track or due to competition with other targets. Such a scenario is exemplified by the motor-driven transport of mRNA granules to synaptic targets along a dendrite. We calculate the hitting probability and conditional mean first passage time (MFPT) for finding a single target. We show that there does not exist an optimal search strategy, although for a fixed hitting probability, a unidirectional rather than a partially biased search strategy generates a smaller MFPT. We then extend our analysis to the case of multiple targets, and determine how the hitting probability and MFPT depend on the number of targets.

Paul C. Bressloff, Jay Newby
University of Utah
Department of Mathematics
bressloff@math.utah.edu, newby@math.utah.edu

MS61

Quantifying Intermittent Transport in Cell Cytoplasm with Application to Viral Infection Modeling

Active cellular transport is a fundamental mechanism for protein and vesicle delivery, cell cycle and molecular degradation. Viruses can hijack the transport system and use it to reach the nucleus. Most transport processes consist of intermittent dynamics, where the motion of a particle, such as a virus, alternates between pure Brownian and directed movement along microtubules. In this talk, we estimate the mean time for a particle to attach to a microtubule network. This computation leads to a coarse grained equation of the intermittent motion in radial and cylindrical geometries. Finally, by using the degradation activity inside the cytoplasm, we obtain refined asymptotic estimations for the probability and the mean time a virus reaches a small nuclear pore.

Thibault Lagache
Ecole Normale Supérieure Paris
lagache@biologie.ens.fr

David Holcman
ENS
holcman@biologie.ens.fr

MS61

First Passage Times and Examples of Reaction Kinetics in Cells

How long does it take a random walker to reach a given target point? This quantity, known as a first passage time (FPT), has led to a growing number of theoretical investigations over the last decade. The importance of FPTs originates from the crucial role played by first encounter properties in various real situations, including transport and reactivity in cellular media, spreading of diseases or target search processes. I will propose here a general theory which allows one to evaluate the mean FPT (MFPT) in complex media. This analytical approach provides a universal scaling dependence of the MFPT on both the volume of the confining domain and the source-target distance. This analysis is applicable to representative models of transport in disordered media, fractals, and anomalous diffusion. I will discuss applications to chemical reactions in confined media such as living cells.

Raphael Voituriez, Olivier Benichou
Universite Pierre et Marie Curie
raphael.voituriez@gmail.com, benichou@lptl.jussieu.fr

MS61

Mean First Passage Time for Diffusion on a Sphere with Localized Traps

A common scenario in cellular signal transduction is that a diffusing surface-bound molecule must arrive at a localized signaling region on the cell membrane before the signaling cascade can be completed. The question then arises of how quickly such signaling molecules can arrive at newly formed signaling regions. Here, we attack this problem by calculating asymptotic results for the mean first passage time for a diffusing particle confined to the surface of a sphere, in the presence of N partially absorbing traps of small radii. The rate at which the small diffusing molecule becomes captured by one of the traps is determined by asymptotically calculating the principal eigenvalue for the Laplace operator on the sphere with small localized traps. The asymptotic analysis relies on the method of matched asymptotic expansions, together with detailed properties of the Green's function for the Laplacian and the Helmholtz operator on the surface of the unit sphere. The asymptotic results compare favorably with full numerical results. Finally, asymptotic results for the mean first passage time for diffusion inside a sphere that has N localized traps on its boundary are given.

Michael Ward
Department of Mathematics
University of British Columbia
ward@math.ubc.ca

Daniel Coombs
University of British Columbia
coombs@math.ubc.ca

Ronny Straube
Max Planck Institute for Dynamics of Complex Systems
Magdeburg, Germany
rstraube@mpi-magdeburg.mpg.de

MS62

Unstable Periodic Orbits and the Dynamics of Plane Couette Flow

Recent computations of precise equilibrium, traveling wave, and periodic orbits in pipes, channels, plane Couette, and isotropic flows form the basis of a new approach for connecting dynamical systems theory to turbulence. These solutions capture complex flow dynamics, give a precise definition for coherent structures, and provide information about the turbulent flow's invariant measure. We give an overview of the area and present recent work in plane Couette flow, including animations of unstable periodic orbits.

John F. Gibson, Predrag Cvitanovic
School of Physics and Center for Nonlinear Science
Georgia Institute of Technology
gibson@cns.physics.gatech.edu,
predrag@cns.physics.gatech.edu

MS62

Unstable Periodic Orbits in Isotropic Turbulence

In this talk we report unstable periodic orbits in high-symmetric flow, obtained numerically from Newton-GMRES computations on a triply periodic box with 256^3 and 512^3 grid points. We first explain a numerical method briefly. Then the spectral and structural properties of unstable periodic orbits are shown to discuss temporal evolution of a flow state along the periodic orbit. We also compare the periodic orbits under different spatial resolutions.

Genta Kawahara
Department of Mechanical Science
Osaka University
kawahara@me.es.osaka-u.ac.jp

Lennaert van Veen
Department of Mathematics and Statistics
Concordia University
lvanveen@mathstat.concordia.ca

Shigeo Kida
Department of Mechanical Engineering and Science
Kyoto University
kida@mech.kyoto-u.ac.jp

MS62

State-space Geometry of a Kuramoto-Sivashinsky Flow in Terms of Relative Periodic Orbits

The long-time dynamics of a chaotic Kuramoto-Sivashinsky flow on a periodic domain is organized by its unstable equilibria, traveling waves, periodic and relative periodic orbits and their stable/unstable manifolds. Quotienting by the O(2) continuous symmetry renders relative periodic orbits periodic, reducing dynamics to mappings between a set of Poincaré sections. The hierarchy of periodic orbits so obtained will enable us to calculate long-time averages of physical quantities such as dissipation rates.

Evangelos Siminos, Predrag Cvitanović
School of Physics, Center for Nonlinear Science
Georgia Institute of Technology
siminos@cns.physics.gatech.edu,
predrag.cvitanovic@physics.gatech.edu

Ruslan L. Davidchack
Department of Mathematics
University of Leicester
rld8@mcs.le.ac.uk

MS62

Comparison of Coherent Structures in Localised and Fully-developed Pipe Turbulence

Only recently were (unstable) exact nonlinear travelling wave (TW) solutions discovered for pipe flow. Evidence is shown which suggests that they are involved in localised turbulence at transitional Re. TWs, however, consist only of extended streaky structures, appropriate near the boundaries but not in the interior of the flow for higher Re. Here instead, a radially-dependent eddy-viscosity is used to determine a turbulent mean profile. Optimal growth of perturbations to this mean profile is considered.

Ashley P. Willis
LadHyX
École Polytechnique
willis@ladhyx.polytechnique.fr

Rich Kerswell
Department of Mathematics
University of Bristol, U.K.
r.r.kerswell@bris.ac.uk

Carlo Cossu
LadHyX, École Polytechnique
Palaiseau , France
carlo@ladhyx.polytechnique.fr

MS63

Efficient Methods for Model Validation: Design of Optimal Experiments

Optimal experiments are crucial for model validation. The talk presents efficient optimal control methods for the determination of optimal experiments, which maximize the information gain subject to constraints. Special emphasis is placed on issues of robustness of optimal experiments against uncertainties in model parameters. Various applications are discussed. They indicate a wide scope of applicability of the methods, and an enormous potential for reducing experimental efforts and improving the statistical quality of models.

Georg Bock
IWR
University of Heidelberg
bock@iwr.uni-heidelberg.de

MS63

Efficient Methods for Model Validation: Parameter Estimation

The development and quantitative validation of complex nonlinear differential equation models is a difficult task that requires the support by numerical methods for sensitivity analysis, parameter estimation, and the optimal design of experiments. The talk presents particularly efficient boundary value problems methods for parameter estimation in nonlinear differential equations, which are based on constrained Gauss-Newton-type methods and a time domain decomposition by multiple shooting. The examples of parameter estimation in biological processes are presented.

Ekaterina Kostina
Philipps-Universitaet Marburg
kostina@mathematik.uni-marburg.de

MS63

Applications of Numerical Optimization in Systems Biology

I provide an overview of optimization methods as applied to systems biology by our group. The applications range from model-based mixed-integer optimal control for the targeted manipulation of dynamical systems in biology to complexity and model reduction in multi-scale modeling. Both cell biological and biomedical problems are treated and the value of model-based optimization for systems biology approaches is demonstrated.

Oliver Slaby
Center for Systems Biology
oliver.slaby@biologie.uni-freiburg.de

Dirk Lebiedz
University of Freiburg
Center for Systems Biology
dirk.lebiedz@biologie.uni-freiburg.de

Marcel Rehberg
Freiburg University, Germany
marcel.rehberg@biologie.uni-freiburg.de

MS63

Optimization-based Model Reduction of Circadian Clock Models

Circadian clocks are endogenous oscillators that are synchronized to their environments by the daily light:dark cycle. Limit cycle ODE models effectively capture the requisite oscillatory and phase response behavior. In this talk we present a model reduction method which reveals the components responsible for proper phase response. We use an optimization method which results in a nonlinear model that is a subset of the full model but which demonstrates the same response to light.

Stephanie Taylor
Colby College
srtaylor@colby.edu

Francis J. Doyle III
Dept. of Chemical Engineering
U.C. Santa Barbara
frank.doyle@icb.ucsb.edu

Linda R. Petzold
Dept. of Computer Science
U.C. Santa Barbara
petzold@cs.ucsb.edu

MS64

Development of Synchronization and Functional Centrality in Modular Neural Networks

We report evidence of a sharp synchronization transition at the edge of merging from segregation to integration in modular (clustered) neural networks. The transition is accompanied with the formation of synchronization cliques (functional module) and with the emergence of neurons whose functional eigenvector centrality exceeds the structural one. We propose that this behavior (unique to modular networks at the edge of merging) affords the network with higher functional plasticity for efficiency multiple task performance.

Einat Fuchs
Princeton University
einat@princeton.edu

Amir Ayali
Department of Zoology, Tel-Aviv University
Tel Aviv, Israel
ayali@tauex.tau.ac.il

Eshel Ben Jacob
School of Physics and Astronomy, Tel-Aviv University
Tel Aviv, Israel
eshelbj@gmail.com

Stefano Boccaletti
CNR-Istituto dei Sistemi Complessi
stefano.boccaletti@isc.cnr.it

MS64

About the Different Approaches to Network's Vulnerability

We review some ideas on the different approaches to the concept of vulnerability of a complex network, i.e., the capacity of a graph to maintain its functional performance under random damages or malicious attacks. Particularly, we emphasize some results related to an efficient and computationally advantageous definition of vulnerability of a complex network through which one is able to overcome a series of practical difficulties encountered by the measurements used so far to quantify a network's security and stability under the effects of failures, attacks or disfunctions.

Regino Criado
Universidad Rey Juan Carlos
regino.criado@urjc.es

Miguel Romance
Departamento de Matematica Aplicada
Universidad Rey Juan Carlos
miguel.romance@urjc.es

Maria Vela-Perez
Departamento de Matematica Aplicada
Universidad Rey Juan Carlos, Spain
maria.vela@urjc.es

Stefano Boccaletti
CNR-Istituto dei Sistemi Complessi
stefano.boccaletti@isc.cnr.it

MS64

Competition of Synchronization Domains and Overlapping Communities in Complex Networks

We report evidence that, under the presence of different functional (synchronized) clusters, interfaces may appear and show a specific dynamical behavior, consisting in an almost periodical switching between the coherent evolution of the two clusters. Such an evidence enables one to devise an algorithm for identifying the structure of overlapping communities in modular networks. Specifically, we consider networks consisting of two interacting domains of phase oscillators. The interaction is realized either through an underlying two moduli-structure or through a one modulus structure with a two independent pacemaker networks on top of it. Under these conditions, at each time, most of the oscillators will contribute to the synchronous behavior of the main cluster there are contained in, whereas a few nodes will find themselves in a frustrating situation of having to decide how to behave under the contrasting inputs received by the two clusters. Specific numerical examples are furnished in support of the main analytical claims.

Inmaculada Leyva
University of Rey Juan Carlos
Madrid, Spain
inmaculada.leyva@urjc.es

Daqing Li
Department of physics
Bar Ilan University
li.daqing.biu@gmail.com

Irene Sendina Nadal
Universidad Rey Juan Carlos
irene.sendina@urjc.es

Juan Almendral
University of Rey Juan Carlos
Madrid, Spain
juan.almendral@urjc.es

Javier Buldu
Universidad Rey Juan Carlos
javier.buldu@urjc.es

Shlomo Havlin
Department of physics
Bar Ilan University
havlins@gmail.com

Stefano Boccaletti
CNR-Istituto dei Sistemi Complessi
stefano.boccaletti@isc.cnr.it

MS65

On the Approximation of Transport Phenomena

Over the last years so-called set oriented numerical methods have been developed for the numerical analysis of dynamical systems. In this talk we will discuss recent developments in this area, and we will particularly focus on the numerical approximation of transport phenomena. We will illustrate the use of these techniques by 3D computations for the antarctic circumpolar current which are based on real data.

Michael Dellnitz
University of Paderborn
Dept of Math & Comp Science
dellnitz@upb.de

Gary Froyland
University of New South Wales
g.froyland@unsw.edu.au

Christian Horenkamp
Chair of Applied Mathematics
University of Paderborn
christian.horenkamp@math.upb.de

Kathrin Padberg
Institute for Transport and Economics
Dresden University of Technology
padberg@vwi.tu-dresden.de

MS65

Coherent Sets and Strange Eigenmodes for Nonautonomous Systems

We present a transfer operator approach to identify coherent sets for nonautonomous systems, which extends the notion of the almost invariant sets in autonomous systems. The behavior of (Lagrangian) coherent sets can be described by the sub-dominant eigenmode of the transfer operator that forms the most persistent spatial pattern and decays at the slowest rate to the steady state. In particular, we determine coherent sets by the Oseledets subspaces of cocycles generated by nonautonomous systems.

Naratip Santitissadeekorn
School of Mathematics and Statistics
University of New South Wales
santitn@unsw.edu.au

Gary Froyland
University of New South Wales
g.froyland@unsw.edu.au

MS65

Almost-invariant Sets as Ghost Rods for Fluid Stir-

ring

In two-dimensional time-dependent flows or three-dimensional flows with a certain symmetry, the braiding of periodic orbits provides a framework for analyzing chaos in the system through application of the Thurston-Nielsen classification theorem. 'Ghost rods', or periodic orbits generated by the dynamics, behave as physical obstructions that 'stir' the surrounding fluid, and these can be used as the basis for this topological analysis. We explore the identification of almost-invariant sets as ghost rods.

Mark Stremler
Virginia Tech
mark.stremler@vt.edu

Shane D. Ross
Virginia Tech
Engineering Science and Mechanics
sdross@vt.edu

MS65

Homoclinic Tangles in Hurricanes

The method of extracting Lagrangian coherent structures using Liapunov exponents is used to discover surfaces that govern transport in geophysical flows. We observe that transport in synoptic-scale hurricane flows is a low-dimensional process whose salient features are adequately described by the mechanism of lobe dynamics associated with a homoclinic tangle. Similarly, the transport structures observed in three-dimensional hurricane flows lend insight into the process of eye-wall replacement that governs storm intensity.

Philip C. du Toit, Jerrold Marsden
Control and Dynamical Systems
California Institute of Technology
pdutoit@cds.caltech.edu, jmarsden@caltech.edu

MS66

Enhancement and Suppression of Turing patterns Near a Forced Turing-Hopf Bifurcation

We study enhancement and suppression of Turing patterns in forced reaction-diffusion systems. In experiment, forcing can suppress Turing patterns in the CDIMA reaction [Horvath, Dolnik, *et al.*, PRL, 1999]. Using symmetry and perturbation analyses of reaction-diffusion systems near a Turing-Hopf bifurcation, we determine when forcing enhances or suppresses patterns and predict how this effect scales with forcing amplitude and frequency. We discuss these results vis-a-vis the aforementioned experiments and simulations of the Lengyel-Epstein and Brusselator models.

Anne Catlla
Wofford College
Dept. of Mathematics
catllaaj@wofford.edu

Chad Topaz
Macalester College
Dept. of Mathematics and Computer Science
ctopaz@macaleser.edu

MS66

Superlattice Patterns in Oscillatory Chemical Systems Forced Near Multiple Resonances

We show the stability of complex patterns, comprised of 4 or more Fourier modes, in systems undergoing a Hopf bifurcation forced near multiple resonant frequencies. Weakly nonlinear analysis of the appropriately extended complex Ginzburg-Landau equation (CGLE) shows that the forcing can be tuned such that resonant-triad interactions with weakly-damped modes stabilize subharmonic 4- and 5-mode superlattice patterns for artificial and experimentally-obtained system parameters. We confirm our analysis by direct numerical simulations of the CGLE.

Jessica M. Conway
University of British Columbia
Dept. of Mathematics
conway@math.ubc.ca

Hermann Riecke
Applied Mathematics
Northwestern University
h-riecke@northwestern.edu

MS66

Control of Turing pattern Formation in a Photosensitive Reaction-diffusion System

Turing patterns are typically composed of stripes or simple hexagonal arrangements of spots. Using the light sensitive chlorine dioxide-iodine-malonic acid (CDIMA) reaction Turing patterns with other geometries could be produced. The talk will review and discuss formation of Turing patterns in the CDIMA reaction-diffusion system in the presence of illumination.

Milos Dolnik
Department of Chemistry
Brandeis University
dolnik@brandeis.edu

MS66

Collective Behavior in Excitable Media: Interacting Particle-Like Waves

We describe studies of interacting particle-like waves in the photosensitive Belousov-Zhabotinsky reaction. Unstable waves are stabilized by global feedback, and the motion of these waves is controlled by imposing excitability gradients that are regulated by a secondary feedback loop. Processional motion is the most common behavior, where waves align with one another. Rotational motion is also observed, which may occur for the same parameters as processional motion depending on initial conditions.

Kenneth Showalter, Mark Tinsley, Aaron Steele
West Virginia University
Department of Chemistry
kshowalt@wvu.edu, mark.tinsley@mail.wvu.edu, asteele11@yahoo.com

MS67

Cooperative Dynamics of Networks with Blinking Connections

In many technological and biological networks, the individual nodes composing the network interact only sporadically via short on-off interactions. We introduce a class of dynamical networks with blinking (stochastically) switching connections and study their synchronization properties and information processing capabilities. We investigate to what extent the trajectories of a stochastically switched system follow the corresponding trajectories of the averaged system, where the fast on-off switching connections are replaced with low (average) coupling strength. We distinguish different types of blinking networks, depending on whether or not the averaged system has a unique attractor and whether or not the attractors are invariant under the dynamics of the blinking system. We describe the corresponding asymptotic behavior of the trajectories of the blinking system and give illustrative examples of blinking networks of different nature.

Igor Belykh
Department of Mathematics and Statistics
Georgia State University
ibelykh@gsu.edu

Martin Hasler
Swiss Federal Institute of Technology Lausanne
martin.hasler@epfl.ch

MS67
Dynamics on Complex Networks with Time Varying Topology from Brain to Climate

A challenging task is to understand the implications of complex network structures on the functional organization of the brain activities. We investigate synchronization dynamics on the cortico-cortical network of the cat and find that the network displays clustered synchronization behaviour and the dynamical clusters coincide with the topological community structures observed in the anatomical network. Next we reconstruct a global climate network from temperature data. Parameters of this network, as betweenness centrality, uncover relations to global circulation patterns in oceans and atmosphere.

Juergen Kurths
Potsdam Institute for Climate Impact Research
Humboldt University Berlin, Germany
kurths@pik-potsdam.de

L. Ping, G. Zamora
Potsdam Institute for Climate Impact Research and
Humboldt University Berlin
juergen.kurths@pik-potsdam.de,
juergen.kurths@pik-potsdam.de

J. Donges
Potsdam Institute for Climate Impact Research and
Humboldt University Berlin
juergen.kurths@pik-potsdam.de

MS67
Adaptive Response to the Spread of Epidemics Using Dynamic Social Networks

We use moving neighborhood network model on scale free geography as the substrate for an agent based model of epidemic spread, where "Suspectible" individuals preferentially move toward hubs, while "Infecteds" agents preferentially migrate toward low degree nodes. We study this behavior over a continuous range of quarantine strategies. By establishing a system wide objective function which values agent interaction, we assess these adaptive epidemic response strategies to identify behaviors that maximize societal value.

Joseph Skufca
Clarkson University
jskufca@clarkson.edu

MS67
Synchronization in populations of heterogeneous oscillators with time-varying coupling

In many networks of interest including technological, biological, and social networks, the connectivity between the interacting elements is not static, but changes in time. Furthermore, the elements themselves are often not identical, but rather display a variety of behaviors, and may come in different classes. Here, we investigate the dynamics of such systems. Specifically, we study a network of two large interacting heterogeneous populations of limit-cycle oscillators whose connectivity switches between two fixed arrangements at a particular frequency. We show that for sufficiently high switching frequency, this system behaves as if the connectivity were static and equal to the time average of the switching connectivity. We also examine the mechanisms by which this fast-switching limit is approached in several nonintuitive cases. The results illuminate novel mechanisms by which synchronization can arise or be thwarted in large populations of coupled oscillators with nonstatic coupling.

Paul So
George Mason University
The Krasnow Institute
paso@gmu.edu

Bernad Cotton
George Mason University
bcotton@gmu.edu

Ernest Barreto
George Mason University
Krasnow Institute
ebarreto@gmu.edu

MS68
Feedback Control of Oscillatory Neurons

We present a survey of our recent results on spike timing control of oscillatory neurons. The single neuron case is detailed extensively, as well as simple pacemaker networks. Our control methods include state feedback linearization, event-based control of phase-reduced models, and spike-time-difference control with an experimental application. We will consider constraints on the control stimulus including absolute magnitude and charge balance. In addition, we will discuss concepts of optimality and robustness.

Per Danzl
University of California, Santa Barbara
Department of Mechanical Engineering
pdanzl@engineering.ucsb.edu

Jeff Moehlis
Dept. of Mechanical Engineering
University of California – Santa Barbara
moehlis@engineering.ucsb.edu

MS68
Synchronous Behavior in Current-Based Integrate-

and-Fire Neuronal Networks

Synchronization is a ubiquitous property of networked dynamical systems, including neuronal networks. In an all-to-all, pulse-coupled network of current-based, integrate-and-fire neurons with sufficiently strong coupling, the neuronal firings become and remain completely synchronized. The mechanism for this synchronization as well as two different methods for obtaining the expected time between synchronous firing events will be presented. Specifically, a probabilistic model for super-threshold driving, and a stochastic exit time calculation for sub-threshold driving will be described.

Katherine Newhall
Rensselaer Polytechnic Institute
newhak@rpi.edu

MS68
Pattern Orthogonalization by Adaptive Networks in Sensory Processing

In the olfactory system it is observed experimentally that the initial processing by the olfactory bulb increases the differences between output activity patterns corresponding to similar odor stimuli. Within the framework of firing-rate models we investigate the ability of neuronal networks to achieve such a *pattern orthogonalization* by employing a biophysically plausible adaptation strategy, the reduction of correlations between the output *channels*. We investigate feed-forward and feed-back networks with linear and with nonlinear dynamics.

Hermann Riecke
Applied Mathematics
Northwestern University
h-riecke@northwestern.edu

Stuart D. Wick
Northwestern University
Dept of Engineering Sciences and Applied Mathematics
stuart.wick@gmail.com

Martin Wiechert, Rainer Friedrich
Friedrich-Miescher Institute, Basel, Switzerland
martin.wiechert@fmi.ch, rainer.friedrich@fmi.ch

MS68
Predictability and Chaos in Networks of Integrate-and-fire Neurons

It has been shown that a single integrate-and-fire (I&F) neuron under a general time-dependent stimulus cannot possess chaotic dynamics despite the firing-reset discontinuity. Here we address the issue of whether pulsed-coupled network interactions can induce chaos in an I&F neuronal ensemble. Using numerical methods, we demonstrate that all-to-all, homogeneously pulse-coupled I&F neuronal networks can indeed give rise to chaotic dynamics under an external periodic current drive. We also provide a precise characterization of the largest Lyapunov exponent for these high dimensional non-smooth dynamical systems.

Douglas Zhou
Courant Institute of Mathematical Sciences
zdz@cims.nyu.edu

MS69
Periodic Pulse Generation in a Mechano-reaction-diffusion Model

In the field of pattern formation, there is an emerging topic in which the effects of mechanical deformations of the domain are studied on the patterns that are generated by reaction and diffusion systems. We address one such system involving the FitzHugh-Nagumo equation (and a related physiological model) are coupled to an equation from elasticity theory governing the deformations of heart muscle tissue. The coupling is through a stretch-activated current and through a deformation-dependent diffusivity. We show the results of numerical simulations and an analysis of some of the recurrent pulse dynamics generated by a single external input.

Matthew Holzer
Boston University
holzer@math.bu.edu

Arjen Doelman
CWI Amsterdam, the Netherlands
A.Doelman@cwi.nl

Tasso J. Kaper
Boston University
Department of Mathematics
tasso@math.bu.edu

MS69
Nonlinear Stability via Renormalization Group Methods

Over the past 3–5 years, it has been shown that renormalization group methods play a central role in the stability analysis of pulses and fronts in nonlinear reaction-diffusion systems, as well as in near-integrable PDEs. The RG method is particularly well-suited to the stability analysis of pulses and fronts whose heights, shapes, and speeds all change in time. In this sense, the RG method offers an advance over other stability techniques that are mainly suitable for traveling waves for which the height, shape, and speed are all fixed in time. The RG method has been applied recently to dynamically evolving pulses in the so-called semi-strong interaction regime of the Gierer-Meinhardt model by the author in a SIMA paper, and this talk will focus on the latest results for a general activator-inhibitor system that includes prototypical systems, such as the Gray-Scott, as special cases.

Keith Promislow
Michigan State University
kpromisl@math.msu.edu

MS69
First– versus Second–order Semi–strong Interaction of Pulses

In recent years, 'semi-strong interaction' arising for two or three component reaction diffusion systems with one singular diffusion length has been studied extensively. It generates motion of the order of the squared diffusion length. We call this 'second order' and show how motion occurs that is of the order of the diffusion ratio, i.e., first order. We prove that first order interaction is often gradient like and illustrate the theory by the Schnakenberg model.

Jens Rademacher

CWI, Amsterdam, NL
jens.rademacher@cwi.nl

MS69

Nonlinear Stability of Front Interactions in a 3-component Model

We study the dynamics of multi-front solutions of a prototype three-component reaction-diffusion system. First, we consider the existence and stability of the stationary patterns – a 1-pulse (or 2-front) solution and a 2-pulse (4-front) solution – by singular perturbation and Evans functions techniques. Then, we use a renormalization group method to rigorously deduce the system of ODEs that govern the front dynamics. Based on our knowledge of the stationary points of this system, i.e. of the stationary patterns, we are able to give an accurate description of the dynamics of N-front patterns (for N not too large).

Peter Van Heijster
CWI, Amsterdam, NL
P.J.A.van.Heijster@cwi.nl

MS70

Structure of Lyapunov Vectors in Spatiotemporal Chaos

We study Lyapunov vectors (LVs) corresponding to the largest Lyapunov exponents in systems with spatiotemporal chaos. We determine intrinsic length scales and spatiotemporal correlations of LVs corresponding to the leading unstable directions by translating the problem to the language of scale-invariant growing surfaces. We find that the so-called 'characteristic' (also known as covariant) LVs exhibit spatial localization, strong clustering around given spatiotemporal loci, and remarkable dynamic scaling properties of the corresponding surfaces. In contrast, the commonly used backward LVs (obtained through Gram-Schmidt orthogonalization) spread all over the system and do not exhibit dynamic scaling due to artifacts in the dynamical correlations by construction. Systems of very different nature as coupled-map lattices and the (continuous-time) Lorenz '96 model exhibit the same features in quantitative and qualitative terms. Additionally we propose a minimal stochastic model that reproduces the results for chaotic systems.

Juan M. Lopez
Instituto de Fisica de Cantabria (IFCA), CSIC-UC
lopez@ifca.unican.es

MS70

Quantifying Spatiotemporal Chaos in Rayleigh-Bénard Convection

Using large-scale numerical simulations we calculate the Lyapunov exponents, Lyapunov vectors, and fractal dimension of fluid convection to explore spatiotemporal chaos over a range of system sizes. Extensive chaos is found even though the convection pattern transitions from boundary to bulk dominated dynamics as the system size is increased. The spectrum of Lyapunov vectors are used to quantify the spatial characteristics of the largest growing perturbations which are then related to the flow field dynamics.

Mark Paul
Department of Mechanical Engineering
Virginia Tech
mrp@vt.edu

MS70

Coarsening to Chaos-stabilized Fronts in Spatiotemporal Chaos

We study the Matthews-Cox equations, which describe the coupling of long-wave and pattern modes in reflection- and Galilean-invariant systems, and present several unexpected properties of their spatiotemporal chaos discovered through extensive large-scale, long- time computations. Beginning from small-amplitude arbitrary initial conditions, the long-wave mode coarsens to a metastable state with multiple "viscous Burgers shock"-like structures. Over much longer time periods, a rapid transition occurs to a single-front state with no chaos within the front ("amplitude death"), which is stabilized by a coexisting spatiotemporally chaotic region and whose features are strongly system size-dependent.

Philip Poon
Department of Mathematics
kfpoon@sfu.ca

Ralf W. Wittenberg
Simon Fraser University
Department of Mathematics
ralf@sfu.ca

MS70

One-dimensional Spatiotemporal Chaos

We review recent progress on the characterization of spatiotemporal chaos (STC) particularly for partial differential equations in one space dimension, concentrating especially on the Kuramoto-Sivashinsky equation and related equations. Characteristic features discussed include the transition to STC, the Lyapunov spectrum, the identification of "building blocks" of extensive chaos, STC with strong scale separation, and the role of large scales in maintaining STC.

Ralf W. Wittenberg
Simon Fraser University
Department of Mathematics
ralf@sfu.ca

MS71

Extension and Unification of Traditional Singular Perturbation Methods for ODEs

The renormalization group (RG) method is one of the singular perturbation methods which provides approximate invariant manifolds as well as approximate solutions of differential equations. It is proved that the RG method unifies traditional singular perturbation methods, such as the averaging method, the multiple time scale method, the normal forms theory, the center manifold reduction, the geometric singular perturbation method and the phase reduction.

Hayato Chiba
Kyoto University
chiba@amp.i.kyoto-u.ac.jp

MS71

Renormalization Group Method Based on the Lie

Symmetry of Dynamical Systems

The renormalization group based which has been developed in quantum field theory is applied to singular perturbation problems in ordinary differential equations and difference equations to construct an asymptotic solution. The asymptotic behaviour of the system is derived from the Lie differential equation, renormalization group equation, of a Lie group which leaves the system approximately invariant even if we consider a difference system. For a 2D symplectic map, the renormalization group equation becomes a Hamiltonian system and a long-time behaviour of the symplectic map is described by the Hamiltonian.

Masatomo Iwasa
Nagoya University
miwasa@allegro.phys.nagoya-u.ac.jp

MS71
Renormalization, Normal Forms, Logarithms, and Geometric Desingularization

In this talk, I will discuss renormalization group theory for perturbation problems. In earlier joint work with Lee DeVille and Kreso Josic, we showed the equivalence between the RG approach of Chen-Goldenfeld-Oono and normal form theory for classes of autonomous and nonautonomous perturbations. In this new work, we focus on problems with gauge functions involving logarithms and fractional powers of the small parameter. RG naturally identifies these gauge functions, as CGO showed, and we present a mathematical analysis of these phenomena.

Tasso J. Kaper
Boston University
Department of Mathematics
tasso@math.bu.edu

Matthew Holzer
Boston University
holzer@math.bu.edu

MS72
Noise-induced Regularity for Reaction-diffusion Equations

This talk will consider examples of stochastic partial differential equations whose underlying deterministic PDE is of reaction-diffusion type. We will show that in the right scaling limits, these systems can exhibit regular behavior, e.g. generate spatiotemporally periodic wavetrains, even though the input is stochastic. The techniques used include classical methods for understanding deterministic reaction-diffusion PDE and large deviations results for stochastic PDE.

Lee DeVille
University of Illinois
Department of Mathematics
rdeville@math.uiuc.edu

Eric Vanden-Eijnden
Courant Institute
New York University
eve2@cims.nyu.edu

MS72
Stochastic Modeling of Unresolved Scales in Spatially Extended Systems

Multiscale complex systems are often subject to uncertainties, since some mechanisms are not represented (i.e., “unresolved”) due to the lack of better scientific understanding for these mechanisms. The impact of these unresolved mechanisms on the resolved ones may be delicate and needs to be quantified or taken into account. A stochastic scheme is devised to take the effects of unresolved mechanisms into account, in the context of solving nonlinear partial differential equations. An example is presented to demonstrate this strategy.

Jinqiao Duan
Illinois Institute of Technology
duan@iit.edu

MS72
Stochastic Partial Differential Equations as Mesoscopic Equations - From Microscales to Macroscales

In the microscale, the time evolution of particles is governed by systems of coupled nonlinear deterministic oscillators (classical case). Stochastic partial differential equations (SPDEs) are derived as a mesoscopic limit for the distribution of particles and their generalizations. The discrete structure of the particle system generates a spatial correlation length which is preserved in the mesoscopic limit. As the correlation length tends to 0, the solutions of the SPDEs tend to solutions of a macroscopic PDE.

Peter Kotelenez
Case Western Reserve University
pxk4@case.edu

MS72
Is the Stochastic Slow Manifold Equal to Averaging Plus Deviations?

We seek to describe the macroscopic behavior of stochastic reaction–diffusion equations by a finite dimensional system. We explore a SPDE with cubic nonlinearity via two approaches which both artificially separate the system into two distinct slow-fast parts. Our aim is to compare the performance of modelling the slow stochastic component by forming the stochastic slow manifold and by averaging and deriving deviations from the average.

Anthony J. Roberts
University of Adelaide
anthony.roberts@adelaide.edu.au

Wei Wang
University of Adelaide
South Australia
wei.wang@adelaide.edu.au

MS73
Chaotic Particle Settling in Laminar Flows: The Stretch, Sediment and Fold Mechanism

We present an asymptotic analysis of heavy Stokes particle transport in laminar flows, in the limit of vanishing particle inertia. By writing the particle motion equation as a perturbed hamiltonian system, and making use of Melnikov’s method, we derive analytical criteria to predict the occurrence of chaotic trajectories. When the flow is a fixed horizontal vortex with time-periodic strength, a ”stretch, sediment and fold" mechanism appears, as a paradigm for chaotic particle settling.

Jean-Regis Angilella
University of Nancy
Jean-Regis.Angilella@ensem.inpl-nancy.fr

MS73

Trapping and Clustering of Heavy Particles in Open Flows

The advection of aerosols is relevant in a variety of physical contexts, including astrophysical, atmospheric and environmental research. Previous studies are consistent with the assumption that such heavy particles always escape in open chaotic advection. In this talk I will show that a different behavior is possible and that permanent trapping and clustering of aerosols can occur for a wide range of conditions (RD Vilela and AE Motter, Phys Rev Lett 99, 264101 2007). In a rather counterintuitive manner, we observe that this phenomenon is determined by a process in which the aerosol particles are continuously scattered by vortices of the advecting flow.

Rafael Dias Vilela
Universidade Federal do ABC
rdvilela@pks.mpg.de

Adilson E. Motter
Northwestern University
motter@northwestern.edu

MS73

Stability and Instability in the Dynamics of Inertial Particles

The dynamics of inertial (i.e., finite-size) particles in fluid flows may differ significantly from infinitesimal fluid particle dynamics. Inertial particles turn out to be attracted to a lower-dimensional slow manifold on which the equations of motion are dissipative. In certain flow regions, the slow manifold becomes unstable and leads to an unexpected departure of inertial particle motion from fluid motion. Here I discuss exact analytic results for the inertial slow manifold and its instabilities. I also show applications to hurricane dynamics, jellyfish feeding, and atmospheric contamination problems.

George Haller
Massachusetts Institute of Technology
Department of Mechanical Engineering
ghaller@mit.edu

MS73

Fingerprints of Random Flows

I will discuss the patterns formed by small rod-like objects advected by a fluid. Their direction field satisfies a nonlinear equation, but I show that the solution can be obtained from that of a linear equation, which is similar to a one-dimensional Schrodinger equation. For periodic flows, the solution has 'bands' (analogous to Bloch bands in solid-state physics) where the rods tumble, interspersed with regions where the rods approach a constant direction. In turbulent flows, simulations show that the direction field of the rods appears to singularities. First, 'scar lines' emerge where the rods abruptly reverse direction. Later, these scar lines become so narrow that they 'heal over' and disappear, but their ends remain as point singularities, which are of the same type as those seen in fingerprints. The theoretical basis for these observations will be explained. I shall also explain how singularities in the direction field of particles in a rheoscopic fluid can be revealed using coloured light sources. I will describe a simple experiment which gives evidence for the existence of singularities with half-integer Poincare index. This talk represents work done jointly with V. Bezuglyy (Open Uinversity) and B. Mehlig (Gothenburg).

Michael Wilkinson
Dept. of Applied Math.
The Open University, Milton Keynes - UK
m.wilkinson@open.ac.uk

MS74

Stabilization of Chemostats Using Feedback Linearization and Dimensional Reduction

Stabilization via feedback linearization of models of competition between two species of microroganisms for two essential resources based in the chemostat is considered. We show that though the full four-dimensional system is not stabilizable due to the dynamical properties of the system, it is possible to achieve the goal in modified form by pursuing a process of dimensional reduction prior to feedback linearization. This technique has appeared in the literature applied to a similar system in the seminal papers of Hoo and Kantor, though the authors appear to have done so as a matter of convenience, and apparently did not realize that their original (higher dimensional) system was not stabilizable without utilizing the reduction procedure. This suggests that the dimensional reduction method could be rather generally applicable.

Mary M. Ballyk, Ernest Barany
New Mexico State University
Dept of Mathematical Sciences
mballyk@nmsu.edu, ebarany@nmsu.edu

MS74

Dynamical Structure of Evolutionary Population Models

Evolution due to competition and natural selection can be modeled by Lotka-Volterra-type population models with parameters that describe phenotypically mediated interactions between organisms. If the time scale of mutational changes is much greater than the time scale of competition, the two types of dynamics separate. In this case, the evolutionary dynamics can be illuminated by the dynamical structure of the underlying Lotka-Volterra model.

Ernest Barany
New Mexico State University
Dept of Mathematical Sciences
ebarany@nmsu.edu

MS74

Evolutionary Branching and Symmetric Bifurcations

Evolutionary branching patterns can be studied in Lotka-Volterra population models with parameters that model phenotypic and environmental variables. The changes in phenotypic patterns of coexisting types of populations for changing values of environmental quantities can be analyzed as local bifurcations. Typical models of interest may have symmetries, which affect the expected bifurcations, and symmetry breaking effects for generalizations of the models may have interesting biological interpretations.

Aysegul Birand
Department of Ecology & Evolutionary Biology
University of Tennessee
abirand@utk.edu

Ernest Barany
New Mexico State University
Dept of Mathematical Sciences
ebarany@nmsu.edu

MS74

Stability and Bifurcations in 1-d Stochastic Population Models

We consider the effect of stochasticity on the bifurcations and stability of one dimensional population models. The two types of stochastic bifurcation are examined for each model and a mathematical framework for identifying these bifurcations is discussed. The stability properties of each model are then determined. These criteria are applied to well known models and a phenomenological interpretation of the stochastic bifurcations is developed.

Suzanne Galayda
New Mexico State University
Department of Mathematics
sgalayda@nmsu.edu

Ernest Barany
New Mexico State University
Dept of Mathematical Sciences
ebarany@nmsu.edu

MS75

Pinning Control of Complex Networks

The question of how the topological properties of a network determine the propensity of a network to synchronize has been deeply studied from different viewpoints. But, perhaps, one of the most important approaches to this issue is the so-called Master Stability Function. In this talk, we shall discuss the problems that this approach have to quantify the pinning controllability of a network. In addition, we shall suggest a new quantity and, based on this new measure, we shall explain how an external perturbation strategy enhances or decreases the pinning controllability of different types of networks.

Juan Almendral
University of Rey Juan Carlos
Madrid, Spain
juan.almendral@urjc.es

MS75

Multi-level Analysis of Complex Networks with Hyperstructures

We introduce the hyper-structures as a general framework that extends the concept of networks and hyper-networks. Several new parameters are presented (such as the efficiency or vulnerability of an hyper-structure) and some relationship between them are included. This new approach allows us to make a multi-level analysis of complex networks that improves the classic complex network and hyper-network analysis of real structures.

Miguel Romance
Departamento de Matematica Aplicada
Universidad Rey Juan Carlos
miguel.romance@urjc.es

Maria Vela-Perez
Departamento de Matematica Aplicada
Universidad Rey Juan Carlos, Spain
maria.vela@urjc.es

Regino Criado
Universidad Rey Juan Carlos
regino.criado@urjc.es

MS75

Signal Processing in Neuronal Networks with Activity-dependent Coupling: New Vistas for Calcium and Noise

How neurons and neuronal networks perform signal processing tasks is one of the most important questions in neuroscience. Earlier research had focused on the integrative properties of individual neurons, and the role of activity-dependent inter-neuronal coupling remained obscure. We study the contribution of synaptic short-term plasticity to the detection, amplification, and storage of weak sensory stimuli in local neuronal circuits. Networks with fast plastic coupling show behavior consistent with stochastic resonance. Addition of slow asynchronous coupling mode leads to the qualitatively different properties of signal detection. Networks with asynchronous coupling also are able to hold information about the stimulus seconds after its cessation, thus representing a testable model of working memory, that is supported by experiments. Our results suggest a new, constructive, role in information processing for calcium-sustained synaptic noise.

Vladislav Volman
The Center for Theoretical Biological Physics
University of California San Diego
volman@salk.edu

MS75

Structure Identification of Dynamical Networks

The research on dynamical networks currently focused on how to understand the relation between structure and dynamics. The question how the topology properties of the network (such as clustering coefficient, connectivity distribution, and average network distance) influence network synchronizability was well studied in the literature. However the inverse problem – how to identify structure of networks (including local dynamics, coupling functions, connection topology, and even interaction delays) from the dynamic evolution – has not been well understood and is very crucial for analysis of real networks. In this talk, I shall briefly review some recent results on structure identification of dynamical networks.

Dongchuan Yu
College of Automation Engineering
Qingdao University
dongchuanyu@yahoo.com

MS76

Uncertainty in Weather and Climate Modeling

As advances in data assimilation continue to improve our estimate of the state of the atmosphere at any given time, modeling errors represent an increasingly important component of forecast uncertainty. In this talk, we describe mathematical efforts to characterize deficiencies in global weather and climate models. As examples, we discuss a simple fluids experiment modeled using 3 variables, and an operational forecast model with 10^9 variables.

Chris Danforth
Mathematics and Statistics
University of Vermont
chris.danforth@uvm.edu

Eugenia Kalnay
Department of Meteorology
University of Maryland
ekalnay@atmos.umd.edu

MS76

Climate and the Cryosphere

Polar sea ice packs and ice sheets are critical components of earths climate system, and leading indicators of climate change. Through nonlinear mechanisms such as the ice-albedo feedback, where melting ice increases solar absorption which in turn melts more ice, the effects of global warming are amplified. Modeling polar processes presents a wide range of mathematical challenges. Well discuss some of these problems, as well as ways of addressing them.

Kenneth M. Golden
University of Utah
Department of Mathematics
golden@math.utah.edu

MS76

Climate As a Fast/slow System

Weather occurs on a fast time scale as compared with variations in the climate. Simple climate models can be used to understand the interaction between these scales. Issues surrounding the impact of the climate on the weather will be discussed

Christopher Jones
University of North Carolina and University of Warwick
ckrtj@email.unc.edu

MS76

Climate and the Earth's Glacial Cycles

It is widely accepted that the Earth's glacial cycles are driven by variations in the Earth's orbit. It is also widely accepted that the orbital variations themselves are insufficient to explain all the properties of the glacial cycles, particularly the rapid temperature increase at the termination of each glaciation. I will discuss some simple mathematical models elucidating the connection between orbital variations and the feedback mechanisms.

Richard McGehee
University of Minnesota
mcgehee@math.umn.edu

MS77

Application of Chaoticity Indicators to Asteroid Missions

Spacecraft orbit design methodologies for missions to asteroids must address unique challenges, including irregular gravitational potential fields (with a priori unknown parameters) and significant perturbation from solar radiation pressure. This talk will present an application of chaoticity indicators and periodic orbit analysis to the concrete task of designing long-term stable spacecraft orbits near asteroids. A unique advantage of this approach is that robustness of these orbits to navigation and gravity parameter uncertainties can be quantified.

Benjamin F. Villac
University of California, Irvine
bvillac@uci.edu

Stephen Broschart
Jet Propulsion Laboratory
Stephen.B.Broschart@jpl.nasa.gov

MS77

Analysis of Invariant Manifold Intersections for ARTEMIS Mission Design

The trajectory design for the Artemis mission requires a transfer that allows the placement of two spacecraft into Earth-moon L1 and L2 Lissajous trajectories from Earth-centered elliptical orbits. These transfers exploit the overlapping dynamical structure of the sun-Earth and Earth-moon systems. Solar quadrant selection adjusts the size, shape, and orientation such that the trajectories in the Sun-Earth system can be shifted to the Earth-Moon system via manifold intersections. This strategy reduces (or eliminates) the insertion delta-V costs, a critical aspect of a limited-fuel mission. Once in the Earth-moon system, the design scheme then focuses on delivery options to best achieve the Lissajous orbits. Several methods have been previously investigated to determine the intersections of invariant manifolds, including generation of pseudo-manifold data using splines, coefficients generated from Cartesian data, and optimization routines. In applying manifold intersections to the Artemis design, numerical sensitivities, discontinuities, and the degree of freedom must be addressed. Trajectory design strategies are demonstrated that support the computation of the Artemis transfer from sun-Earth manifold structures onto an Earth-moon invariant manifold and therefore onto the appropriate Lissajous orbits.

David C. Folta
NASA Goddard Spaceflight Center
david.c.folta@nasa.gov

Kathleen Howell
University of Illinoins at Urbana-Champaign
howell@purdue.edu

MS77

Poincar and Space

Poincars work on the Three Body Problem had a huge impact on mathematics, which continues today. His work has also profoundly affected space exploration since the Three Body Problem is at the heart of interplanetary space flight. In this talk we explore how his work affected the design of space missions and deepened our understanding of the dynamics of the Solar System. Including the role of Poincars other great opus: algebraic topology.

Martin W. Lo
California Inst of Technology
Jet Propulsion Laboratory
Martin.Lo@jpl.nasa.gov

MS77

Numerical Computation of Libration Point Orbits, its Manifolds, and Connections

This talk will summarize some numerical methods, developed by the Barcelona Dynamical Systems group, useful for the design of libration point missions. The computation and continuation of invariant tori, their stable/unstable manifolds, and homoclinic/heteroclinic connections will be discussed. A driving goal will be the implementation of interactive software tools for trajectory design. In this sense, results on the numerical globalization of the center manifold of the collinear libration points of the RTBP as NHIM will be presented.

Josep-Maria Mondelo
Universitat Autonoma de Barcelona
jmm@mat.uab.cat

MS78

A New Saddle-point Finding Algorithm

A new type of global numerical mountain-pass type algorithm designed to find saddle-point solutions in PDEs and on multidimensional energy surfaces is presented. Convergence estimates and numerical implementation of this algorithm are discussed and examples are provided.

Jeremy Chamard
PHD student at the University of Surrey
j.chamard@surrey.ac.uk

MS78

Numerical Investigation of the Smallest Eigenvalues of the p-Laplace Operator

It is known that the smallest Dirichlet eigenvalue $\lambda_1(p)$ of the p-Laplace operator $-div(|\nabla u|^{p-2}\nabla u)$, $p \in (1,\infty)$ is positive, simple, and isolated, and is the minimum of the Rayleigh quotient. The second eigenvalue $\lambda_2(p)$ is well defined and has a variational characterization. The Rayleigh quotient can be used to numerically approximate $\lambda_1(p)$. We apply a variant of the mountain pass algorithm to approximate $\lambda_2(p)$. Approaches available so far worked well for p close to 2. We investigate the behavior for p getting close to 1 and getting large. In the literature there are theoretical results describing the behavior of $\lambda_{1,2}(p)$ as $p \to \infty$, and $\lambda_1(p)$ as $p \to 1$.

Jiri Horak
University of Cologne, Germany
jhorak@math.uni-koeln.de

MS78

Algorithms for Finding Saddle Points and Calculating Rates of Chemical Reactions

A computational method for simulating the dynamics of atomic systems on time scales much longer than can be accessed with classical dynamics will be presented. Possible reaction mechanisms available to the system are found by exploring the potential energy surface from minima to find nearby saddle points. Reaction rates are then calculated using harmonic transition state theory, and the system is propagated in time according to the kinetic Monte Carlo algorithm.

Graeme Henkelman
Assistant professor at the University
of Texas at Austin
henkelman@mail.utexas.edu

Rye Terrell
University of Texas at Austin
ryeterrell@ryeterrell.net

MS79

Two Parameter Family of Bent DNA and Predicted DNA Looping Behaviors Induced by the LacR Protein

We represent a large family of intrinsically curved DNA molecules using an elastic rod with stress-free curvature and two free parameters to describe the stress-free torsion of the molecule. We exercise the rod model over this two dimensional design space to predict the energetics and topology of loops formed from designed DNA sequences by the Lac repressor protein. We show quantitative and qualitative agreement between our calculations and experiments on three sequences in this family.

Todd Lillian
Graduate Student
University of Michigan
tlillian@umich.edu

Noel Perkins
Professor of Mechanical Engineering
University of Michigan
ncp@umich.edu

MS79

Overstretching and twisting of DNA modeled at the base-pair level

Single molecule stretching experiments on DNA have indicated that DNA twist tightens upon stretching and there is a phase transition in DNA from regular B-form to an overstretched form at large magnitudes of the stretching force. A thorough exploration of the bifurcation diagram for equilibrium configurations of short DNA segments (with force or extension as a free parameter) shows that the observed behavior is consistent with the existing discrete, base-pair level model for DNA mechanics.

David Swigon
Department of Mathematics
University of Pittsburgh
swigon@pitt.edu

MS80

Collective Phase Sensitivity of a Population of Coupled Oscillators

The collective phase response to a macroscopic external perturbation of a population of interacting nonlinear elements exhibiting collective oscillations is formulated for the case of globally coupled oscillators. The macroscopic phase sensitivity is derived from the microscopic phase sensitivity of the constituent oscillators by a two-step phase reduction. We apply this result to quantify the stability of the macroscopic common-noise-induced synchronization of two uncoupled populations of oscillators undergoing coherent collective oscillations.

Hiroya Nakao
Department of Physics
Kyoto University
nakao@ton.scphys.kyoto-u.ac.jp

Yoji Kawamura
The Earth Simulator Center
Japan Agency for Marine-Earth Science and Technology
ykawamura@jamstec.go.jp

Kensuke Arai
Department of Physics
Graduate School of Sciences, Kyoto University
arai@ton.scphys.kyoto-u.ac.jp

Hiroshi Kori
Division of Advanced Sciences
Ochanomizu University
kori.hiroshi@ocha.ac.jp

Yoshiki Kuramoto
Kyoto University
kuramoto@kurims.kyoto-u.ac.jp

MS80

Encoding by Sequential Clustering in Coupled Phase Oscillator Systems

Partially synchronized cluster states are studied in globally coupled phase oscillator systems. We show that one may design coupling functions that ensure the existence and stability of given cluster states. We also show that for saddle cluster states, forcing the system by steady but spatially nonhomogeneous inputs may produce cyclic sequences of transitions between the cluster states. That is, information about inputs can be encoded via a 'winnerless competition' process into spatiotemporal codes.

Gabor Orosz
University of California, Santa Barbara
Department of Mechanical Engineering
gabor@engineering.ucsb.edu

Peter Ashwin
University of Exeter
School of Mathematical Sciences
p.ashwin@exeter.ac.uk

Stuart Townley
University of Exeter, UK
s.b.townley@exeter.ac.uk

MS80

Partially Integrable Dynamics of Phase Oscillator Ensembles

We consider oscillator ensembles consisting of subpopulations of identical units, with a general heterogeneous coupling between subpopulations. Using the Watanabe-Strogatz ansatz we reduce the dynamics of the ensemble to a relatively small number of dynamical variables plus constants of motion. This reduction remains valid in the thermodynamic limits. The theory is applied to the standard Kuramoto model and to the ensemble of nonlinearly coupled oscillators, when the interaction function depends on the order parameter.

Michael Rosenblum
Potsdam University
Department of Physics
mros@uni-potsdam.de

Arkady Pikovsky
University of Potsdam
pikovsky@uni-potsdam.de

MS80

Networks of Phase Oscillators: From Mean Field to Distance-dependent Coupling

In certain networks of globally coupled phase oscillators, dynamics is based on structurally stable heteroclinic connections between unstable cluster states. Introduction of a distance-dependent metrics lifts the permutation symmetries and disables the formation of such connections. By varying the parameters of the metrics, we observe a sequence of different periodic and chaotic regimes on the way from slow switching between the clusters to splay states.

Michael Zaks
Department of Stochastic Processes, Institute of Physics
Humboldt University of Berlin
zaks@physik.hu-berlin.de

Marco Kaeselitz
Institute of Physics
Humboldt University of Berlin
kaeselitz@physik.hu-berlin.de

MS81

Generalized Wilson-Cowan Rate Equations for Correlated Activity in Neural Networks

Population rate or activity equations are the foundation of a common approach to modeling for neural networks. These equations provide mean field dynamics for the firing rate or activity of neurons within a network given some connectivity. The shortcoming of these equations is that they take into account only the average firing rate while leaving out higher order statistics like correlations between firing. A stochastic theory of neural networks which includes statistics at all orders was recently formulated. We describe how this theory yields a systematic extension to population rate equations by introducing equations for correlations and appropriate coupling terms. Each level of the approximation yields closed equations, i.e. they depend only upon the mean and specific correlations of interest, without an ad hoc criterion for doing so. We show in an example of an all-to-all connected network how our system of generalized activity equations captures phenomena missed by the mean fieldrate equations alone.

MIchael Buice
LBM/NIDDK
National Institutes of Health
buicem@niddk.nih.gov

MS81

Kinetic Theories for Neuronal Dynamics and

Maximum-Entropy Closures

We analyze (1+1)-D kinetic equations for neuronal network dynamics, which are derived via an intuitive closure from a Boltzmann-like equation governing the evolution of a one-particle (i.e., one neuron) probability density function. We demonstrate that this intuitive closure is a generalization of moment closures based on the maximum-entropy principle. By invoking maximum-entropy closures, we show how to systematically extend this kinetic theory to obtain higher-order, (1+1)-D kinetic equations and to include coupled networks of both excitatory and inhibitory neurons.

David Cai
Courant institute
New York Unvirsity
cai@cims.nyu.edu

MS81

A Kinetic Theory Approach to Capturing Interneuronal Correlations in Feed-forward Networks

We present an approach for using kinetic theory to capture first and second order statistics of neuronal activity. We coarse grain neuronal networks into populations of neurons and calculate the population average firing rate and output cross-correlation in response to time varying correlated input. We derive coupling equations for the populations based on first and second order statistics of the network connectivity. By analyzing the correlated activity of feed-forward networks with a variety of connectivity patterns, we provide evidence supporting our hypothesis that second order statistics of the network connectivity are sufficient to determine second order statistics of neuronal activity.

Duane Nykamp
School of Mathematics
University of Minnesota
nykamp@math.umn.edu

Chin-Yueh Liu
School of Mathematics
University of Minnesota
liux0518@math.umn.edu

MS81

A Diagrammatic Subnetwork Expansion for Pulse-coupled Network Dynamics

The study of dynamics on networks is becoming increasingly more relevant within biology. An important subclass of biological networks are 'pulse-coupled' networks, which encompass many types of ecological, gene-regulatory and neuronal networks. For these types of networks, there are often statistical features of the dynamics (such as correlations in the activity of different nodes in the network) which are relevant either for observers, or for controlling the dynamics of other downstream networks. An important question is: what is the relationship (or map) between a pulse-coupled network's architecture and any given statistical feature of its dynamics? In this talk I will present a framework which takes a first step towards answering this question. This framework allows various long-time measurements of a pulse-coupled network's stationary dynamics to be expanded in terms of the network's connectivity. Such measurements include the occurrence rate of pulses as well as higher order correlations in activity between various nodes in the network. The various terms in this expansion can be interpreted as diagrams corresponding to subnetworks of the original network which span both space (in terms of the network's graph) as well as time (in the sense of causality).

Aaditya Rangan
CIMS
New York University
rangan@math.nyu.edu

MS82

Noise-Induced Transitions in Slow Wave Neuronal Dynamics

Many neuronal systems exhibit slow random alternations in activity states. We analyze the noise-induced transitions and statistical properties in relaxation oscillator models for such systems. We find that the statistical properties can be used to distinguish among biophysical mechanisms, such as multiplicative or additive negative feedback: different slow negative feedbacks may lead to a particular pattern of temporal correlations. Applications to models of cellular pacemaker neurons and of spontaneously active networks will be discussed.

Sukbin Lim
Courant Institute of Mathematical Sciences, NYU
sukbin@cims.nyu.edu

John M. Rinzel
Courant Institute and Center for Neural Science
New York University
rinzel@cns.nyu.edu

MS82

Synchronization Dynamics with Correlated Stimuli

We study the synchronization of 2 neural oscillators that are weakly and identically coupled, that receive shared and unshared external (weak) noise. In the phase reduction model, we solve the Fokker-Planck equation and perform asymptotic reduction that agrees remarkably well with full system with weak noise and weak coupling. Our phase model accurately predicts the behavior of a realistic synaptically coupled Morris-Lecar system.

Cheng Ly
University of Pittsburgh
Department of Mathematics
cheng70@gmail.com

Bard Ermentrout
University of Pittsburgh
bard@pitt.edu

MS82

The Axonal Plexus: A Description of the Behavior of a Betwork of Axons Connected by Gap Junctions

Gap junctions are associated with very fast oscillations (VFOs, $>$ 80 Hz) in the neocortex and hippocampus. We show how an axonal plexus (a network of axons connected by gap junctions) can exhibit (1) noisy activity, (2) stochastically-driven VFOs, or (3) re-entrant VFOs depending on the somatic voltage (V_S) and gap junction conductance (g_{gj}). We discuss applications of this analysis for VFOs in gamma oscillations, slow-wave sleep, and seizure initiation.

Christoph Borgers
Tufts University
christoph.borgers@tufts.edu

Erin Munro
Department of Mathematics
Boston University
ecmun2002@yahoo.com

MS82

Cooperative Coding in Sensory Networks

Correlations among neural spike times are ubiquitous, and open the possibility for cooperative coding of sensory inputs across neural populations. The structure of the correlations that emerge in a given population, however, depends strongly on the nonlinear dynamics of its constituent neurons and synapses. This is because these dynamics control how correlated inputs are transformed into correlated spikes. We study archetypal models of corresponding to different sensory circuits, and describe the basic features of the different cooperative codes that result.

Eric Shea-Brown, Andrea K. Barreiro
Department of Applied Mathematics
University of Washington
etsb@amath.washington.edu,
barreiro@amath.washington.edu

Fred Rieke
University of Washington
Physiology and Biophysics
rieke@u.washington.edu

Evan Thilo
Neurobiology
University of Washington
thiloe@washington.edu

MS83

Irregular Transient Dynamics with Negative Lyapunov Exponent

High-dimensional, nonlinear dynamical systems may exhibit seemingly chaotic and yet linearly stable transients, that can last for exponentially long times. Such a type of evolution that was, in the past, mostly observed in abstract models of coupled maps, does appear also in more realistic systems like networks of coupled leaky integrate and fire neurons or in one-dimensional systems of colliding particles. The possible relevance of the phenomenon in connection to information processing is also briefly discussed.

Antonio Politi
Istituto Sistemi Complessi CNR
Firenze, Italy
antonio.politi@isc.cnr.it

MS83

Transient Spatiotemporal Chaos in Coupled Excitable Elements

In various excitable systems spatiotemporal chaos collapses into a regular asymptotic state, with the average lifetime increasing exponentially with the network size. During the transient phase spatiotemporal chaos is extensive; the Kaplan-Yorke dimension increases linearly with the network size. The asymptotic state is characterized by negative transverse Lyapunov exponents on the attractor of the invariant synchronization manifold. The average lifetime depends on the number of transverse directions that are unstable along a typical excitation cycle.

Renate A. Wackerbauer
University of Alaska Fairbanks
Department of Physics
ffraw1@uaf.edu

MS83

Experimental Investigation of Long-lived Transients in Transitional Pipe Flow

One of the principal questions in describing the transition to turbulence in pipe flow is whether the turbulent flow state is sustained or is along-lived transient. In this paper we present recent experimental results that indicate that the lifetime of localized turbulence in pipe flow ('puffs') remains transient at all observed Re. These findings are in agreement with earlier reports. Long-lived transients are also found in other shear flows and is supported theoretically.

Jerry Westerweel
Laboratory for Aero en Hydrodynamics
Delft University of Technology, 2628 CD Delft,
Netherlands
J.Westerweel@tudelft.nl

MS84

Train Dynamics and Discontinuity Induced Bifurcations

We investigate the dynamics of a wheel set suspended under a railroad car running on a sinusoidally perturbed track, assuming that the perturbations of the two rails are in phase. The wheels move laterally and yaw, and the relative motion between the wheel set and the car body is restrained by a linear spring and a dry friction damper. The use of recently developed theoretical and numerical tools allows us to shed light on the intricate dynamics of this piecewise smooth system.

Alessandro Colombo
Politecnico di Milano
alessandro.colombo@polimi.it

Hans True
Technical University of Denmark
ht@imm.dtu.dk

MS84

The Boundary of Chaos for Maps with a Single Discontinuity

Monotonic maps with a single discontinuity arise in a variety of situations. We describe the infinite sets of periods for such maps on the boundary of chaos; this gives a sense of the routes to chaos in such maps. The description involves an explicit subshift of finite type which describes the sequences of different renormalizations possible in these maps.

Paul Glendinning
University of Manchester

p.a.glendinning@manchester.ac.uk

MS84

Global Phenomena in a Neighborhood of Codimension Two Local Singularities of Planar Filippov System

We present a study of codimension two singularities of planar Filippov systems. For this purpose we establish two different definitions of topological equivalence which, in some cases, lead to different unfoldings of these singularities.

Marcel Guardia
Universitat Politecnica de Catalunya
marcel.guardia@upc.edu

MS84

Old Dogs and New Tricks: A Geometric Approach to Nonsmooth Systems

The dynamics of switching or dry-friction systems can be changed catastrophically by orbits that just graze a switching surface. The effect of grazing on local and global dynamics is not yet fully understood even in some simple scenarios. Here we apply ideas from the singularity theory of smooth systems to reveal the geometry of piecewise-smooth flows, including invariant manifolds created by degenerate grazing, and mechanisms for sudden destruction of limit cycles.

Mike R. Jeffrey
University of Bristol
mike.jeffrey@bristol.ac.uk

MS85

A Multiscale Approach for the Simulation of Coarse Fokker-Planck Equations

The dynamics of multiscale systems typically takes place over multiple time and space scales. Direct computation of such systems is therefore often too expensive and specialized techniques are required to reduce the computational effort. We consider systems in which the interest is in the slow evolution of the density of a large number of individual particles (such as bacteria or agents). In case the effective behaviour of an individual is given by a stochastic differential equation, the density evolves according to the corresponding Fokker-Planck equation, which is unavailable in closed form. We propose a multiscale procedure that combines elements from equation-free and heterogeneous multiscale methods to numerically integrate this unknown Fokker-Planck equation using only appropriately chosen microscopic simulations.

Yves Frederix
Dept. of Computer Science, K.U. Leuven
Yves.Frederix@cs.kuleuven.be

MS85

Applications of Discrete-kinetic Schemes to Several Concrete Problems

We will focus on problems for which one can provide a kinetic description, and analyse the asymptotic behavior of the solution in order to help provide numerical schemes that are faster and lighter than ones based on microscopic descriptions but are still able to give a mesoscopic picture of the phenomena. In accordance with the methods that were developed by Goudon and Lafitte for radiative transfer problems and by Carrillo, Goudon and Lafitte for the interaction of fluid and particles, in connection with pollution phenomena, we will show the results of some numerical simulations performed for concrete problems in the physical, chemical or biological fields.

Pauline Lafitte
Project team SIMPAF, INRIA Lille
Pauline.Lafitte@inria.fr

MS85

Equation-assisted Methods for Particle Simulations of Kinetic Models

Many particle systems in which both position and velocity are important can be described via a kinetic mode, which is only approximated by an advection-diffusion-like equation in an appropriate long (diffusive) time-scale limit. We will discuss equation-free methods for this type of problem. At the microscopic level, we will use a particle simulation of the kinetic model, around which we will wrap a coarse time-stepper. We will discuss several ways to use the approximate long time-scale model to accelerate the computations – hence the term equation-assisted. First, this model can be used to reduce variance via the technique of control variates. Also, when computing coarse steady states via a Newton-Krylov method, the approximate macroscopic model can be used as a preconditioner. These ideas will be illustrated via an example from bacterial chemotaxis.

Giovanni Samaey
Department of Computer Science, K. U. Leuven
giovanni.samaey@cs.kuleuven.ac.be

MS85

United by Noise: Randomness Helps Swarms Stay Together

Direction switches, seen in animal groups such as locust swarms, can be modelled by systems of self-propelled particles (SPP). Using a coarse-grained approach we determine the mean time between direction switches as a function of group density. Our systematic approach also allows us to identify key differences between our SPP model and locust data, revealing, in particular, that individuals increase the randomness of their movements in response to a loss of group alignment.

Christian Yates
Center for mathematical biology
Oxford University, Oxford
yatesc@maths.ox.ac.uk

MS86

Progress in Observing Reconnecting Vortices in Superfluid Helium

I describe recent advances in the visualization of the motions of superfluid helium-4. Particles suspended in the fluid, when they are small enough, make it possible to witness the dynamics of individual quantized vortex lines. Trapped on the vortex cores, the particles show that the vortices align with the axis of rotation, undergo reconnection with each other, and form rings whose diameters become smaller over time. I also discuss possible limitations of the technique.

Gregory Bewley
Max Planck Institute for Dynamics and Self-Organization
gregory.bewley@ds.mpg.de

Daniel Lathrop
University of Maryland, College Park
dplathrop@gmail.com

Katepalli Sreenivasan
International Centre for Theoretical Physics, Trieste, Italy
director@ictp.it

MS86

Particles Suspended in Turbulence: Clustering, Caustics and Collisions

An initially uniform scatter of inertial particles in a randomly stirred or turbulent fluid can cluster together. We analyze this "unmixing" effect by calculating the Lyapunov exponents for dense particles suspended in a random three-dimensional flow by Pad-Borel summation of a perturbation series. Particles can cluster onto a fractal set whose dimension is in satisfactory agreement with previously reported results from simulations of turbulent Navier-Stokes flows [Bec et al. (2006)]. This talk is based on joint work with M. Wilkinson, St. Ostlund, and K. Duncan.

Bernhard Mehlig
Gothenburg Univ
Gothenburg, Sweden
Bernhard.Mehlig@physics.gu.se

MS86

Phase Separation, Sedimentation, and Clustering of Inertial Particles

Demixing binary fluid mixtures by a slow temperature ramp induces cycles of nucleation, coarsening and sedimentation [J. Vollmer, et al, PRL **98** (2007) 115701]. At nucleation droplets are passive, but upon growing they become inertial. Initially gravity is negligible, but it becomes dominant upon sedimentation. Particle tracking experiments (trajectories, interactions, particle size distribution) in the regime where gravity becomes relevant are discussed from the perspective of models addressing the period of the nucleation waves and the coagulation of particles in turbulent flow, respectively.

Juergen Vollmer
MPI Dynamics and Self Organization
juergen.vollmer@ds.mpg.de

Tobias Lapp, Izabella Benczik
MPI Dynamics and Self-Organization
Goettingen
tobias.lapp@ds.mpg.de, izabella.benczik@ds.mpg.de

MS86

Modeling Aggregate Dynamics: An Inertial Particle Approach

We present a coupled model for advection, aggregation and fragmentation that is based on the dynamics of individual inertial fractal particles in two-dimensional periodic flows. We find that the interplay of aggregation and fragmentation leads to a steady state for the size distribution of the aggregates which depends crucially on the mechanism of fragmentation. We demonstrate how this fractal dimension as well as the binding strength of the aggregates influences the shape of the size distribution.

Jens Zahnow
Carl von Ossietzky University
Oldenburg, Germany
zahnow@icbm.de

Rafael Dias Vilela
Universidade Federal do ABC
rdvilela@pks.mpg.de

Tamas Tel
Eötvös Loránd University, Hungary
Inst for Theoretical Physics
tel@poe.elte.hu

Ulrike Feudel
University of Oldenburg
ICBM, Theoretical Physics/Complex Systems
u.feudel@icbm.de

MS87

Age-structured Models of the Killer T cell Response to Acute Infection

Several theories exist concerning primary T cell responses to infection, the most prevalent being that T cells follow developmental programs that govern, to large extents, the durations of expansion and contraction phases. We propose an alternative hypothesis that the T cell response is governed by a negative feedback loop between conventional and adaptive regulatory T cells. We develop age-structured models using partial and delay differential equations to compare the two possibilities.

Peter S. Kim
University of Utah
Department of Mathematics
kim@math.utah.edu

Peter Lee
Stanford University
School of Medicine
ppl@stanford.edu

Doron Levy
University of Maryland
dlevy@math.umd.edu

MS87

The Impact of Transgenic Mosquitoes on Dengue Virulence to Humans and to Mosquitoes

Dengue is a major public health concern in the tropics and subtropics. Innovative control strategies based on transgenesis of *Aedes aegypti* mosquitoes, the primary vector of dengue, to render them incompetent for dengue transmission are under development. We model the evolutionary impact of different transgenic mosquito strategies on dengue-induced mortality, i.e. dengue virulence, to both humans and mosquitoes. We find that strategies that block transmission or reduce mosquito biting select for changes in dengue virulence in humans. The selection can be for either higher or lower virulence depending on the interaction between the effect of the transgene and trade-offs in epidemiological traits. For dengue infection in mosquitoes, the transgenic strategies of transmission blocking, decreased mosquito biting, increased mosquito background mortality, and increased mosquito infection-induced mortality can alter dengue virulence to mosquitoes. Increasing mosquito background mortality selects for higher virulence to mosquitoes, while the direction of selection for the other strategies again is dependent on the impact of the transgene on trade-offs between epidemiological traits. Our results suggest that dengue control strategies that raise mosquito background mortality or mosquito infection-induced mortality pose less risk of causing increased virulence to humans than strategies that block transmission or reduce mosquito biting.

Jan Medlock
Clemson University
Department of Mathematical Sciences
medlock@clemson.edu

Paula Luz
Yale University School of Medicine
Epidemiology and Public Health
paula.luz@yale.edu

Claudio Struchiner
Oswaldo Cruz Foundation
Program for Scientific Computing
stru@procc.fiocruz.br

Alison Galvani
Department of Epidemiology and Public Health
Yale University School of Medicine
alison.galvani@yale.edu

MS87

Infectious Diseases and Cancer

Several cancers have an infectious disease origin. For example, Human Papillomavirus and Helicobacter pylori infections are associated with cervical and gastric cancer risk, respectively. In many cases, the association between a pathogen and cancer is well established; however the mechanisms of this association are not completely understood. A mathematical framework coupling transmission dynamics models with multistage carcinogenesis models is presented. Contrary to alternative approaches, this framework captures properly the time scales of both disease processes, allowing us to investigate in detail the mechanisms by which infectious agents cause cancer. Some examples are discussed.

Rafael Meza
UBC Centre for Disease Control
Division of Mathematical Modeling
Rafael.Meza@bccdc.ca

MS87

Investigating Causes of Seasonality in Outbreaks of Respiratory Syncytial Virus in Utah

Children's hospitals around the world see seasonal outbreaks of Respiratory Syncytial Virus (RSV), which is a major cause of lower respiratory tract disease in infants. We attempt to explain the form of seasonality seen in outbreaks of RSV in Utah using a differential equation model. The model incorporates yearly fluctuation of a transmission parameter that causes a parametric resonance effect and a period-doubling bifurcation that could explain the biennial patterns suggested by outbreak data.

Damon Toth
University of Utah
Department of Mathematics
toth@math.utah.edu

MS88

Computation of Global Manifolds in Slow-fast Systems with Mixed-mode Oscillations

Computing manifolds in systems with multiple time scales is a challenge due to the extreme sensitivity of the initial value problem in this class of systems. We discuss a general boundary value problem approach and demonstrate how it can be used to produce accurate two-dimensional invariant manifolds and canards in systems with two slow variables. We show how this helps understanding the organization of mixed-mode oscillations when a global return mechanism exists.

Mathieu Desroches
University of Bristol
Engineering Mathematics
m.desroches@bristol.ac.uk

Bernd Krauskopf
University of Bristol
Department of Engineering Mathematics
b.krauskopf@bristol.ac.uk

Hinke M. Osinga
University of Bristol
Engineering Mathematics
H.M.Osinga@bristol.ac.uk

MS88

Singular Hopf Bifurcation

Hopf bifurcation is a frequent byproduct of an equilibrium point crossing a fold of a slow-fast system. This process, also called a folded saddle-node type II in systems with two slow variables, is one mechanism for generating mixed mode oscillations. I discuss normal forms for singular Hopf bifurcations, secondary bifurcations and the global changes in intersections of invariant manifolds that lead to MMOs. Chemical examples are presented.

John Guckenheimer
Cornell University
jmg16@cornell.edu

MS88

Mixed-mode Dynamics and the Canard Phenomenon: Towards a Classification

Mixed-mode dynamics is complex dynamical behavior that is characterized by an alternation of small-amplitude (subthreshold) oscillations and large (relaxation-type) excursions. Using geometric singular perturbation theory and desingularization (blow-up), we propose a unified approach for studying this dynamics in the context of three-dimensional multiple-time-scale systems. We show that the mixed-mode behavior in such systems is due to an underlying canard phenomenon, and we indicate how the structure of the resulting mixed-mode oscillations can be classified accordingly.

Nikola Popovic
University of Edinburgh
School of Mathematics
nikola.popovic@ed.ac.uk

MS88

Multiple Rhythms in a Respiratory Pacemaker Network

Mammalian respiration is a multi-phase rhythm that is driven by a central pattern generator (CPG) in the brain stem. It has been posited that this CPG consists of multiple reciprocally connected inhibitory neuronal pools, together with an excitatory kernel. I will discuss rhythmogenesis in a model for this network, including the emergence of ectopic or mixed-mode-like rhythms in transitions between certain experimentally observed rhythms.

Jonathan E. Rubin
University of Pittsburgh
Department of Mathematics
rubin@math.pitt.edu

MS89

Vortex Wake Structure of Rigid Panels with Biologically Inspired Geometry

Digital Particle Image Velocimetry (DPIV) was used to measure the velocity field in the wake of rigid pitching panels with a trapezoidal geometry, chosen to model idealized ?sh caudal ?ns. A Lagrangian coherent structure (LCS) analysis was employed to investigate the vortical structure of the wake. A classic reverse von Karman vortex street pattern is observed along the mid-span of the near wake, but three dimensional effects away from the midspan increase the wake complexity. This work is funded by NIH CNRS Grant 1R01NS054271.

Melissa A. Green
Princeton University
magreen@princeton.edu

Clarence Rowley
Princeton University
Department of Mechanical and Aerospace Engineering
cwrowley@princeton.edu

Alexander Smits
Princeton University
asmits@princeton.edu

MS89

Collision Manifolds and Point Vortex Problems

In this talk, I would like to apply a technique known as McGehee's collision manifolds in celestial mechanics into point vortex problems. Some properties about collision singularities of vortices are discussed in detail based on this technique.

Yasuaki Hiraoka
Hiroshima University
newton@usc.edu

MS89

Dynamical and Statistical Predictions of Shallow Water Models

A statistical equilibrium theory based on the Lagrangian of the rotating shallow water equations is presented with applications to cooperative features in the Jovian atmosphere. Jupiter's large planetary spin is shown to play significant role in the energy gap between cyclonic and anticyclonic structures that forms the basis for preferring the anticyclonic spots as having lower free energy than their cyclonic counterparts when the flows are non quasi-geostrophic. Simulation results show that this statistical model predicts key features of the Jovian atmosphere in a single end-state, including (1) the asymmetrical anticyclonicity of the Great Red Spot and other southern coherent vortices, (2) the high rim velocity of the GRS observed by the Voyager missions in the 1970s and unexplained since then, and (3) the Limaye bands.

Chjan C. Lim
Mathematical Sciences, RPI
limc@rpi.edu

MS89

The N-vortex Problem in Planar Multiply Connected Circular Regions

In this talk, I would like to give an explicit representation for the equation of motion for N point vortices in a bounded planar multiply connected region inside the unit circle that contains many circular boundaries. The equation is derived from an explicit formula of the Kirchhoff-Routh path function in the multiply connected domain given by Darren Crowdy. The velocity field induced by the point vortices is described in terms of the Shottky-Klein prime function associated with the multiply connected region. The explicit representation us to study the motion of N point vortices, the N-vortex problem, in the multiply connected circular regions by analytic and numerical means. We also give some recent results on this topic.

Takashi Sakajo
Hokkaido University
Department of mathematics
sakajo@math.sci.hokudai.ac.jp

MS90

Normal Forms for the PCR3BP to Detect Invariant Manifolds Close and Far from Equilibria

Using the Poincaré-Delaunay formulation of the Planar Circular Restricted Three Body Problem we consider stable and unstable manifolds of a collinear Lagrangian point. Two different normal forms are computed: one for the region close to the libration point and one for a region far away from it. This gives analytic knowledge of the manifolds in these two disconnected regions while in the intermediate zone they can be numerically approximated.

Laura Di Gregorio, Pierpaolo Pergola, Bianca Thiere
Department of Mathematics
University of Paderborn
lalla@math.upb.de, pergola@math.upb.de,
thiere@math.uni-paderborn.de

Michael Dellnitz
Institute for Mathematics
University of Paderborn

dellnitz@uni-paderborn.de

MS90

The Role of Invariant Manifolds in Solar System Models

In this paper we study the use in space mission design of the invariant stable/unstable manifolds associated to the central manifolds of libration points (or their dynamical substitutes). We also analyze some transport phenomena in the Solar System using the behaviour of the above mentioned manifolds. The study is perfomed using simplified Solar System models, such as the Restricted Three Body Problem or the Quasi-Bicircular Four Body Problem.

Elisa Maria Alessi
Departament de Matematica Aplicada
Universitat de Barcelona
elim@maia.ub.es

Elena Fantino
Departament de Matematica Aplicada I
Universitat Politecnica de Catalunya
elena.fantino@upc.edu

Yuan Ren
Departament de Matematica Aplicada
Universitat Politecnica de Catalunya
cosmo.ren@gmail.com

Gerard Gomez
Departament de Matematica Aplicada
Universitat de Barcelona
gerard@maia.ub.es

Josep Masdemont
Departament de Matematica Aplicada
Universitat Politecnica de Catalunya
josep@barquins.upc.edu

MS90

Dynamics of Tethered Satellites

Tethered satellites are believed to be useful in future space applications. The study of these applications, however, require a precise framework of mathematical models. In this work we unify existing tether models mathematically. We show that the slack tether model can be obtained from the massive tether model as a vanishing viscosity solution. The dumbbell motion is identified within the full dynamics and criteria for its stability is derived analytically.

Kristian U. Kristiansen
Department of Mathematics and Surrey Space Centre
University of Surrey
k.kristiansen@surrey.ac.uk

Phil Palmer
Surrey Space Centre
p.palmer@surrey.ac.uk

Mark Roberts
University of Surrey, UK
m.roberts@surrey.ac.uk

MS90

Stabilization of Displaced Periodic Orbits in the Solar Sail Restricted Three-body Problem

This paper investigates displaced periodic orbits in the circular restricted three-body problem with the Earth and Moon as the two primaries and the third massless body a solar sail. By making use of modern dynamical systems theory, the approximate analytical solutions are found and utilized in a numerical search to determine the displaced orbits. These periodic orbits are shown to be unstable and an optimal linear feedback control is implemented to stabilize the orbits.

Jules Simo, Colin R. McInnes
Department of Mechanical Engineering
University of Strathclyde
jules.simo@strath.ac.uk, colin.mcinnes@strath.ac.uk

MS91

Hopf Bifurcation in Coupled Cell Networks

When studying coupled cell networks of differential equations - the coupled cell systems - it is known that the network architecture affects the kinds of bifurcations that can be expected to occur. We address this question by considering Hopf bifurcation in symmetric and interior symmetric networks. We show that although in general group theoretic methods can be applied, these are not sufficient to predict the kinds of Hopf bifurcations that can occur.

Ana Paula Dias
Department of Mathematics
University of Porto
apdias@fc.up.pt

MS91

Equivalence of Coupled Systems

We describe results on dynamical equivalence of various types of network - continuous, discrete, hybrid and asynchronous. These results apply to systems with general phase spaces (such as an n-dimensional sphere) and do not assume that one can linearly combine inputs to obtain equivalence (the method employed by Stewart and Dias).

Mike Field, Nikita Agarwal,
Department of Mathematics
University of Houston
mikefield@gmail.com, nagarwal@math.uh.edu

MS91

Bifurcations from Quotient Coupled Cell Systems

A coupled cell network is coupled system of ODEs. Every coupled cell system, when restrict to a flow invariant subspace defined by equality of certain cell coordinates, is associated with a quotient network. Given a (quotient) network, we describe a general method to construct coupled cell networks admitting it as a quotient. Also, we investigate the impact of a generic codimension-one synchrony-breaking bifurcation from a synchronous equilibrium, occurring in the quotient network, for the different networks having it as a quotient network.

Manuela A. Aguiar
Faculdade de Economia
Universidade do Porto
maguiar@fep.up.pt

Ana Paula Dias

Department of Mathematics
University of Porto
apdias@fc.up.pt

Martin Golubitsky
Ohio State University
Mathematical Biosciences Institute
mg@mbi.osu.edu

Maria Leite
The University of Oklahoma
mleite@ou.edu

MS91

Bridge Theory of Coupled Cell Systems and Biological Modelling

Networks are ubiquitous in biology. The topology of a network influences its dynamics. It is therefore important to understand the generic dynamics of networks. This talk and following several others are dedicated to this subject. In this talk, we will study first the dynamics of coupled feedback loops and then discuss how the results may be used in modeling. Field will discuss ODE-equivalence. Dias, Leite, Josic will talk about how structure constrains dynamics of some specific networks. Taylor will discuss the pattern formation on the lattice network. Theoretical studies aim to help understand better the real world. Paszek and Mincheva will demonstrate what happen in mathematical modellings based on experimental data

Yunjiao Wang
The School of Mathematics
University of Manchester
Yunjiao.Wang@manchester.ac.uk

Maria Leite
The University of Oklahoma
mleite@ou.edu

MS92

Resetting Behavior of Bursting in Secretory Pituitary Cells

We study a class of models for pituitary cells for which the spikes of the active phase are transient oscillations generated by unstable limit cycles emanating from a subcritical Hopf bifurcation around a stable steady state. We discuss the distinct properties of the response to attempted resets from the silent phase to the active phase. In particular, while resetting is difficult and succeeds only in limited windows of the silent phase, paradoxically, it can dramatically exceed the native active phase duration.

Hinke M. Osinga
University of Bristol
Department of Engineering Mathematics
H.M.Osinga@bristol.ac.uk

Julie V. Stern
National Institute of Health
jvstern@aol.com

Andrew LeBeau
NIH
lebeau@helix.nih.gov

Arthur Sherman
National Institutes of Health
asherma@nih.gov

MS92

Effect of A-type Potassium Channels on Bursting in a Lactotroph Model

Addition of a fast activating/inactivating A-type potassium conductance (g_A) to a model of pituitary lactotroph switched the electrical activity from spiking to bursting. At high g_A, the bursting pattern was controlled by the slow dynamics of intracellular calcium as in classical bursting models. However, for low g_A, the bursting pattern was still present when calcium was clamped. In this talk, I will present a mechanism for this type of bursting "without a slow variable".

Joel Tabak
Dept of Biological Sciences
Florida State University
joel@neuro.fsu.edu

MS92

Bursting in a Somatotoph Cell Model

Pituitary somatotrophs release growth hormone in response to spontaneous calcium entry through voltage-gated calcium channels (VGCC), which is governed by plateau-bursting electrical activity and is regulated by several neurohormones, including GH-releasing hormone (GHRH) and somatostatin. We combine experiments and theory to clarify the mechanisms underlying spontaneous and receptor-controlled electrical activity. In the model, the plateau-bursting is controlled by two functional populations of BK channels, characterized by distance from the VGCC. The rapid activation of the proximal BK channels is critical for the establishment of the plateau, whereas slow recruitment of the distal BK channels terminates the plateau. The model is compatible with a wide variety of experimental data involving pharmacology and ion substitution. Similar to other models of hormone secreting cells (eg. pancreatic beta-cells) the plateau-bursting in the somatotroph model results form the interplay between VGCC and calcium sensitive potassium channels. However the beta-cell (square-wave or fold-homoclinic) bursting relies on the existence of a supercritical Hopf bifurcation in the fast subsystem while somatotroph bursting requires fold-subHopf structure. We study the transition between those two types of bursting and show that it could be accounted for by a single physiologically plausible control parameter. Some theoretical as well as experimental implications of this result will be discussed.

Krasimira Tsaneva-Atanasova
Department of Engineering Mathematics
University of Bristol
K.Tsaneva-Atanasova@bristol.ac.uk

Arthur S. Sherman
National Institute of Health
sherman@helix.nih.gov

Hinke M. Osinga
University of Bristol
Department of Engineering Mathematics
H.M.Osinga@bristol.ac.uk

MS92

Multiple Time Scales, Bursts, and Canards in a Pituitary Cell Model

Tabak et al. showed that clamping calcium in a pituitary lactotroph model does not stop the cell from bursting which suggests an intrinsic bursting mechanism independent of calcium. We are able to identify different time scales in the reduced, calcium clamped model and hence, a multiple time-scales analysis is possible. We then show that the bursting behaviour can be explained via the canard phenomenon. A special feature of this model is the form of the 2D slow manifold which changes from cubic-shaped to cusp-shaped under the variation of the main control parameter. This has profound consequences on the global return mechanism within the relaxation oscillatory bursting pattern.

Martin Wechselberger, Theodore Vo
University of Sydney
wm@maths.usyd.edu.au, thvo4579@mail.usyd.edu.au

MS93

Dynamics in Auditory Cortex

The responses of neocortical cells to sensory stimuli are variable and state-dependent. Although it has been hypothesized that intrinsic cortical dynamics play an important role in trial-to-trial variability, the precise nature of this dependence is poorly understood. We show here that in auditory cortex, population responses to click stimuli can be quantitatively predicted on a trial-by-trial basis by a simple dynamical system model estimated from spontaneous activity immediately preceding stimulus presentation. This suggests that the complex and state-dependent pattern of trial-to-trial variability can be explained by a simple principle: that sensory-evoked responses are shaped by the same intrinsic cortical dynamics that govern ongoing spontaneous activity.

Carina Curto
New York University
curto@courant.nyu.edu

MS93

Phase Response Curve in the Presence of Noise

Many neurons exist in a noisy environment. This noise can affect both the firing properties of these neurons as well as their responses to inputs and to other neurons. In this talk, I use perturbation theory to explore the phase-dependence of the variance of noisy neural oscillators and the consequence of this for both coding efficiency (Fisher information) and their ability to synchronize in networks.

Bard Ermentrout
University of Pittsburgh
bard@pitt.edu

MS93

Spike-time Reliability of Layered Neural Oscillator Networks

This talk concerns the reproducibility, or *reliability,* of the response of large neural oscillator networks to fluctuating stimuli. Focusing on a class of layered networks, we show – via qualitative theory and simulations – that individual neurons can be reliable or unreliable depending on network conditions, but pooled responses of sufficiently large subsystems are typically reliable. In addition, it will be shown that some types of noise affect reliability more seriously than others.

Kevin K. Lin
Department of Mathematics
University of Arizona
klin@math.arizona.edu

Eric Shea-Brown
Department of Applied Mathematics
University of Washington
etsb@amath.washington.edu

Lai-Sang Young
Courant Institute of Mathematical Sciences
New York University
lsy@cims.nyu.edu

MS93

Epithelial Oscillations Enhance Information Transmission and Signal Detection in Ampullary Electroreceptors

We report on the role of stochastic epithelial oscillations (EO) in peripheral ampullary electroreceptors. Using modeling we contrast signal detection and information transfer by electroreceptors in two situations: (i) when EO are coherent, and (ii) when the coherence of EO is destroyed. We show that the coherent oscillations lead to significant enhancement of information transfer and to enhanced discriminability of weak signals. Models predictions are supported by the analysis of experimental recording from the paddlefish electroreceptors.

Alexander Neiman
Ohio University
Athens, OH
neiman@helios.phy.ohiou.edu

Tatiana Engel
Department of Neurobiology
Yale University School of Medicine
tatiana.engel@yale.edu

Ibiyinka Fuwape
Department of Physics and Astronomy
Ohio University
fuwape@helios.phy.ohiou.edu

David Russell
Department of Biological Sciences
Ohio University
russeld2@ohio.edu

Lutz Schimansky-Geier
Institute for Physics
Humboldt University at Berlin
alsg@physik.hu-berlin.de

MS94

An Explicit Theory for Pulses in Singularly Perturbed Reaction-diffusion Equations

In recent years, various authors have developed methods to study the existence, stability and bifurcations of pulses in a number of model problems, such as the Gray-Scott and the Gierer-Meinhardt equations. Although these methods are in principle of a general nature, they do rely heavily on the characteristics of these models. For instance, the slow spatial problem is linear in the models. This fact is crucially used in the stability analysis. Here, we present and apply a significantly extended explicit theory for pulses in the most general (singularly perturbed) setting.

Arjen Doelman
CWI Amsterdam, the Netherlands
A.Doelman@cwi.nl

MS94

Bifurcations of a Nonlinear Mathieu-wave Equation

We will start with two averaging-normalization theorems for nonlinear evolution equations. As we will show, the combination of averaging and numerical bifurcation techniques (MATCONT) is very powerful. We demonstrate this for a parametrically excited wave equation to find an almost-invariant 6d manifold with periodic solutions bifurcating into 2-tori and 3-tori.

Ferdinand Verhulst
Department of Mathematics
Utrecht University
F.Verhulst@uu.nl

MS94

Bifurcation Analysis and Computation of Travelling Waves in a Non-equilibrium Richard's Equation

In this talk a model from hydrology is presented which is related to the conventional Richards equation to describe the flow of water in unsaturated porous media. The extension of the Richards equation to take into account additional dynamic memory effects was suggested by Hassanizadeh and Gray in the 90's. This gives rise to an extra mixed space-time derivative term in the PDE model. It is possible, by using a travelling wave coordinate formulation, to analyse the related dynamical system in the phase plane. We derive, that below a certain threshold value of the dimensionless relaxation coefficient τ, we expect monotonous waves for the PDE (stable node in the phase plane), whereas, for higher values of τ it is shown that waves will appear with small oscillations on top of the wave (stable spiral point n the phase plane). In two space dimensions, this phenomenon is often connected to so-called gravity-driven finger structures. To support the above analysis, the full PDE solution is numerically computed by an adaptive grid PDE method which is based on smoothed equidistribution enhanced by a smartly chosen time-dependent adaptivity parameter in the monitor function. Theory from applied analysis is shown to fit nicely with numerical experiments.

Paul A. Zegeling
Department of Mathematics
Utrecht University
P.A.Zegeling@uu.nl

MS94

Vegetation Patterns and Busse Balloons

Vegetation patterns play a crucial role in desertification problems, i.e. at the (in general irreversible) transition from a vegetated area to a desert. This process has been modeled by several types of reaction-diffusion problems. In an idealized setting, a vegetation pattern is a spatially periodic solution of the model. Desertification takes place as this pattern destabilized and bifurcates. In this talk we discuss typical characteristics of the Busse balloon, i.e. the region in (wave number, parameter)-space of stable spatially periodic patterns, associated to an extended Klausmeier model for desertification.

Sjors van der Stelt
Korteweg-de Vries Instituut
University of Amsterdam
S.vanderstelt@uva.nl

MS95

Lyapunov Exponents in Nonuniformly Hyperbolic Dynamics

Given a smooth dynamical system, we study level sets of Lyapunov regular points with equal exponent. Possible measures for the "complexity" of such level sets are their Hausdorff dimension or their topological entropy (i.e. the entropy of the dynamical system restricted to it). If the dynamics is not uniformly hyperbolic, then the set of points with zero Lyapunov exponent can be considered to be quite large or small (when measured e.g. in terms of dimension and entropy). This is investigated by means of the thermodynamic formalism for sub-systems which are uniformly hyperbolic. Such a scheme can be successfully applied to primary examples of conformal dynamics such as parabolic interval maps and rational maps on the Riemann sphere. But principle techniques also extend to surface diffeomorphisms and certain flows in 3-dimensional manifolds.

Katrin Gelfert
Northwestern University
gelfert@pks.mpg.de

MS95

Applications of Large Deviations to Extreme Value Theory for Dynamical Systems

Extreme value theory for dynamical systems concerns the distribution of successive maxima or minima of the time-series arising from an observable on a dynamical system. We illustrate some applications of Large Deviations for dynamical systems to this theory, such as for obtaining extreme value laws for hyperbolic billiards and Lozi-like maps. We also illustrate an application to deriving almost sure recurrence results for the phase space from the induced system.

Chinmaya Gupta
University of Houston
ccgupta@uh.edu

MS95

Large Deviations for Nonuniformly Hyperbolic Dynamical Systems

Large deviations theory is concerned with the probability of outliers in the convergence of scaled Birkhoff sums of an observable on an ergodic dynamical system to the mean of the observable. We obtain large deviation estimates for a large class of nonuniformly hyperbolic systems: namely those modeled by Young towers with summable decay of correlations. In the case of exponential decay of correlations, we obtain exponential large deviation estimates given by a rate function. In the case of polynomial decay of correlations, we obtain polynomial large deviation estimates, and exhibit examples where these estimates are essentially optimal.

Matthew Nicol
University of Houston
nicol@math.uh.edu

Ian Melbourne
University of Surrey
Department of Mathematics and Statistics
i.melbourne@surrey.ac.uk

MS95

Thermodynamic Formalism for Multimodal Maps

Thermodynamic formalism provides a wealth of statistical information for a dynamical system. In particular it gives us the important measures: equilibrium states. It also gives us a way to understand the properties of these measures, for example how they scale at various points in the space, and the large deviations properties of the system. I will explain recent progress in the use of thermodynamic formalism in the study of non-uniformly expanding interval maps.

Mike Todd
University of Porto
mtodd@fc.up.pt

MS96

On Highly Nonlinear Linear Fokker Planck Equations

I will study the occurrence of anomalous diffusion and its associated family of statistical evolution equations. Starting from a non-Markovian process a la Langevin I will show that the mean probability distribution of the displacement of a particle follows a generalized non-linear Fokker-Planck equation. The general results can be applied to a wide range of physical systems that present a departure from the Brownian regime.

Miguel Fuentes
Santa Fe Institute
fuentesm@santafe.edu

MS96

Stochastic Resonance and Noise-induced Synchronization in the Human Brain

We provide the first experimental evidence that stochastic resonance within the human brain can enhance behavioral responses to weak visual inputs. We also demonstrate that both detection of weak visual signals and phase synchronization of electro-encephalogram (EEG) signals from widely separated areas of the human brain are increased by addition of weak visual noise. These results imply that noise-induced large-scale neural synchronization may play a significant role in information transmission within the human brain.

Keiichi Kitajo
Brain Science Institute, RIKEN
kkitajo@brain.riken.jp

MS96

Parallels Between the Dynamics at the Noise-perturbed Onset of Chaos in Logistic Maps and the Dynamics of Glass Formation

Abstract not available at time of publication.

Alberto Robledo
Instituto de Fisica, UNAM
robledo@fisica.unam.mx

MS96

Revisiting Noise-induced Order

Noise induced phenomena in Belousov-Zhabotinsky map (BZ map) are investigated. We found that (i) noise induced chaos and noise induced order coexist depending on size of fluctuation of noise, and that (ii) these phenomena are robustly observed in window region of BZ map indicated by numerically calculated Lyapnov exponents. A physically tractable framework for random dynamics studies is proposed to study weak chaos and its observability.

Yuzuru Sato
RIES, Hokkaido University
ysato@math.sci.hokudai.ac.jp

MS97

Mathematical Models and Measures of Mixing: Part I

Mixing by stirring can be measured in a variety of ways including tracer particle dispersion, the scalar flux-gradient relationship, or via suppression of scalar density variation in the presence of inhomogeneous sources and sinks. The mixing efficacy of a flow is often expressed in terms of enhanced diffusivity and quantified as an effective diffusion coefficient. In this work we compare and contrast these various notions of effective diffusivity. Via thorough examination of a simple shear flow mixing a scalar sustained by a steady source-sink distribution, we explore apparent inconsistencies and propose a conceptual approach that captures some compatible features of these different models and measures of mixing. Part II of this talk is in MS108.

Katarina Bodova, Zhi Lin
Department of Mathematics
University of Michigan
kbodova@umich.edu, linzhi@umich.edu

Charles R. Doering
University of Michigan
Mathematics, Physics and Complex Systems
doering@umich.edu

MS97

Modulational Instabilities of Periodic Waves of equations of Korteweg-Devries type

We consider the stability of spatially periodic traveling wave solutions to equations of Korteweg-DeVries type. We derive two indices which detect the presence of instability. The first index detects instabilities associated to eigenvalues on the real axis. The second detects bands of spectrum which emerge from the origin off of the imaginary axis. Both of these indices can be expressed in terms of the map from the constants of integration of the traveling wave ODE to the conserved quantities of the PDE, and thus admit an interpretation in terms of Whitham modulation theory.

Jared Bronski
University of Illinois Urbana-Champain
Department of Mathematics
jared@math.uiuc.edu

MS97

Internal Wave Induced Shear Instability

Recent advancements in field observation techniques have re- vealed that large internal gravity waves are a common occurrence in ocean flows. Because of the waves' large amplitudes, self-generated shear instabilities become possible and offer a breaking mechanism in alternative to that familiar from overturning of surface waves. The resulting fluid motion plays a relevant role in the mixing and transport phenomena within the ocean. Experimental observations for near two-layer stratification show evidence of shear instability in the form of Kelvin Helmholtz bellows originating around the region of maximum displacement of the pycnocline. In an effort to understand the precise mechanism of instability, we simulate numerically the generation and propagation of solitary waves starting from a step function initial con- dition, and monitor the wave-induced shear instabilities. The parameters of the simulation and the overall set-up are chosen to represent as closely as possible that of an experimental facility. A conservative projection method for the variable density Euler equations is implemented and validated against experimental data, as well as theoretical results from computing the eigenmodes of the associated linearized problem around a travelling wave solution.

Roberto Camassa
Mathematics
UNC Chapel Hill
camassa@email.unc.edu

MS97

The Exact Evolution of the Scalar Variance in Pipe and Channel Flow

In 1953 G.I. Taylor showed theoretically and experimentally that a passive tracer diffusing in the presence of laminar pipe flow would experience an enhanced diffusion in the longitudinal direction beyond the bare molecular diffusivity, D, in the amount $a^2U^2/(192D)$, where a is the pipe radius and U is the maximum fluid velocity. This behavior is predicted to arise after a transient timescale a^2/D, the diffusive timescale for the tracer to cross the pipe. Typically, D is very small, so provided a fairly long time has passed, this is a very large diffusive boost. Before this timescale, the evolution is expected to be anomalous, meaning the scalar variance does not grow linearly in time. Some elements of this anomalous growth can be understood using free space approximations and have been explored in the literature, but a full rigorous description at intermediate times requires a more careful study. Based on a microscopic approach, we provide an exact description of the scalar variance evolution valid for all times for channel and pipe flow. We show how this formula limits to the Taylor regime, and study rigorously the anomalous regime demonstrating its sensitivity on the initial data. We find that the anomalous exponents depend nontrivially upon the form of the data, and further explore what features the free space approximations capture. This work is in close collaboration with Roberto Camassa (UNC) and Zhi Lin (Michigan)

Richard McLaughlin
Applied Mathematics
UNC Chapel Hill
rmm@email.unc.edu

MS98

Stochastic and Deterministic Models of Avian Influenza

Markov chains and their deterministic mean-field approximations (MFA) are popular models in biology. However, MFA often fail to represent the expectations of corresponding Markov chains. We discuss this failure for a transmission model of avian influenza in wild waterfowl. We explain why the epidemic-free region of the Markov chain is, in this case, much larger than that of its MFA. Nevertheless, we conclude the MFA greatly helps understanding the Markov chain dynamics.

Romulus Breban, John Drake
School of Ecology
University of Georgia
breban@gmail.com, jdrake@uga.edu

David Stallknecht
Southeastern Cooperative Wildlife Disease Study
University of Georgia
dstall@vet.uga.edu

Pejman Rohani
Institute of Ecology
University of Georgia
rohani@uga.edu

MS98

Use of Nonlinear Data Analysis Techniques in the Detection of Disease Clusters

Finding clusters or hot spots of disease over a wide spatial area is a priority of many epidemiologists and health departments. Our research centers on using techniques from nonlinear data analysis and information theory together with an agent-based particle-mesh heuristic clustering algorithm to find clusters of disease. We test our algorithm with geographically distributed data from both sparsely and densely populated areas using specifically targeted artificially injected disease clusters on top of the real data.

Linda Moniz
Applied Physics Laboratory
Johns Hopkins University
Linda.Moniz@jhuapl.edu

William Peter
Johns Hopkins University
Applied Physics Laboratory
bill.peter@jhuapl.edu

MS98

Will Pre-Exposure Prophylaxis Increase Transmission of Drug-resistant HIV? Insights from an Ordinary Differential Equation (ODE) Model

A very promising HIV-prevention method, Pre-Exposure Prophylaxis (PrEP), is currently being evaluated in clinical trials. However, there are concerns that some people may become infected despite taking PrEP and thus select and transmit drug-resistant viruses. We constructed a complex ODE model to predict the consequences of widescale usage of PrEP at the population level. Surprisingly, we found that levels of transmitted drug resistance will increase but not because of selection of resistance due to PrEP.

Virginie Supervie
Semel Institute for Neuroscience and Human Behavior
University of California, Los Angeles
v.supervie@gmail.com

Gerardo Garcia-Lerma
2Centers for Disease Control and prevention
Atlanta, Georgia
jng5@cdc.gov

Walid Heneine
Centers for Disease Control and prevention
Atlanta, Georgia
wmh2@cdc.gov

Sally Blower
Semel Institute of Neuroschience and Human Behavior
UCLA
sblower@mednet.ucla.edu

MS98

Modeling Control Measures of Smallpox Attack Outbreaks

In recent years, the threat of biologic terrorism and warfare has ignited the debate about whether to reintroduce smallpox vaccination. An additional or alternative control measure to vaccination is to use antiviral compounds for prophylaxis and/or treatment. Although providing for antiviral therapy is more expensive than vaccination, recent experiments indicate that they could be significantly more effective in reducing morality and number lesions. We construct both a deterministic and stochastic model that allows us to predict the evolution of a smallpox outbreak under alternative epidemic control measures that combines either or both therapeutics and vaccination. We use our models to estimate the impact of these control policies in the event of hypothetical smallpox attacks of different scales. We assess the health and cost trade-offs of the different control measures for the US population.

Raffaele Vardavas
RAND Health
RAND, CA
rvardava@rand.org

Spencer Jones
RAND Health Communications
sjones1@rand.org

Rob Boer
Pfizer
fietsrob@gmail.com

Samuel Bozzette, Shinyi Wu
RAND Health
sambozzette@yahoo.com, shinyi@rand.org

MS99

Constructing Mostly Conjugate Models to Chaotic Flows within Dynamical Systems

We address a fundamental modeling issue in science as related to dynamical systems: when is a toy model of a physical system a good representation? When nonconjugate systems are compared, we which to give quality of comparison. We show that a fixed point iteration scheme yields a limit point, that is a function we call a commuter that by a defect measure suggests dynamical proximity of models. We develop models for ODEs and Maps.

Erik Bollt
Clarkson University
bolltem@clarkson.edu

MS99

A Chaotic Differential Equation with an Exact Symbolic Dynamics

We show a continuous-time chaotic set can be defined using a driven linear differential equation. A nonlinear differential equation is derived for which this set is an exact analytic solution. This nonlinear system describes a chaotic semi-flow, and a return map is conjugate to a chaotic shift map. An extension to the differential equation yields an invertible flow with a return map conjugate to the bakers map. Significantly, these systems provide the first examples of which we are aware of chaotic ordinary differential equations possessing an exact symbolic dynamics.

Ned J. Corron
U.S. Army RDECOM
ned.corron@us.army.mil

MS99

Symbolic Dynamics of a Chaotic Hybrid System

We develop a dynamical system that is both chaotic and exactly solvable. The system is a hybrid system containing both continuous and discrete-valued states. An analytic solution is obtained and is shown to exhibit better stability properties than previous examples. This system allows for a clear exposition of the connection between nonlinear dynamics, information theory and statistical physics.

Lucas Illing
Reed College
illing@reed.edu

MS99

Paucity of Attractors

We study the number of attractors supported by a unimodal map driven by a repeating signal. Interestingly, with increasing drive signal length the system exhibits a paucity of attractors. That is, the probability that a randomly choosen signal results in multi-attractors goes to zero for long drive signals. This mechanism may play a role in allowing complex multi-stable systems to respond consistently to external influences.

Shawn Pethel
U.S. Army RDECOM
shawn.pethel@us.army.mil

MS100

Numerical Studies of vortex–body Interactions in

Flexible Biomorphic Systems

The structures that enable propulsion in airborne and aquatic creatures are generally flexible. Through such flexibility, the structures – tail, fins, or wings – will passively respond to disturbances in the fluid environment in which the creature operates. These disturbances may be self-generated – for example, when a flapping wing re-encounters its own shed vorticity during the following stroke – or may be produced externally, such as the vortical wake of an upstream obstacle. In either case, the passive response of the structure affects its propulsive characteristics, sometimes with advantageous consequences, and it is of interest to analyze such vortex-structure interactions in abstracted model problems. In this work, we conduct high-fidelity numerical simulations with a viscous vortex particle method coupled with body dynamics to analyze two problems that are representative of vortex-body interactions. In the first problem, a flexible flapping wing in hovering mode is considered. Various kinematic regimes lead to widely different vortex pairing patterns and significant changes in lift generation. In the second, an articulated three-body system with free hinges is placed in the wake of a cylinder. Even several diameters downstream, the system has a profound effect on the vortex shedding of the cylinder, and tends to propel itself upstream.

Jeff D. Eldredge, Jonathan Toomey, David Pisani
University of California, Los Angeles
Mechanical & Aerospace Engineering
eldredge@seas.ucla.edu, toomey@seas.ucla.edu, pisanid@ucla.edu

MS100

Far-field Vortex Structure in Flapping-flight Problem

Insects flap their wings periodically to generate vortices separated from the wing; these are essential to achieve high performance in force generation and manoeuvring. The general theoretical analysis of such vortex-using flapping flight based on the Navier-Stokes equations has not thus far been achieved. In this talk, we start with the analysis of several numerical models which incorporate flapping motion, vortex separation and centroidal motion. Then, we will present a theoretical paradox concerning the flight of insects in two-dimensional space: insects maintaining their bodies in a particular position (hovering) cannot, on average, generate hydrodynamic force if the induced flow is temporally periodic and converges to rest at infinity. On the basis of these assumptions, the relationship between this paradox, the results of numerical models and real insects that actually achieve hovering will be discussed.

Makoto Iima
Research Institute for Electronic Science
Hokkaido University
makoto@nsc.es.hokudai.ac.jp

MS100

An Inviscid Model for Vortex Shedding in Fish Swimming

The net locomotion of a deformable body submerged in an infinite volume of fluid depends critically on the dynamic coupling between the body shape deformations and the unsteady motion of the surrounding fluid. A mathematical description of this coupling at finite Reynolds numbers would require taking into account the detailed effects of viscosity which are primarily manifested in the dynamics of the thin shear layers around the body that separate at the body tail to create vortical structures. In this talk, we propose an idealized model for the swimming of a deformable body in response to prescribed (actively controlled) shape deformations and the effect of wake vorticity. The vortex wake is modeled using pairs of point vortices shed periodically from the tail of the deformable body. This low-order modeling approach allows one to isolate and examine the role of the vortex wake in achieving a net locomotion.

Eva Kanso
University of Southern California
kanso@usc.edu

MS100

Momentum-Conserving Models for Aquatic Locomotion through Discrete Vortex Shedding

The shedding of vorticity from solid surfaces is central to the locomotion of a variety of marine animals and aquatic vehicles. Hydrodynamic models which account for the viscous physics underpinning vortex shedding are frequently too complex to be studied analytically or to be used for model-based control design. We describe an approach to introducing thrust-producing vortex shedding to Hamiltonian models for the locomotion of deformable bodies in inviscid fluids.

Scott Kelly
Department of Mechanical Engineering
UNC-Charlotte
scott@kellyfish.com

MS101

Pulling and Twisting Helices: From Geometry to Experiments

Helices are one of the simplest and most ubiquitous curves found in nature. In particular, many experiments on single proteins and nano-tubes consist in pulling and twisting helical structures and measuring the corresponding strains. In this talk, I will first review some classical and new properties of helices. Then, I will consider elastic helical filaments which correspond to uniform equilibria of Kirchhoff's rod theory. I will show how a complete geometric classification of such solutions can be accomplished. This analysis will provide a mathematical basis on how to best extract elastic parameters from data.

Alain Goriely
University of Arizona
Program in Applied Mathematics
goriely@math.arizona.edu

Bojan Durickovic
Program in Applied Mathematics
University of Arizona
bojan@math.arizona.edu

MS101

A Generalized Approach to Stability of Nonlinearly Elastic Rods in the Presence of Constraints

We present a unified approach to the stability of equilibria for nonlinearly elastic rods, subjected to general loadings, boundary conditions and constraints (both point-wise and integral type), based upon the linearized dynamic stability criterion. Discretization of the governing equations leads to a generalized eigenvalue matrix problem. An efficient, sparse-matrix friendly algorithm is used to determine its first few left-most eigenvalues, which, in turn, yield stability/instability information. For conservative problems, our formulation is shown to be equivalent to that arising in the determination of constrained local minima of the potential energy. Our approach has the same computational efficiency as the conjugate-point method, the latter of which is convenient in the case of Dirichlet boundary conditions and integral constraints. In addition, the proposed method is applicable to mixed and/or Neumann boundary value problems, to non-conservative problems, and/or to problems in the presence of pointwise constraints. We illustrate the method with several examples.

Tim Healey
Cornell University
Theoretical & Applied Mechanic
Email tjh10@cornell.edu

Ajeet Kumar
Theoretical & Applied Mechanics
Cornell University
ak428@cornell.edu

MS101
Conjugate Point Test for Stability of Elastic Rod Configurations Subject to a Repulsive Self-contact Potential

We generalize the Jacobi conjugate point test to determine the stability of equilibrium configurations of an elastic rod subject to a repulsive self-contact potential. Computationally, conjugate point determination requires the solution of a system of integrodifferential equations (coupled to the integrodifferential equilibrium equations). We compute the stability of families of 2D rod configurations determined via parameter continuation using the NOX/LOCA package.

Robert S. Manning
Mathematics Department
Haverford College, Haverford
rmanning@haverford.edu

Kathleen A. Hoffman
University of Maryland, Balt. Co.
Deapartment of Math. and Stat.
khoffman@math.umbc.edu

MS101
Magnetically-induced Localised Buckling of a Conducting Elastic Rod

We use an elastic rod model to study the magnetically-induced buckling of a conducting wire, motivated by stability problems of electrodynamic space tethers. The governing non-canonical Hamiltonian equations are found to be completely integrable if the rod is transversely isotropic. Remarkably, unlike in the non-magnetic case, extensibility of the wire destroys integrability, leading to a multiplicity of localised solutions and spatial chaos. A codimension-two Hamiltonian Hopf-Hopf bifurcation is found to act as an organising centre.

Gert van der Heijden
Department of Civil, Environmental and Geomatic Engineering
University College London
g.heijden@ucl.ac.uk

MS102
Stimulus-Dependent Correlations and Population Codes

The magnitude of correlations between stimulus-driven responses of pairs of neurons can itself be stimulus-dependent. I will examine how this dependence impacts the information carried by neural populations about the stimuli that drive them. Stimulus-dependent changes in correlations can both carry information directly and modulate the information separately carried by the firing rates and variances. Fisher information and other measures will be used to quantify these effects and show that, although stimulus dependent correlations often carry little information directly, their modulatory effects on the overall information can be large.

Kresimir Josic
University of Houston
Houston, TX
josic@math.uh.edu

MS102
Oscillations in Biochemical Reaction Networks

Understanding the dynamics of interactions in complex biochemical reaction networks is an important problem in cellular biology. Mathematical models of biochemical networks lead to dynamical systems with many unknown parameters. A bipartite graph associated with a biochemical reaction network can be used to predict oscillations based only on the network's structure without knowing parameter values. We will discuss general graph-theoretic conditions for oscillations associated with a positive cycle or a negative cycle.

Maya Mincheva
Northern Illinois University
mincheva@math.niu.edu

MS102
Oscillations and Feedback Regulation in NF-kappaB Signaling

Feedback regulation is a common structural motif controlling dynamics of genetic networks. Here we discuss how negative and positive feedbacks contribute to the control of temporal and spatial activity of transcription factor NF-kappaB in immune response and inflammation. Our theoretical and experimental advances implicate that negative feedback regulation in the system is crucial for modulation of NF-kappaB oscillations whereas positive feedback due to cytokine production plays important role in cell-to-cell communication and signal proliferation.

Pawel Paszek
University of Liverpool
p.paszek@liverpool.ac.uk

Michael White
Liverpool University
mwhite@liv.ac.uk

MS102
Discrete Snaking: Localized States in One, Two

and More Dimensions

We consider discretized, nonlinear diffusion equations on lattices of nearest-neighbour and next-nearest-neighbour coupled cells. Bifurcations to spatially periodic patterns occur from the trivial state, and saturate at finite amplitude even when the 'diffusive' coupling terms have negative coefficients. A variety of localized states also arise: we compare the bifurcation structure in one and two dimensions with the spatially continuous canonical case. Finally, we discuss applications in physics and biology.

Chris Taylor
DAMTP, University of Cambridge
C.Taylor@damtp.cam.ac.uk

Jonathan Dawes
University of Bath
J.H.P.Dawes@bath.ac.uk

MS103

Effective Dynamics in Nonlinear Lattices

We consider for general nonlinear lattices the macroscopic dynamics of modulated pulses. The latter are obtained by modulating macroscopically in space and time the amplitudes of plane wave solutions to the linearized (microscopic) lattice model. We present various ansatzes which can be made by assuming different amplitude-, time- and space-scalings, and explain the method for deriving and justifying rigorously the macroscopic evolution equations for the corresponding amplitudes. Moreover, time permitting, we present a general framework showing how the Hamiltonian and Lagrangian structures of the obtained macroscopic dynamics can be derived directly from the mentioned structures of the microscopic lattice model.

Johannes Giannoulis
TU Muenchen
Zentrum Mathematik
giannoulis@ma.tum.de

MS103

Coherent Structures in Hamiltonian lattices

This talk gives an overview over some common aspects of the problems discussed in this minisymposium, and aims to bridge between the following topics: (i) Existence, computation, and qualitative properties of several types of coherent structures, (ii) Modulations and macrosocopic dynamics of coherent structures. To this end we consider simple Hamiltonian lattices, and introduce different types of coherent structures like wave trains, fronts, or KdV-like solitons. Then we discuss various scalings of space and time, and show how these give rise to different models for the macroscopic dynamics.

Michael Herrmann
Oxford Centre for Nonlinear PDE
Mathematical Institute, University of Oxford
Michael.Herrmann@maths.ox.ac.uk

MS103

Integrable Continuum Approximations for the Fermi-Pasta-Ulam Lattice

The Fermi-Pasta-Ulam experiment is famous for the unexpected recurrent behavior of long waves. Attempts to explain this observation usually involve an approximation by a KdV equation and a non-rigorous KAM argument. A rigorous justification of the KdV approximation for finite times was given only recently, independently by Bambusi-Ponno and Wayne-Schneider. In this talk I will show how to derive the KdV equation as a resonant normal form, and I will present an improvement to this first approximation. This is a step towards the justification of the so-called metastability scenario.

Bob Rink
Department of Mathematics
Free University of Amsterdam
brink@few.vu.nl

MS103

The Role of Spinodal Region in the Kinetics of Lattice Phase Transitions

Martensitic phase transitions in crystalline solids are commonly modeled on the continuum level with a nonconvex elastic energy, with phase boundaries represented by strain discontinuities. Subsonic phase boundaries violate the Lax condition, leading to a nonuniqueness of solutions of the associated Riemann problem unless an additional kinetic relation is prescribed. This relation links the rate of energy dissipation due to the moving phase boundary to its velocity and is not provided by the continuum theory. In the earlier work with L. Truskinovsky we derived an explicit kinetic relation by replacing the continuum model with its natural discrete analog. Specifically, we considered a one-dimensional Hamiltonian lattice model of phase transitions which included a two-parabola interaction potential between the nearest neighbors and also took into account an arbitrary number of harmonic long-range interactions. Accounting for the energy carried away by the phonons emitted by a moving phase boundary, we calculated the rate of macroscopic dissipation as the function of the velocity of the phase boundary, thus obtaining the closing kinetic relation for the continuum theory. In this talk I will show how these results can be extended to the case of three-parabola interaction potentials with non-degenerate spinodal (nonconvex) region and discuss how the width of the spinodal region affects the kinetics of a phase boundary in a lattice.

Anna Vainchtein
Department of Mathematics
University of Pittsburgh
aav4@pitt.edu

MS104

High-performance Computation for Path Problems in Graphs

Directed graphs model influence and interaction in biological networks and in dynamical systems generally. The path structure of graphs is used to determine chains of influence, irreducible components, and various measures of centrality. We discuss directions and challenges for high-performance computation of path structure in large graphs. We highlight our work on new data structures and algorithms for a novel sparse matrix multiplication primitive, and our implementations on hybrid multicore architectures.

Aydin Buluc, John R. Gilbert
Dept of Computer Science
University of California, Santa Barbara
aydin@cs.ucsb.edu, gilbert@cs.ucsb.edu

MS104
Graph Decomposition for Biological Networks

We explore horizontal-vertical decomposition (HVD) method on metabolic networks of 42 organisms. We show that HVD helps to significantly reduce the dimension of ODE system needed to find trajectory of a given metabolite concentration. To further reduce complexity, we propose cutting several vertices of highest degrees (hubs) from the network. Cutting as few as 10 hubs reduces the number of edges by a factor of two, making the structure of the network more apparent and analyzable.

Alice Hubenko
UCSB
Department of Mechanical Engineering
hubenko@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

MS104
Coarse Grained Analysis of Graph Dynamic Evolution

I will discuss the use of equation-free techniques to study the dynamics of evoving networks. The case studies will include examples where only the topology of a network evolves, as well as cases where the state on the nodes of a fixed network, or the state on the nodes of a changing network also evolve. I will demonstrate the use of coarse projective integration as well as coarse fixed point/ bifurcation techniques. I will also discuss the case of using datamining tools (and, in particular, diffusion maps) to extract good observables from network simulation data.

Yannis Kevrekidis
Princeton
yannis@princeton.edu

MS104
Computing with Graphs in Star-P

Star-P is a parallel implementation of the Matlab(R) programming language. Its first class support for sparse matrices can be used to build graph algorithms in the familiar language of linear algebra. The Star-P system manages array level parallelism, freeing users from worrying about low-level parallel programming with MPI, and allows them to focus on algorithms instead. We will describe how one may express common graph primitives in such an array-based programming environment and applications we have built using this infrastructure.

Viral B. Shah
Interactive Supercomputing
vshah@interactivesupercomputing.com

John R. Gilbert
Dept of Computer Science
University of California, Santa Barbara
gilbert@cs.ucsb.edu

Steve Reinhardt
Interactive Supercomputing
spr@interactivesupercomputing.com

MS105
Orbital Stability of Periodic Waves for Generalized KdV

It will be demonstrated that spatially periodic waves to the KdV equation are orbitally stable when the perturbation is periodic with the period being some integral multiple of the period of the underlying wave. Exploiting the integrability of the system is a key ingredient in the proof.

Todd Kapitula
Department of Mathematics
Calvin College
tkapitula@gmail.com

Bernard Deconinck
University of Washington
bernard@amath.washington.edu

MS105
Nonlinear Stability of Plane Wave Solutions of the Nonlocal Nonlinear Schrodinger Equation

We study nonlinear stability of plane wave solutions of a nonlocal nonlinear Schrodinger equation. The nonlocal potential appears in a variety of problems and the familiar cubic nonlinearity in NLS can be obtained in a delta function approximation. Including the nonlocality gives a more meaningful description of microscopic interactions which has a profound effect on the dynamics.

Richard Kollar
University of Michigan
Department of Mathematics
kollar@umich.edu

Beranrd Deconinck
University of Washington
bern4rd@gmail.com

Brandon Bale
Aston University, Birmingham, UK
bgbale@hotmail.com

Nathan Kutz
University of Washington
kutz@amath.washington.edu

MS105
Stability of Traveling Waves in Quasi-linear Hyperbolic Systems with Relaxation and Diffusion

We establish the existence and the stability of traveling wave solutions of a quasi-linear hyperbolic system with both relaxation and diffusion. The traveling wave solutions are shown to be asymptotically stable against small perturbations provided that the diffusion coefficient is bounded by a constant multiple of the relaxation time. The result provides an important first step toward the understanding of the transition from stability to instability as the diffusion coefficient increases.

Tong Li
Department of Mathematics
University of Iowa
tli@math.uiowa.edu

MS105

Multi-dimensional Stability of Noncharacteristic Boundary Layers in Gas Dynamics

In this talk, we present our recent results on asymptotic stability of noncharacteristic boundary layers of a class of symmetrizable hyperbolic-parabolic systems including the compressible gas dynamics equations. Specifically, we show that under the assumption of uniform Evans stability, boundary layers with arbitrary amplitudes are asymptotically linearly and nonlinearly stable. This together with earlier verification of the Evans condition yields multidimensional stability of small-amplitude layers.

Toan Nguyen
Indiana University
nguyentt@indiana.edu

Kevin Zumbrun
Indiana University
USA
kzumbrun@indiana.edu

MS106

Transfer Operators in Dynamical Systems – An Overview

Given a dynamical system on a state space X, a transfer operator is simply the induced action on a suitable space of functions defined on X. In this sense, the notion is as old as the subject itself. Starting from this point of view we will outline the modern history of transfer operators in ergodic theory (in this context, more commonly called Perron-Frobenius operators), recent theoretical advances, numerical approaches and problems for the future.

Christopher Bose
Dept Mathematics & Statistics
University of Victoria
cbose@math.uvic.ca

MS106

Coherent Sets, Slow Transport, and Perron-Frobenius Cocycles for Oceanic and Atmospheric Dynamics

Transport and mixing processes play an important role in many natural phenomena, including ocean circulation, atmospheric dynamics, and fluid dynamics. Ergodic theoretic approaches to identifying slowly mixing structures in autonomous systems have been developed around the Perron-Frobenius operator and its eigenfunctions. We describe an extension of these techniques to non-autonomous systems in which one can observe time dependent, but slowly dispersive structures, which we term coherent sets. We state a result on the structure of the Lyapunov spectrum of the Perron-Frobenius cocycle, state a strengthened version the Multiplicative Ergodic Theorem for non-invertible matrices, and develop a numerical algorithm to approximate the Oseledets subspaces that describe coherent sets. The underlying ideas and numerical results will be illustrated with case studies from oceanic and atmospheric applications.

Gary Froyland, Simon Lloyd
University of New South Wales
g.froyland@unsw.edu.au, s.lloyd@unsw.edu.au

Anthony Quas
University of Victoria
aquas@uvic.ca

MS106

Fast Approximation of Long Term Dynamical Behaviour for Continuous-Time Systems

Transfer operator methods are widely used in applications to determine long term dynamical behaviour. They are based on simulations of the dynamical system. However, for systems arising from ODEs, simulation is computationally very expensive. Instead of the associated transfer operator we propose to analyze the infinitesimal generator of the system. We develope theory and show numerical examples in the talk.

Peter Koltai
Zentrum Mathematik
Technische Universitat Munchem
koltai@ma.tum.de

Gary Froyland
University of New South Wales
g.froyland@unsw.edu.au

Oliver Junge
Center for Mathematics
Munich University of Technology, Germany
junge@ma.tum.de

MS106

Convergence of Ulam's Method for Non-uniformly Expanding Maps

Most convergence proofs for Ulam's discretisation of Frobenius-Perron (transfer) operators rely more or less explicitly on the existence of a spectral gap for the transfer operator. In non-uniformly expanding scenarios, there is no spectral gap. This talk will describe two aspects of Ulam's method applied to the transfer operators for a family of 1d maps with an indifferent fixed point: first, convergence for approximations of the absolutely continuous invariant measure; second, numerical evidence for a "discretisation induced spectral gap" exhibiting interesting scaling.

Rua Murray
Department of Mathematics and Statistics
University of Canterbury, NZ
R.Murray@math.canterbury.ac.nz

MS107

Metrics on the Space of Bounded Keplerian Orbits and a New Approach to the Orbit Determination of Space Debris

We construct a natural metric on the space of bounded, Keplerian orbits and analyze the topological properties of the mapping into the space $S^2 \times S^2$. We discuss the implications for space situational awareness and present a novel method for orbit determination based on two optical observations of a piece of Earth-orbiting space debris particle; a single observation of which constrains its location in phase space to lie within a two-dimensional manifold.

Jared M. Maruskin
San Jose State University
maruskin@math.sjsu.edu

MS107

Intersections of Phase Volumes Bounded by Invariant Manifolds

Stable and unstable invariant manifolds associated to hyperbolic bound orbits are phase space structures that govern the transport of, e.g., particles in the gravity field of two massive bodies. We discuss interesting phase space transport scenarios arising from the intersection of these structures, e.g., collisions. We also discuss symplectic twist maps which approximate phase volume mapping, capturing phenomena observed in the full equations of motion, such as chaotic zones and stable/unstable resonant orbit pairs.

Shane D. Ross
Virginia Tech
Engineering Science and Mechanics
sdross@vt.edu

MS107

Fundamental Limits on Uncertainty Propagation in Astrodynamical Systems

Fundamental constraints, such as integral invariants and phase volume conservation, exist for orbit uncertainty propagation in astrodynamics due to its Hamiltonian nature. We apply Gromov's Non-Squeezing Theorem to find a new fundamental constraint that exists on general mappings of orbit distributions. The projection of future orbit uncertainties in each coordinate-momentum pair must be greater than or equal to a fundamental limit called the symplectic width. This serves as an "uncertainty' principle for spacecraft uncertainty distributions.

Daniel Scheeres
University of Colorado, Boulder
scheeres@colorado.edu

MS107

Phase Volume Propagation Using Intervals

Validated numerical methods, such as those based on interval numerics, allow us to automatically, and rigorously, generate error bounds on a numerical simulation. This talk will discuss some of the fundamental trade-offs present in the propagation of phase volumes using interval methods, and the use of subdivision algorithms as a solution to controlling the error over-estimation. Applications to astrodynamics, such as the computation of periodic orbits or targeting problems will be considered.

Benjamin F. Villac
University of California, Irvine
bvillac@uci.edu

MS108

Mathematical Models and Measures of Mixing: Part II

Mixing by stirring can be measured in a variety of ways including tracer particle dispersion, the scalar flux-gradient relationship, or via suppression of scalar density variation in the presence of inhomogeneous sources and sinks. The mixing efficacy of a flow is often expressed in terms of enhanced diffusivity and quantified as an effective diffusion coefficient. In this work we compare and contrast these various notions of effective diffusivity. Via thorough examination of a simple shear flow mixing a scalar sustained by a steady source-sink distribution, we explore apparent inconsistencies and propose a conceptual approach that captures some compatible features of these different models and measures of mixing. Part I of this talk is in MS97.

Charles R. Doering
University of Michigan
Mathematics, Physics and Complex Systems
doering@umich.edu

Katarina Bodova, Zhi Lin
Department of Mathematics
University of Michigan
kbodova@umich.edu, linzhi@umich.edu

MS108

A Homogenization-Based Perspective on Mixing Measures

Homogenization theory provides a rigorous framework for calculating the effective diffusivity of a decaying passive scalar field in a turbulent flow. We show that, when the scalar field is constantly replenished by a steady source, the conclusions of homogenization theory are altered in subtle ways. This reformulation offers a means of relating effective diffusivity to the multiscale mixing efficiencies of Doering & Thiffeault (2006) and reconciling an apparent contradiction between the two measures at large Peclet number.

Shane R. Keating
New York University
Courant Institute of Mathematical Sciences
skeating@cims.nyu.edu

MS108

Multiscale Mixing Measures on Arbitrary Domains and Effects of Diffusivity on Optimal Mixing

We present a multiscale mixing measure on arbitrary domains that is based on averaging the density field at various scales and use some mean value extension theorems for the Helmholtz equation to show that this measure is equivalent to a norm that involves the Laplacian. We use this measure to frame an optimal control problem, discuss some previous results obtained in the absence of diffusion and investigate how diffusion effects the optimal mixing strategies.

George Mathew
University of California at Santa Barbara
gmathew@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

MS108

Orbits that Stir

A stirring device consisting of a periodic motion of rods in a viscous fluid induces a mapping of the flow domain to itself. The periodicity of the fluid motion creates various types of periodic orbits, both stable and unstable. We show that these orbits can dictate how large-scale stirring and mixing proceeds in the device. We also discuss how the topological properties of aperiodic trajectories is a readily accessed measure of stirring effectiveness.

Jean-Luc Thiffeault

Dept. of Mathematics
University of Wisconsin - Madison
jeanluc@math.wisc.edu

MS109

Asymmetry-Induced Stabilization in Multistrain Disease Spread on Migration-Coupled Patches

We study the dynamical properties of a model for multistrain diseases with cross immunity and antibody-dependent enhancement on two coupled patches. Diffusive coupling is introduced in the form of a constant migration term. A Hopf bifurcation is observed in the single patch case. Asymmetry in the two patches' parameters increases the region of steady state stability. We motivate our results via analytical treatment. Synchrony properties for asymmetric patches are also investigated.

Simone Bianco
Dept. of Applied Science
College of William and Mary
sbianco@wm.edu

Leah Shaw
The College of William & Mary
lbshaw@wm.edu

MS109

High-throughput Population Biology-based Modeling of Malaria Infections

Realistic modeling of pathogen/host population dynamics often involves factors known to be important but of uncertain magnitude or duration. This talk focuses on the application of multiprocessor computing to sweep the parameter space of models of malaria parasites in human host, incorporating realistic host-pathogen interactions. Our purpose is not to fit parameters but rather to determine which factors most affect severity of infection. I discuss how our results relate to findings of recent field studies.

Philip G. Mcqueen
National Institutes of Health
mcqueenp@mail.nih.gov

MS109

Universal Testing is the Best HIV Prevention Strategy

The CDC has put out official recommendations for universal testing for HIV. They have recommended that health care professionals test all individuals during a standard medical visit; the beliefs being that as many as a third of infected individuals do not know they have HIV. I compare this course of action to other prevention strategies and show it is our most promising plan to stop the HIV epidemic.

Brandy L. Rapatski
Richard Stockton College of New Jersey
Brandy.Rapatski@stockton.edu

MS109

Dynamics of Indirectly Transmitted Infectious Diseases

There are numerous examples of human pathogens which persist in environmental reservoirs, e.g., cholera and schistosomiasis. We model the dynamics of infectious diseases for which the primary mode of transmission is indirect and mediated by contact with a contaminated reservoir. We include in our model the action of the native immune system and include a critical threshold for infection in susceptible individuals. We identify a bifurcation (control) parameter, which is an analog of R0 for models with indirect transmission, which determines whether outbreaks die-off, lead to epidemics, or lead to endemic disease states.

Howard Weiss
Georgia Tech
weiss@math.gatech.edu

MS110

Kolmogorov-Sinai entropy and Decay of Correlation from Poincare Recurrences

In this talk, I show how to calculate and to estimate a lower bound of the KS entropy, a sort of Shannon's entropy per unit of time, from the recurrence times of chaotic systems. These results are a consequence of the fact that the series of returns do contain the same information of the trajectory that generated it. That suggests that recurrence times are indeed optimal candidates for making models of complex systems.

Murilo Baptista
Centro de Matemática
University of Porto (Portugal)
murilo.baptista@fc.up.pt

MS110

Recurrence Plots and their Application in Reconstructing Driving Forces

A recurrence plot is a two-dimensional graph primarily for visualizing time series. It shows whether states of two corresponding times are close or not. Since there is no assumption, it can be used for nonstationary data. Although a recurrence plot is a binary matrix, the original time series can be reproducible from it up to the freedom of choice of coordinates. By combining this property with overembedding, one can reproduce multiple driving forces.

Yoshito Hirata
Institute of Industrial Science
The University of Tokyo
yoshito@sat.t.u-tokyo.ac.jp

Kazuyuki Aihara
JST/University of Tokyo, Japan
Dept of Mathematical Sciences
aihara@sat.t.u-tokyo.ac.jp

MS110

How Recurrences Determine Dynamics

I will present a theorem which shows that recurrences determine an attractor up to a homeomorphism. This allows us to conclude that recurrences determine the dynamical behaviour of a system and it provides a mathematical foundation for several methods which are applied in the study of dynamical systems, such as the detection of generalised synchronisation. A corollary then shows that there is a one-to-one relationship between the adjacency matrix of networks and a recurrence matrix. This will then allow us to apply concepts from graph theory to the study of dynamical systems. New applications are motivated by our mathematical analysis; these range from a more efficient reconstruction of n-dimensional structures from distance inequalities, which is needed, e.g., for the reconstruction of protein structures from NMR measurements, to new classifications of the complexity of networks, which, e.g., help to understand the synchronisability of ensembles of coupled oscillators.

Marco Thiel
Department of Physics - King's College
University of Aberdeen, UK
m.thiel@abdn.ac.uk

MS110

Identification of Indirect Coupling by Recurrence

We propose a method to uncover the coupling configuration by means of recurrence properties in modelled systems. The approach hinges on a generalization of conditional probability of recurrence, which was originally introduced to detect and quantify the weak coupling directionality between two interacting subsystems. Here, we extend that approach to the case of multivariate time series, where indirect interaction might be present. We test our method by considering three coupled Van der Pol oscillators contaminated with normal distributed noise and three Lorenz systems coupled by time delays. Our results confirm that the proposed method can be used to identify indirect coupling, which is very relevant for experimental time series analysis.

Yong Zou
Potsdam Institute for Climate Impact Research
Germany
Yong.Zou@pik-potsdam.de

MS111

Chaotic Dynamics and the Acceleration of High Energy Cosmic Rays by Nonlinear Shocks

The efficiency of diffusive shock acceleration may be significantly increased by the scattering of high energy cosmic rays in the converging flow of the precursor to a self-consistent,nonlinear shock. This process defines a new type of confinement problem,however,namely that of a high energy particle in an array of compressive shocklet trains.Here we discuss the nonlinear dynamics of generation of and confinement in such shock trains. The key concept of "loss islands" in phase space will be addressed in detail.

Patrick Diamond
Department of Physics
University of California, San Diego, USA
phd@mamacass.ucsd.edu

Mikhail Malkov
University of California, San Diego
San Diego, USA
mmalkov@physics.ucsd.edu

MS111

High Energetic Beams as a Result of Non-adiabatic Acceleration in Earth's Magnetotail

Deterministic chaos occurring in the earths magnetotail result in ions beams moving at the lobe. Chaos is generated by jumps of adiabatic invariant accompanying the interaction of particle with the current sheet. Successive jumps of the invariant within regularity regions at the entry and exit to the current sheet compensate each other and ejected ions form small scale beams - beamlets. We discuss the quantitative properties of beamlets.

Maksim Dolgonosov, Lev Zelenyi
Space Research Institute
Moscow, Russia
cactus@iki.rssi.ru, lzelenyi@iki.rssi.ru

MS111

Out of Equilibrium Dynamics in Presence of Wave-particles Interaction: The Case of the Free Electron Laser

Free Electron Lasers represent one example of systems with long range interaction, where the interplay between collective and individual degrees of freedom is well known to be central. Long living out-of-equilibrium states are displayed which bear an extraordinary conceptual importance as they corresponds to the solely experimentally accessible regimes. I shall here review the phenomenology of such metastable states focusing in particular on the emergence of out of equilibrium phase transitions.

Duccio Fanelli
Dipartimento di Energetica "S. Stecco"
University of Florence, Italy
duccio.fanelli@gmail.com

MS111

Resonant Interaction of Electrons and Electromagnetic Waves in the Earth's Magnetotail

We investigate the resonant interaction between monochromatic electromagnetic waves and charged particles in configurations with magnetic field reversals (e.g. the earth magnetotail). We discuss two phenomena occurring during slow passages of particles through resonances with the wave: capture into resonance and scattering on resonance. These processes result in destruction of adiabatic invariants, chaotization and almost free acceleration of particles. We calculate the characteristic times of mixing due to resonant effects and separatrix crossings.

Dmitri Vainchtein
Dept. of Mechanical Engineering
Temple University, USA
dmitri@temple.edu

Anatoly Neishtadt
Space Research Institute,
Moscow
aneishta@iki.rssi.ru

Alexei Vasiliev
Space Research Institute
Moscow, Russia
avasiliev@gmail.com

MS112

Conformational Statistics of DNA

DNA can be viewed as a semiflexible polymer, and represented at a coarse scale as a continuous helical elastic rod. In this talk, methods from the theory of Lie groups are used to analyze equilibrium conformations of helical rod models of DNA with end constraints. When the ends of a segment of DNA are free to move, the resulting cloud of reference frames visited by the distal end of the segment relative to the proximal end can be characterized as a probability density function on the Euclidean motion group. The relationship between this pdf and the stiffness parameters of the helical rod model is derived using methods of noncommutative harmonic analysis.

Greg Chirikjian
Johns Hopkins University
Dept of Mechanical Engineering
gregc@jhu.edu

MS112

Existence Results for Elastic Rods with Self-Repulsive Potentials

In the classic theory of elastic rods, two non-adjacent points along the rod may upon contact occupy the same physical space. We develop an elastic rod model with a pairwise repulsive potential such that if two non-adjacent points along the rod are close in physical space, there is an energy barrier that prevents contact. For adjacent pairs, the repulsive potential is negligible and the elastic rod is described by a classical elastic rod model. The framework for this model is developed to prove the existence of minimizers within each homotopy class, where the idea of topological homotopy of a curve is generalized to a framed curve, or an elastic rod. Finally, the first-order necessary conditions are derived.

Kathleen A. Hoffman
University of Maryland, Balt. Co.
Deapartment of Math. and Stat.
khoffman@math.umbc.edu

Thomas I. Seidman
University of Maryland Baltimore County
seidman@math.umbc.edu

MS112

Elasticity and Electrostatics of Plectonemic DNA

We present a self-contained theory for the mechanical response of DNA in single molecule experiments. Our model is based on a 1D continuum description of the DNA molecule and accounts both for its elasticity and for DNA-DNA electrostatic interactions. We consider the classical loading geometry used in experiments where one end of the molecule is attached to a substrate and the other one is pulled by a tensile force and twisted by a given number of turns. We focus on configurations relevant to the limit of a large number of turns, which are made up of two phases, one with linear DNA and the other one with superhelical DNA. The model takes into account thermal fluctuations in the linear phase and electrostatic interactions in the superhelical phase. The values of the torsional stress, of the supercoiling radius and angle, and key features of the experimental extension-rotation curves, namely the slope of the linear region and thermal buckling threshold, are predicted. They are found in good agreement with experimental data

Sebastien Neukirch
d'Alembert Institute for Mechanics
UPMC Univ Paris 6
sebastien.neukirch@lmm.jussieu.fr

MS112

Behavior of Hemitropic Rods Subjected to Axial End Displacement

A framework for modeling nonlinear behavior of hemitropic rods (using the Cosserat Theory) will be presented. The persistence of fundamental properties from the classical solutions of Euler (isotropic) buckling, such as the existence of discrete modes, will be demonstrated. In addition, unclassical features, such as the existence of nontrivial (buckled) states under tension, will also be demonstrated. Finally, stability analysis using an adaptation of conjugate point theory applied to the linearized system will be presented.

Chris Papadopoulos
University of Puerto Rico, Mayagüez
cmpapadopoulos@uprm.edu

MS113

Multilayer Dynamics in Wireless Networks

In recent years, the evolution of wireless communication has been proceeding rapidly, with the diffusion of cellular phones, broadband wireless access, wireless LAN, sensor networks, and so on. Along with the diversification of wireless communication terminals and increasing traffic, there is increasing interference and competition for use of finite wireless resources. To solve these roblems, wireless access network systems are becoming increasingly larrge and complex. When we design these systems, we have to consider the following problems. How to share wireless resources among multiple users and communication types? How to deal with complex variations and fluctuations, in space and time, of wireless channel states on various scales, including radio wave interference and user traffic? How to coordinate various dynamic communication control functions including autonomous distributed and cooperative control? This presentation reviews these problems and introduces our approach to dealing with these problems in the design of dynamic wireless access network systems.

Akio Hasegawa, Peter Davis, Tetsuro Ueda, Sadao Obana
ATR Adaptive Communications Research Laboratories
ahase@atr.jp, ahase@atr.jp, ahase@atr.jp, ahase@atr.jp

MS113

Graph Decomposition and Functional Dynamics Analysis on Cell Regulation Networks

Considerable research effort has been devoted to extracting information from large amount of data generated by currently prevalent high-throughput experiments in cell biology. Despite much progress on the analysis of individual pathways, the determination of functional motifs and modules heavily depends on researchers' experience. Here, we propose an automatic scheme which identifies minimal production unit and feedback controllers and as a result defines modules with different sizes and complesity. Furthermore, dynamical systems analysis could be efficiently applied to the reduction of the network structure, digging out the underlhing key protein species and key reactions.

Yueheng Lan
Department of Mechanical and Environmental Engineering
University of California at Santa Barbara
ylan2@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

MS113
Communities in Social Networks

Networks (graphs) arise pervasively in biology, physics, technology, the social sciences, and myriad other areas. They typically exhibit a complicated mixture of random and structured features. Over the past several years, my collaborators and I have conducted several studies of cohesive mesoscopic structures known as "communities," which consist of groups of nodes that are closely related. In this talk, I will survey some of the prominent community-detection methods—which borrow ideas from statistical physics, graph theory, sociology, and more—and discuss results my collaborators and I have obtained using networks constructed from data such as Facebook friendships, Congressional committee assignments and voting/legislation cosponsorship, and NCAA football schedules. The results I will discuss will include how network communities influence rank-ordering results (in the football example) and how one might use them to infer or at least make intelligent guesses about demographics (the Facebook example) or political activities (the Congress examples).

Mason A. Porter
University of Oxford
Oxford Centre for Industrial and Applied Mathematics
porterm@maths.ox.ac.uk

MS113
Modeling and Control of Cascading Dynamics in Power Grids

This presentation explores how we grasp and tame cascading failures to cause large blackouts of power grids. The 2003 blackout in North America poses an important problem of modeling and control of complex power grids. Cascading dynamics leading to blackouts possess multi-time scale, hence hybrid, and spatiotemporal properties. We develop mathematical models of cascading dynamics with taking these properties into account and also perform dynamical system analysis of the models.

Yoshihiko Susuki
University of California, Santa Barbara
Department of Mechanical Engineering
susuki@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

Takashi Hikihara
Kyoto University
Department of Electrical Engineering
hikihara@dove.kuee.kyoto-u.ac.jp

MS114
Modulated Travelling Waves in Discrete Reaction Diffusion Systems

We consider reaction-diffusion systems posed on the real line that incorporate a discrete coupling on an underlying lattice. The existence of weak sinks is established, which can be thought of as interfaces that separate two spatially periodic structures with different wave numbers. The corresponding modulated wave train is time periodic in the frame that moves with the speed of the interface.

Hermen Jan Hupkes
Department of Applied Mathematics
Brown University
hjhupkes@dam.brown.edu

Bjorn Sandstede
Brown University
bjorn_sandstede@brown.edu

MS114
Asymptotic Behavior of Small Solutions for Hamiltonian Systems on Lattices

We study the long-time behaviour of oscillations in lattices of ininitely many particles interacting via certain nonlinear potentials. We also allow for background potentials. Prototypes of such systems are the Klein-Gordon chain and the FPU system on the infinite chain as well as on the two dimen- sional lattice. The main focus is on the dispersion in such Hamiltonian systems. In par- ticular we discuss an approach inspired by PDE theory to proof asymptotic stability for a certain class of non-linearities and initial data which are small in a suitable sense. It is based on optimal decay rates for solutions of the linearised system and also applies to systems in several dimensions. Finally we discuss the borderline where the arguments above fail. Namely, it turns out that in case of stronger nonlinearities the solution of the system near the wave fronts is not any more dominated by that of the linearised system. To understand the impact of the nonlinearity we formally derive PDEs that describe the dynamics of the chain near these fronts. Towards an improved stability result the obtained Hamiltonian PDEs are analysed numerically and analytically.

Carsten Patz
WIAS Berlin
patz@wias-berlin.de

MS114
Existence and Stability of Discrete Waves in Generalized DNLS Equations: Analytical Methods

The existence of periodic and decaying solutions in Generalized DNLS will be considered. Calculus of variations and the Nehari manifolds are employed to establish the existence of these solutions. We present some extensions of our results, combining the Nehari manifold approach and the Mountain Pass argument. We consider the stability of these type of solutions and illustrate how the continuation of solutions proceeds from the anti-continuum limit. Time-permitting, we will present some recent results on how to extend such approaches in saturable discrete vector solitons in one-dimensional lattices.

Vassilis M. Rothos
Aristotle University of Thessaloniki
rothos@gen.auth.gr

MS114
Emergence of Macroscopic Dissipation in Lattice Models

We study the existence of travelling wave solution for a

Fermi-Pasta-Ulam chain. Motivated by martensitic phase transitions the elastic interaction energy is assumed to be a multi-well potential. We focus on the special case where the potential is piecewise quadratic, with two wells representing two stable phases. In the physically interesting regime of subsonic speeds there exist pase transition solutions, that is, 'heteroclinic' travelling waves. We deduce important information on their macroscopic dissipation, namely, the kinetic relations governing the dependence of the configurational force on the speed of the moving interface. This is joint work with Johannes Zimmer (Bath)

Hartmut Schwetlick
Department of Mathematics
University of Bath
H.Schwetlick@bath.ac.uk

MS115
Determining Information Flow in Networks Containing One Hundred Neocortical Neurons

How does information flow through networks of neurons? Several tools, including transfer entropy, Granger causality, and directed information can be applied to this question. Yet indirect connections, various delays, and feedback loops can complicate the task. We applied the above methods in simple validation studies, demonstrating that many of these issues can in principle be overcome. We present preliminary results from networks recorded with a 512 electrode array (with Alan Litke of UC Santa Cruz).

John M. Beggs
Indiana University
Dept. of Physics
jmbeggs@indiana.edu

MS115
Anatomic Connectivity Reconstruction from Functional Connectivity in Scale-Free Neuronal Networks"

We present a study of scale-free networks of identical, conductance-based, integrate-and-fire excitatory neurons. We study such networks using the mean-field approach. The results are compared to the direct numerical simulations of the coupled integrate-and-fire neurons. We show that the firing rates of neurons in a scale-free networks themselves follow a scale-free distribution. At the same time we present examples of networks where the scale-free nature is evident even from gain curves. Ultimately our analysis provides a link between the functional and anatomical connectivity of such networks.

Maxim S. Shkarayev
Mathematical Science Department, Rensselaer Polytech Inst.
shkarm@rpi.edu

MS115
Network Dynamics of Hodgkin-Huxley Neurons

The reliability and predictability of neuronal network dynamics is a central question in neuroscience. We present a numerical analysis of the dynamics of all-to-all pulsed-coupled Hodgkin-Huxley (HH) neuronal networks. Since this is a non-smooth dynamical system, we propose a pseudo-Lyapunov exponent (PLE) that captures the long-time predictability of HH neuronal networks. The PLE can capture very well the dynamical regimes of the network. Furthermore, we present an efficient library-based numerical method for simulating HH neuronal networks.

Yi Sun
New York University
Courant Institute
yisun@cims.nyu.edu

David Cai
Courant institute
New York Unvirsity
cai@cims.nyu.edu

MS115
A Neuronal Network Model of Primary Visual Cortex Explains Spatial Frequency Selectivity

We address how spatial frequency selectivity arises in Macaque primary visual cortex (V1) by simulating V1 with a large-scale network model consisting of $O(10^4)$ excitatory and inhibitory integrate-and-fire neurons with realistic synaptic conductances. The model cortex has distributions of spatial frequency selectivity and of preference that resemble experimental findings from the real V1. Two main sources of spatial frequency selectivity in the model are the spatial arrangement of feedforward excitation, and cortical inhibition.

Wei Zhu
Mathematics, University of Alabama
wzhu7@bama.ua.edu

Michael J. Shelley
New York University
Courant Inst of Math Sciences
shelley@cims.nyu.edu

Robert Shapley
Center for Neural Science
New York University
shapley@cns.nyu.edu

MS116
Coupling-Induced Bipartite-Pointer States in Arrays of Electron Billiards: Quantum Darwinism in Action?

I shall discuss a quantum system composed of an open array of billiards (dots) connected in series. Besides pointer states occurring in individual dots, there are sets of robust states which only arise in the array. We define these new states as bipartite-pointer states, since they can not be described in terms of simple linear combinations of single-dot states. The ability of the robust states to create offspring indicates that quantum Darwinism is in action.

Richard Akis
Dept. Electrical Engineering
Arizona State University
rakis@asu.edu

MS116
Transmission and Scarring in Graphene Quantum Dots

We study electronic transport in quantum-dot structures made of graphene. Focusing on the rectangular dot geometry and utilizing the non-equilibrium Green's function to calculate the transmission in the tight-binding framework, we find significant fluctuations in the transmission as a function of the electron energy. The fluctuations are correlated with the formation of quantum scarring states, or pointer states in the dot. Both enhancement and suppression of transmission have been observed. As the size of the quantum dot is increased, more scarring states can be formed, leading to stronger transmission or conductance fluctuations.

Ying-Cheng Lai
Arizona State University
Department of Electrical Engineering
yclai@chaos1.la.asu.edu

Liang Huang
Department of Electrical Engineering
Arizona State University, Tempe, Arizona 85287, USA
liang.huang@asu.edu

David Ferry
Arizona State University
ferry@asu.edu

Richard Akis
Dept. Electrical Engineering
Arizona State University
rakis@asu.edu

Stephen Goodnick
Arizona State University
stephen.goodnick@asu.edu

MS116
Scattering Echoes in a Ripple Waveguide

We observe time-periodic echoes in the transmitted electron probability for a quantum waveguide with a ripple cavity. Knowing the period of the echoes, we can determine the horseshoe development parameter which characterizes the classical chaotic scattering inside the cavity. We use Husimi plots to identify scattering resonances in the conductance fluctuations supported by the stable and unstable manifolds of the outer fixed points of the ripple cavity. We also investigate the time evolution of a Gaussian wavepacket incident on the ripple cavity and show that the transmitted wavepacket is emitted in periodic pulses. The period of the pulses is consistent with theoretical predictions obtained from the classical phase space and the result which we obtain from the quantum conductance fluctuations.

Hoshik Lee
Naval Research Labortory
Temple University
hoshik.lee@temple.edu

Christof Jung
Instituto de Ciencias Fisicas
Universidad Nacional Autonoma de Mexico
jung@ce.fis.unam.mx

Linda Reichl
Center for Complex Quantum Systems
The University of Texas at Austin
reichl@physics.utexas.edu

MS116
Quantum Chaos and Tunneling

First, I will discuss some general aspects of tunneling in quantum chaotic systems to orient the audience. Then I will show results from recent boundary element method calculations to study tunneling in closed and open rectangular double-well potentials separated by a barrier. We place various shaped scattering inclusions in the wells to generate various regular and chaotic behavior. The results will be compared with microwave wave-chaos experiments of the same configuration.

Louis M. Pecora
Naval Research Lab
pecora@anvil.nrl.navy.mil

MS117
Monge-Ampere Based Adaptive Methods

Many physical systems, ranging from NLS to chemotaxis have solution which blowup in a finite time. The behaviour of the solution as it approaches blowup is often hard to study analytically and careful numerical calculations are usually required to understand it futehr. However, these problems develop singularities with very small time and length scales. To resolve these an adaptive numerical method is usually required. In this talk I will describe a moving mesh method based on the Monge-Ampere equation which moves mesh points towards the singularity. The mesh points together with the underlying solution of the system then can be studied as a coupled dynamical system. The result is that it is possible to construct reliabel and accurate numerical methods which work very well for a wide range of blowup problems. In this talk I will describe the method, its dynamics and the problems it can solve.

Chris Budd
Dept. of Mathematical Sciences
University of Bath, UK
mascjb@bath.ac.uk

MS117
Blowup Solutions of the Korteweg-de Vries Equation

In this talk we study singular solutions of the generalised Korteweg-de Vries equation (KdV). The stability of solitary waves of the KdV had already been studied extensively. These solitons can become unstable and become infinite in finite time, in other words blow up. We analyse the structure of these blowup solutions. After introducing a dynamical rescaling the solutions are found as bounded solutions to an ODE. We study this ODE using asymptotic methods to construct the solutions.

Vivi Rottschafer
Leiden University
Dept of Mathematics
vivi@math.leidenuniv.nl

MS117
(In-)Stability of Finite-time Singularities in the Harmonic Map Heat Flow

The harmonic map heat flow is a model for nematic liquid crystals and also has origins in geometry. We present an analysis of the asymptotic behaviour of singularities arising in this heat flow. While blow-up is known to occur for radially symmetric equivariant solutions, we investigate stability for blow-up in a wider class. We also extend this asymptotic analysis to the case of the Landau-Lifshitz-Gilbert equation of micro-magnetics where we show that blow-up must occur but that it is unstable. This is joint work with Jan Bouwe van den Berg.

JF Williams
Simon Fraser University
Dept. of Mathematics
jfw@math.sfu.ca

MS117

Stability of Blowup Solutions in the Ginzburg-Landau Equation

In this talk we study the stability of radially symmetric blowup solutions of the Ginzburg-Landau equation with analytic methods. So far, the stability of blowup solutions had only been examined numerically. In these numerical simulations 'ring-like' solutions were found to be stable. We use Evans function techniques to study the stability of these solutions, however, due to the nature of the problem these standard methods are not directly applicable.

Martin van der Schans
Leiden University
Dept. of Mathematics
mvdschan@math.leidenuniv.nl

Vivi Rottschafer
Leiden University
Dept of Mathematics
vivi@math.leidenuniv.nl

MS118

Three-parametric Phase Space of the Lorenz System

In this talk we present an extensive numerical study of the Lorenz model, changing all three parameters of the system, locating the chaotic regions and different bifurcations. From the numerical study we show that the region of parameters where the Lorenz model is chaotic is bounded for fixed r. We give a theoretical proof of this fact by using Fenichel theory and by obtaining theoretical bounds for the chaotic region. The theoretical bounds are complemented with numerical studies performed using the Maximum Lyapunov Exponent and OFLI2 techniques, and a comparison of both sets of results is shown. Finally, we provide a complete three-dimensional model of the chaotic regime depending on the three parameters.

Roberto Barrio
University of Zaragoza, SPAIN
rbarrio@unizar.es

Fernando Blesa
University of Zaragoza
fblesa@unizar.es

Sergio Serrano
University of Zaragoza, SPAIN
sserrano@unizar.es

MS118

Bifurcations of the Lorenz Manifold

The Lorenz manifold, the two-dimensional stable manifold of the origin of the Lorenz system, intersects the two-dimensional unstable manifolds of the secondary equilibria or bifurcating periodic orbits in structurally stable heteroclinic orbits. Finding and following these global objects in the parameter ϱ allows us to describe the combinatorial structure that links heteroclinic orbits with homoclinic explosion points.

Bernd Krauskopf
University of Bristol
Department of Engineering Mathematics
b.krauskopf@bristol.ac.uk

Hinke M. Osinga
University of Bristol
Department of Engineering Mathematics
H.M.Osinga@bristol.ac.uk

Eusebius J. Doedel
Concordia University
Dept of Computer Science
doedel@encs.concordia.ca

MS118

Asymptotics and Complex Singularities of the Lorenz Equation

Ever since Lorenz (1963) introduced a system of three simple ordinary differential equations, much of the discussion of his system and its strange attractor has adopted a dynamical point of view. In contrast, we allow time to be a complex variable and look upon solutions of the Lorenz system as analytic functions. Formal analysis gives the form and coefficients of the complex singularities of the Lorenz system. Very precise (¿ 500 digits) numerical computations show that the periodic orbits of the Lorenz system have singularities which obey that form exactly or very nearly so. Both formal analysis and numerical computation suggest that the mathematical analysis of the Lorenz system is a problem in analytic function theory.

Divakar Viswanath
University of Michigan
divakar@umich.edu

Sonmez Sahutoglu
Department of Mathematics
University of Michigan
sonmez@umich.edu

MS118

Period-doubling Cascades Galore

Many systems have period doubling cascades, including the Lorenz system. I will discuss why these exist. This is joint work with Evelyn Sander of George Mason University.

James Yorke
Institute for Physical Sciences and Technology
University of Maryland, USA
Yorke2@IPST.UMD.EDU

Evelyn Sander
George Mason University, USA
sander@math.gmu.edu

MS119

Lyapunov Vectors and their Cousins in the Atmospheric and Oceanic Sciences

Lorenz's seminal work was motivated by limits to meteorological prediction. Lyapunov vectors, singular vectors (SVs) and bred vectors (BVs) are all used to study error growth. SVs and BVs are used by two leading weather services in evaluating their numerical forecasts. These two approaches yield distinct, and sometimes opposite, results in practice, depending on the time scale under consideration. They are compared to Lyapunov vectors, and ideas are illustrated with simple "toy" models of geophysical flows.

Michael Ghil
Département Terre-Atmosphère-Océan et CERES-ERTI
Ecole Normale Supérieure, Paris France
ghil@lmd.ens.fr

MS119

Covariant Lyapunov Vectors and their Applications

Covariant Lyapunov vectors (CLVs) define an intrinsic, non orthogonal basis at each point in phase space which is covariant with the dynamics. Individual vectors have a clear physical meaning as opposed to Gram-Schmidt vectors obtained from the standard orthogonalization procedure introduced by Benettin et al.. Thanks to an innovative numerical algorithm, we discuss recent results and promising applications. In particular, CLVs can be used to quantify the degree of hyperbolicity in high dimensional systems.

Francesco Ginelli
Institut des Systèmes Complexes Paris-Ile-de-France
and Service de Physique de l'Etat Condense' CEA/Saclay
francesco.ginelli@cea.fr

Roberto Livi
Dipartimento di Fisica
Firenze, Italy
livi@fi.infn.it

MS119

Lyapunov Modes for Low Dimensional Heat Flow

The complete functional form for all the Lyapunov modes is presented, including the dependence of the coefficients, and frequencies, on the mode number. At higher mode numbers the mixing of transverse (T) and longitudinal-momentum proportional (LP) modes is observed, with a total T mode spread over three different vectors. This spreading is time dependent, with the T mode appearing to wander randomly over the the group of vectors as the system evolves.

Gary P. Morriss
School of Physics, University of New South Wales,
Sidney, Australia
G.Morriss@unsw.edu.au

MS119

Collective Dynamics and Effective Dimension of Large Chaotic Systems from Lyapunov Vector Analysis

We show that covariant Lyapunov vectors can capture the collective dynamics of large chaotic systems, in terms of a few collective modes with delocalized vectors, amidst microscopic, localized modes. We discuss how this forces to reconsider the usual definition of extensivity of chaos. We also show that chaotic solutions of spatially-extended dissipative systems evolve within a finite-dimensional "physical" manifold, hyperbolically isolated from a residual set of trivially decaying Lyapunov modes.

Kazumasa A. Takeuchi
Department of Physics, the University of Tokyo (Japan)
kazumasa@daisy.phys.s.u-tokyo.ac.jp

Hugues Chate
Service de Physique de l'Etat
Condense', CEA/Saclay, France
hugues.chate@cea.fr

MS120

Gamma Frequency Coherence and Downstream Effects when the Target Network Includes $GABA_A$-receptor Mediated Local Inhibition

More coherent excitatory signals in the brain are known to have a competitive advantage over less coherent ones. We show here that this advantage is amplified greatly when the target includes inhibitory interneurons acting via $GABA_A$-mediated synapses and the coherent signal oscillates at gamma frequency. We hypothesize that therein lies, at least in part, the functional significance of the experimentally observed link between attentional biasing of stimulus competition and gamma frequency rhythmicity.

Christoph Borgers
Tufts University
christoph.borgers@tufts.edu

Nancy Kopell
Boston University
Department of Mathematics
nk@bu.edu

MS120

Periodic Forcing Near Hopf Bifurcation; Application to the Auditory System

Several authors model auditory receptors as systems near Hopf bifurcation and the input to these receptors as a periodic forcing. We discuss the mathematics of such systems (including asymmetry and multiplicity of the response curve) as well as the implications of the mathematics for the auditory system. This is joint work with Claire Postlethwaite, LieJune Shiau, and Yanyan Zhang.

Martin Golubitsky
Ohio State University
Mathematical Biosciences Institute
mg@mbi.osu.edu

MS120

Gamma-oscillations in Networks with Excitatory and Inhibitory Neurons: The Specific Role of Type I and Type II Neurons for Synchronization and Stability

It is believed that the slow decay rate of inhibition is an important factor behind gamma oscillations. Börgers and Kopell studied networks of excitatory and inhibitory cells, both modeled as type I neurons, and showed that slowly decaying inhibition is equivalent to a dynamic saddle-node

bifurcation. We use type II neurons as excitatory cells and show that slow passage through Hopf is the relevant dynamic bifurcation. The accompanying delay effect makes gamma rhythm less robust.

Martin Krupa
Radboud University Nijmegen
Donders Institute for Brain, Cognition and Behavior
mkrupa@science.ru.nl

Christoph Borgers
Tufts University
christoph.borgers@tufts.edu

Stan Gielen
Radboud University Nijmegen
sgielen@donders.ru.nl

MS120
Stability and Synchronization in Networks of Pulse-coupled Oscillators with Delays and Asymmetric Connectivity

We analyzed the dynamics of neuronal oscillators whose entrainment is believed to support information transfer in biological networks. We specially focused on asymmetric oscillators as proper model for biological phase oscillators with varying coupling strengths caused by, e.g. plasticity and learning. Stability analysis in the case of delayed excitatory and inhibitory coupling revealed a broad spectrum of stable and unstable entrainment as different phase relations and distinct bifurcation routes between them.

Magteld Zeitler
Radboud University Nijmegen
m.zeitler@donders.ru.nl

Andreas Daffertshofer
Vrije Universiteit Amsterdam
a.daffertshofer@fbw.vu.nl

Stan Gielen
Radboud University Nijmegen
sgielen@donders.ru.nl

MS121
Discrete Dirac Structures and Variational Discrete Dirac Mechanics

We construct discrete analogues of Dirac structures by considering the geometry of symplectic maps and their associated generating functions, by analogy to continuous Dirac structures that are expressed in terms of the geometry of symplectic vector fields and their associated Hamiltonians. This yields a unified treatment of implicit discrete Lagrangian and Hamiltonian systems, and nonholonomic integrators. The variational structure is described by the discrete Hamilton-Pontryagin principle on the discrete Pontryagin bundle.

Melvin Leok
Purdue University
Department of Mathematics
mleok@math.purdue.edu

Tomoki Ohsawa
University of Michigan
Department of Mathematics
ohsawa@umich.edu

MS121
Arnold Diffusion in a Chain of Coupled Pendula

Arnold diffusion can manifest itself in strange dynamics of a chain of weakly coupled pendula. The energy can diffuse from one pendulum to its neighbor, following any prescribed itinerary. These “deterministically random” motions coexist with KAM tori, which occupy most of the system’s phase space. This is joint work with Vadim Kaloshin and Maria Saprykina.

Mark Levi
Department of Mathematics
Pennsylvania State University
levi@math.psu.edu

MS121
The Geometry and Dynamics of a Rigid Body Interacting with Point Vortices

The geometric structures underlying the problem of a rigid body interacting with point vortices is exhibited by reformulating it as a geodesic motion on the product of a space of embeddings with the Euclidian group. Using symplectic reduction by stages with respect to the particle relabeling symmetry and global translations and rotations yields a finite-dimensional Hamiltonian description. This yields a non-canonical Poisson bracket, and a canonical description is obtained after a momentum shift.

Joris Vankerschaver
California Institute of Technology
Control and Dynamical Systems
jv@caltech.edu

MS121
Stability of Relative Equilibria of Nonholonomic Integrators

Nonholonomic integrators are discrete-time analogues of nonholonomic mechanical systems. Conditions for partial asymptotic stability of relative equilibria of nonholonomic integrators with symmetry are established. For integrators obtained by discretization of continuous-time dynamics, stability conditions are compared to those of the associated continuous-time systems. The results are then illustrated with a stability analysis of the discrete roller racer.

Dmitry Zenkov
North Carolina State University
Department of Mathematics
dvzenkov@ncsu.edu

MS122
Hamiltonian Formulation of Reduced Maxwell-Vlasov Equations

We present a Hamiltonian formulation of the reduced Vlasov-Maxwell equations. The macroscopic fields are expressed in terms of Lie transforms generated by some functional from the Poisson bracket of the exact Vlasov-Maxwell equations. We further reduce the dynamical system in order to take into account the main approximations of a Free Electron Laser setting. A reduced Hamiltonian model is derived using a fully Hamiltonian framework.

Cristel Chandre
Centre de Physique Théorique - CNRS
Cristel.Chandre@cpt.univ-mrs.fr

MS122

A Model of the Nonlinear Coupling of MHD Driven Thermoelectric Currents to Edge Topological Instabilities in Tokamak Plasmas

A model describing the nonlinear coupling of field-aligned thermoelectric currents to edge MHD instabilities in tokamaks is described. This coupling creates a positive feedback loop that results in the amplification a homoclinic separatrix tangle which bounds the plasma. This produces an exponential growth of resonant magnetic perturbation that enhance the diffusion of chaotic magnetic field lines across the edge of the plasma and heat flux into the separatrix lobes. *Supported U.S. DoE DE-FC02-04ER54698.

Todd E. Evans
General Atomics
San Diego, USA
evans@fusion.gat.com

Marcin Jakubowski
2Max Planck Institut für Plasmaphysik
EURATOM Association, Greifswald, Germany

Andreas Wingen
Institut für Theoretische Physik
Heinrich-Heine-Universität Düsseldorf, Germany

MS122

Sequential Suboptimal Control of Current Profile in Tokamak Plasmas

We present a framework to solve a finite-time optimal control problem for parabolic partial differential equations with diffusivity-interior actuators, which is motivated by the control of the current density profile in tokamak plasmas. By using proper orthogonal decomposition we obtain a bilinear reduced-order model. Based on quasilinearization of the optimality conditions derived from Pontryagins principle we propose a convergent iterative scheme for suboptimal closed-loop control which avoids repeated numerical computation of the Riccati equation.

Chao Xu
Mechanical Engineering and Mechanics
Lehigh University, USA
chx205@lehigh.edu

Yongsheng Ou
Mechanical Engineering and Mechanics
Lehigh University, USA
yoo205@lehigh.edu

Eugenio Schuster
Mechanical Engineering and Mechanics
Lehigh University, USA
schuster@lehigh.edu

MS122

A Hamiltonian Model for Magnetic Reconnection in Collisionless Plasmas

The process of magnetic reconnection, consisting of the modification of the topology of a magnetic field in a plasma, is relevant for several phenomena occurring in laboratory and astrophysical plasmas. In this contribution the noncanonical Hamiltonian structure of a model for magnetic reconnection and the role of Casimir invariants, on the related nonlinear dynamics, are discussed. Subsequently, the existence of negative energy modes for homogeneous equilibria is shown and a stability criterion is derived.

Emanuele Tassi
Centre de Physique Théorique, CNRS Luminy, Marseille, France
emanuele.tassi@polito.it

Philip Morrison
Physics Department
University of Texas at Austin
morrison@physics.utexas.edu

Daniela Grasso
CNR-INFM, CNISM and Burning Plasma Research Group
Dipartimento di Energetica, Politecnico di Torino, Italy
daniela.grasso@infm.polito.it

MS123

How Much to Spend for the Fight Against Terrorism? An Optimal Control Approach

A control model is presented which studies optimal spending for the fight against terrorism. It is assumed that economic damages are larger the greater the number of terrorists and that the success of counter terror operations depends on public opinion. With these assumptions it is demonstrated that the long run outcome may crucially depend on initial conditions. It is numerically proven that a threshold may exist which separates the basin of attraction of optimal paths.

Jonathan Caulkins
H. John Heinz III School of Public Policy and Management
Carnegie Mellon University
caulkins@andrew.cmu.edu

Dieter Grass
Dept. of Operations Research and Systems Theory
Vienna University of Technology
dieter.grass@tuwien.ac.at

MS123

A Dynamic Model of Terrorist Organizations

The membership of a terrorist organization can be modeled as a linear dynamical system. Interestingly, analysis of this system can be used to prove sufficient conditions for defeating the organization. As well, the model addresses qualitatively the problem of allocating resources between attacking the leadership or the rank-and-file of the organization. These and other results demonstrate the potential of dynamic models in terrorism research.

Alexander Gutfraind
Center for Applied Mathematics
Cornell University
ag362@cornell.edu

MS123

Evidence for Universal Dynamics in Modern Conflicts and Terrorism

We show that common dynamical patterns underlie the evolution of irregular warfare – such as the ongoing conflicts in Iraq, Colombia and Afghanistan – and global terrorism. Our work suggests that these conflicts are being carried out in a generic way, irrespective of the individual conflict's specific origin, geographic location, ideology, and religious issues. In each case, the insurgency resembles a similar soup of continually evolving attack units. Our findings suggest that the observed dynamics emerge as a consequence of how humans naturally 'do' asymmetric warfare. Having established the quantitative power of our model, we use it to predict the duration of wars, and test out the consequences of different intervention strategies. We then turn to look at the connection with transnational 'maras', street gangs, and online gangs which form around Internet role-playing games such as World of Warcraft.

Neil F. Johnson
Dept. of Physics
University of Miami
njohnson@physics.miami.edu

Mike Spagat
Dept. of Economics, Royal Holloway College
University of London
m.spagat@rhul.ac.uk

MS123

A Dynamical Model of Terrorism

We consider the population in a given region as being made up of three primary components: terrorists, those susceptible to both terrorist and pacifist propaganda, and non-susceptibles, or pacifists. The dynamical behavior of these three populations is studied using a model that incorporates the effects of both direct military/police intervention to reduce the terrorist population, and nonviolent, persuasive intervention to influence the susceptibles to become pacifists.

Firdaus Udwadia
Viterbi School of Engineering and Dept. of Mathematics
University of Southern California
fudwadia@usc.edu

George Leitmann
Graduate School, College of Engineering
University of California at Berkeley
gleit@uclink4.berkeley.edu

Luca Lambertini
Department of Economics
University of Bologna
lamberti@spbo.unibo.it

PP0

Teaching Dynamical Systems at the High School Level

We describe a high school workshop on the fundamental concepts of dynamical systems. Basic skills were developed in the context of geometric and logistic growth models. The impact of model parameters and initial conditions on transient and long-term behaviors of solutions were compared and contrasted using spreadsheets. Probability concepts were introduced and used in the context of life tables, leading to a discussion of age-structured population models. The course culminated in the consideration of a stage-structured model for the loggerhead turtle that enabled students to investigate conservation efforts focused on various life stages.

Mary M. Ballyk
New Mexico State University
Dept of Mathematical Sciences
mballyk@nmsu.edu

Suzanne Galayda
New Mexico State University
Department of Mathematics
sgalayda@nmsu.edu

PP0

Correlation Transfer in Neural Oscillators

Populations of neurons in a variety of brain regions show temporal correlations between their spike trains. A potential source of such correlations is common external input, which is transformed onto correlated output through the neural dynamics. We are interested in how particular neural dynamics will affect how these inputs are mapped into outputs; in this study we examine correlation transfer in pairs of uncoupled oscillators receiving partially correlated input. Specifically, we consider a one-parameter set of oscillators, which are characterized by a phase-resetting curve (PRC), given by the linear combination of two prototypical examples: the theta model PRC, typical of Type I excitable neurons, and the PRC near a Hopf bifurcation for a Type II excitable neuron. We examine the correlation coefficient between spike counts over a time window T. For very long time ($T \to \infty$) we use linear response theory for renewal processes to write this quantity as the ratio of integrals related to exit time moments. We find that correlation transfer over long time scales exhibits striking differences from the short-time (synchrony) correlation levels computed by Marella and Ermentrout (PRE 2008); they also differ qualitatively from the results on the linear integrate-and-fire neuron presented in de la Rocha et al. (Nature 2007, PRL 2008). We find that correlation transfer for neural oscillators is nearly independent of both input statistics (mean and variance of afferent currents) and output statistics (firing rate and CV). Moreover, Type I neurons maintain a positive limiting correlation coefficient; correlation in the Type II case decays to near zero.

Andrea K. Barreiro, Eric Shea-Brown
Department of Applied Mathematics
University of Washington
barreiro@amath.washington.edu,
etsb@amath.washington.edu

Evan Thilo
University of Washington
Department of Applied Mathematics
thiloe@u.washington.edu

PP0

Fractals, Bifurcations and Chaos in Open Hamiltonians

In this work we study the different kind of orbits that appear in Hamiltonian systems with escapes. This is done by analysing the fractal structures that appear on the regular and escape regions, the families of symmetric periodic orbits, their bifurcations and the chaotic regions. We use different state-of-the-art numerical techniques as the OFLI2 chaos indicator and a systematic search of symmetric periodic orbits. We show how the different numerical techniques provide complementary information which allows us to get a good picture of the problems. The paradigmatic example of the Henon-Heiles Hamiltonian is studied in detail.

Fernando Blesa
University of Zaragoza
fblesa@unizar.es

Roberto Barrio, Sergio Serrano
University of Zaragoza, SPAIN
rbarrio@unizar.es, sserrano@unizar.es

PP0

Stability Analysis of a Spatially Distributed Predator-Prey System

We consider a predator-prey system described by a system of two reaction-diffusion equations, with a linear diffusion for the prey and a nonlinear diffusion for the predator. In the case of a linear diffusion for both, the asymptotic behavior of the system is similar to the Lotka-Volterra system. Can a nonlinear diffusion (which may correspond to a collective-type behavior for predators) change the situation and cause pattern formation?

Elena Braverman
Department of Mathematics & Statistics
University of Calgary
maelena@math.ucalgary.ca

Leonid Braverman
St. Mary University College
Athabasca University
leonid.braverman@stmu.ab.ca

PP0

Fast Computation of Ftle Fields

This work develops an efficient method for computing finite time Lyapunov exponent (FTLE) fields, which are used to extract Lagrangian coherent structures (LCS) in unsteady flows. In particular, when computing a time-series of FTLE fields, flow map computations are greatly reduced by implementing a method of “stitched” interpolations. This method is compared for efficiency and accuracy against a number of alternative methods as well as the traditional computational approach.

Steven Brunton
Princeton University
sbrunton@princeton.edu

Clarence Rowley
Princeton University
Department of Mechanical and Aerospace Engineering
cwrowley@princeton.edu

PP0

Phase Space Transport and the Ionization of Kicked Rydberg Atoms

A highly excited Rydberg atom exposed to periodic external electric field impulses exhibits chaotic behavior. We study the system where an atom is exposed to alternating positive and negative impulses. The ionization of this system can be studied using the geometry of homoclinic tangles and the associated lobe dynamics. This approach enables us to design novel experiments with Rydberg atoms that can be realized in current experimental setups and to give predictions for the signature of chaotic ionization in these experiments. In particular we demonstrate a procedure for experimentally mapping out the geometric structure of the escaping lobes using highly excited potassium atoms exposed to alternating positive and negative kicks.

Korana Burke
UC Merced
kburke@ucmerced.edu

Kevin A. Mitchell
Univ of California, Merced
School of Natural Sciences
kmitchell@ucmerced.edu

PP0

Role of Plasticity in Coincidence Detection in the Avian Auditory Brainstem

The role of synaptic plasticity in temporal coding of neuronal networks is explored with an example of coincidence detection in the avian auditory brainstem, used in sound localization. Using a firing rate model and the integrate and fire neuron model of the reduced avian brainstem network we show that short term synaptic depression plays a role of gain control mechanism in enhancing coincidence detection among the nucleus laminaris(NL) neurons in the brainstem by making their firing rate phase dependent and less input frequency dependent.

Lakshmi Chandrasekaran
Dept. of Neurobiology
Northeastern Ohio univerisities college of medicine, OH
lc42@njit.edu

Amitabha Bose
New Jersey Inst of Technology
Department of Mathematical Sciences
bose@njit.edu

PP0

Ergodic Model for the Dynamics of a Pure Electron Plasma

In a Penning trap in which Larmor, bouncing and diocotron frequencies are of the same order of magnitude, the trajectory of single electrons is intractable analytically. However, perturbations to the ideal electrostatic potential lead to a sort of ergodic density for the electrons. According to this hypothesis, a model for the dynamics of the electron plasma is presented, in which the electron-neutral collisions are taken into account by using a Monte Carlo approach.

Gianni Coppa
Politecnico di Torino
Dipartimento di Energetica
gianni.coppa@polito.it

Antonio D’Angola
Universita’ degli Studi della Basilicata
antonio.dangola@unibas.it

Roberta Mulas
Politecnico di Torino, Italy
roberta.mulas@polito.it

PP0

Bifurcations in Lasers with Strong Optical Feedback

An effective but quite sensitive way of stabilizing lasers used in optical communication is to include strong optical feedback from a short external cavity. A numerical continuation study of a composite-cavity-mode model of such a system reveals bifurcations of relative equilibria (with respect to an underlying S1 symmetry). Group orbit reduction allows for the continuation of periodic orbits and uncovers complicated dynamics indicating system sensitivity on certain laser parameters.

Victoria J. Crockett, Sebastian Weiczorek, Peter Ashwin
University of Exeter
v.j.crockett@exeter.ac.uk, s.m.wieczorek@ex.ac.uk, p.ashwin@ex.ac.uk

Bernd Krauskopf
University of Bristol
Department of Engineering Mathematics
b.krauskopf@bristol.ac.uk

PP0

Phase-Locking and Phase-Resetting in a Relaxation Oscillator

We compare the dynamics of a periodically forced relaxation oscillator to that of a circle map derived from the phase-resetting response of this oscillator. Using numerical continuation, we compute bifurcation diagrams for the differential equations, with the stimulation period as bifurcation parameter. The period-1 solutions, which belong either to isolated loops or to an everywhere-unstable branch at small stimulus amplitudes, merge together to form a single branch at larger amplitudes. We show and explain that this amplitude corresponds, in the circle map, to a change of topological degree from one to zero.

Huguette Croisier
University of Liege (Belgium)
hcroisier@ulg.ac.be

Michael Guevara
McGill University
(Montreal, QC, Canada)
michael.r.guevara@mcgill.ca

Pierre C. Dauby
University of Liege (Belgium)
pc.dauby@ulg.ac.be

PP0

Patterns of Cooperation

We propose a model for the formation of cooperation networks among self-interested agents, which reproduces phenomena from biology, sociology, politics, and economics. Its twofold nature opens rich potentialities for the analytical treatment: The underlying differential equations allow for a stability analysis by means of dynamical systems theory. The discrete nature of the evolving network enable the application of graph theoretical tools. All told makes the model a candidate for a unified framework for phenomena from several disciplines.

Anne-Ly Do
Max Planck Institute for the Physics of Complex Systems
ly@pks.mpg.de

Thilo Gross
MPI for the Physics of Complex Systems
gross@pks.mpg.de

PP0

Computing the Best Positive Semi-Definite Approximation of a Symmetric Matrix Using a Flow

We work with real symmetric matrices and the Frobenius inner product. We consider the **best positive semi-definite approximation problem**: Given a real symmetric matrix A, find the positive semi-definite matrix that is closest to A. Consider the differential equation:

$$X' = (A - X)X^2 + X^2(A - X).$$

Theorem: Let A have eigenvalues which are distinct and nonzero. Let $X(0) := rI$ where $0 < r$. If $rI - A$ is positive definite then the solution $X(t)$ of the differential equation converges to the positive semi-definite matrix which is closest to A.

Kenneth R. Driessel
Mathematics Department
Iowa State University
driessel@iastate.edu

PP0

Pros and Cons of Intrinsically Bursting Neurons in a 3-Cell Network

We seek to understand the role of intrinsically bursting neurons in the generation of synchronized bursts within the preBotzinger Complex of the respiratory brainstem. We study this issue in an ordinary differential equation model due to Butera et al. Based on a combination of phase plane analysis and numerical simulation, we propose advantanges and disadvantages arising due to the presence of an intrinsically bursting neuron in a three-neuron network.

Justin Dunmyre
University of Pittsburgh
jrd34@pitt.edu

Jonathan E. Rubin
University of Pittsburgh
Department of Mathematics
rubin@math.pitt.edu

PP0

Global Asymptotic Stability of Solutions of Nonautonomous Master Equations

The master equation of a finite-state jump process is a system of linear ODEs of the form $\dot{p} = A(t)p$ which describe the evolution of the probability distribution p of the process. The master equation of time-homogeneous processes (i.e., A is constant) are well-studied, however time-inhomogeneous ones have been virtually ignored. We provide a number of conditions on the time-dependent matrix A that guarantee that all probability distribution solutions of the master equation approach each other in time.

Berton A. Earnshaw, James P. Keener
University of Utah
earnshaw@math.utah.edu, keener@math.utah.edu

PP0

Modelling and Simulations of the Migration of Pelagic Fish

We applied an interacting particle model to the Icelandic capelin stock to reproduce the spawning migration route for three different years, successfully predicting the route for 2008. Using available temperature data and approximated currents and without using artificial forcing terms or a homing instinct, our model was able to reproduce the observed migration routes from all three years. By means of a sensitivity analysis we identified oceanic temperature and the balance between the influence of interaction among particles and the particles' response to temperature as the control parameters most significant in determining the migration route. One significant contribution of this paper is the inclusion of orders of magnitude more particles than similar models, which affects the global behaviour of the model by propagating information about surrounding temperature through the school more efficiently. In order to maintain the same dynamics between different simulations, we argue a linear relationship between the time-step, radii of interactions and the spatial resolution and we argue that these scale as $N^{-1/2}$, where N is the number of particles.

Baldvin Einarsson
University of Iceland
baldvine@gmail.com

PP0

Modeling Electrophysiology, Calcium Dynamics, and Autocrine Regulation in GnRH Neurons

Gonadotropin-releasing hormone (GnRH) neurons secrete in a circhoral pulsatile pattern required for normal reproductive function. Their electrophysiology has been extensively studied. A plausible mechanism for GnRH pulsatility has been proposed, involving autoregulation of GnRH neurons through GnRH receptors. Mathematical models have been developed to explain certain features of each of these, separately. We present an integrated model to study the implications of autoregulation for electrophysiology and calcium dynamics in GnRH neurons.

Patrick A. Fletcher
Department of Mathematics
University of British Columbia, Vancouver, BC, Canada
fletcher@math.ubc.ca

Atsushi Yokoyama
Department of Bioscience and Bioinformatics,
Ritsumeikan University, Kusatsu Shiga, Japan
rs025010@se.ritsumei.ac.jp

Yue-Xian Li
University of British Columbia
Department of Mathematics
yxli@math.ubc.ca

PP0

Fidelity Criteria and Entropy

I propose expected log likelihood per time (the cross entropy rate) as a fidelity measure for dynamical models. By this measure the performance of any model fit to a *true* system is bound to be worse than Kolmogorov and Sinai's entropy rate. I illustrate with a sequence of more and more complex hidden Markov models that approximate the Lorenz system and find that approaching the KS bound requires millions of discrete states.

Andrew M. Fraser
Los Alamos National Laboratory
andy@fraserphysics.com

PP0

Tools for Design of Potentials for Particle Self-Assembly

Motivated by recent work on design of interaction potentials that assemble particles into lattices, we propose new tools to apply to this problem. First, we introduce a distance between point sets, that can be used to compare particle configurations with target structures. Second, we use local dynamical analysis tools to provide necessary conditions for assembly. Finally, we discuss fundamental limitations imposed by geometry on the kinds of lattices that may be ground states of particle systems.

Symeon Grivopoulos, George Mathew, Gunjan Thakur, Marko Budisic
Department of Mechanical Engineering
University of California at Santa Barbara
symeon@engr.ucsb.edu, gmathew@engr.ucsb.edu,
gunjan@engineering.ucsb.edu,
mbudisic@engineering.ucsb.edu

Igor Mezic
University of California, Santa Barbara
mezic@engineering.ucsb.edu

PP0

Multiple Timescales in Models of Intracellular Calcium Dynamics

Calcium is crucial for a huge range of cellular processes. It acts as an intracellular messenger, relaying information within cells via oscillations in calcium concentration to regulate cell activity. A key feature of intracellular calcium models is that they have multiple timescales. Using geometric singular perturbation techniques we can exploit this separation in timescales to analyse the models. This analysis helps us to explain the observed dynamics, including complicated oscillations known as mixed-mode oscillations.

Emily Harvey
University of Auckland
emily@math.auckland.ac.nz

PP0

Identifying Coupling Types from Observed Data

Identifying coupling types is a key technique to investigate interactions within coupled systems. There are a lot of existing methods for identifying directional couplings between two elements but there are few methods which can identify influence of a common third element and provide a significance level. In this poster, we propose such a method using recurrence plots as tools. The proposed method is robust against observational noise. We apply it to artificial and real data.

Yoshito Hirata
Institute of Industrial Science
The University of Tokyo
yoshito@sat.t.u-tokyo.ac.jp

Fumiaki Iida
Graduate School of Engineering,
The University of Tokyo
fiida@nanolab.t.u-tokyo.ac.jp

Kiyoshi Kotani
Graduate School of Frontier Science,
The University of Tokyo
kotani@k.u-tokyo.ac.jp

Kevin Judd
Department of Mathematics and Statistics
University of Western Australia
kevin@maths.uwa.edu.au

Kiyoshi Takamasu
Graduate School of Engineering,
The University of Tokyo
takamasu@pe.t.u-tokyo.ac.jp

Kazuyuki Aihara
JST/University of Tokyo, Japan
Dept of Mathematical Sciences
aihara@sat.t.u-tokyo.ac.jp

PP0

Control of Spatio-Temporal Patterns in the Gray-Scott Model

We study numerically the effects of time-delayed feedback control on the dynamics of spatio-temporal patterns in the Gray-Scott system, finding stability boundaries in the parameter space of control strength and time delay. For spatio-temporal chaos, control either stabilizes uniform steady states or leads to bistability between a trivial steady state and a travelling wave. For stable travelling pulses, control can provide either a stationary Turing pattern or bistability.

John Hogan
Bristol Centre for Applied Nonlinear Mathematics
Department of Engineering Mathematics, University of Bristol
s.j.hogan@bristol.ac.uk

Yuliya Kyrychko
University of Bristol
y.kyrychko@bristol.ac.uk

Konstantin Blyuss
Bristol Centre for Complexity Sciences
Department of Engineering Mathematics, University of Bristol
k.blyuss@bristol.ac.uk

Eckehard Schöll
Technische Universität Berlin
Institut für Theoretische Physik
schoell@physik.tu-berlin.de

PP0

Detection of Coherent Oceanic Structures Via Transfer Operators

The detection of coherent oceanic structures plays a crucial role for climate change research. From a dynamical systems point of view coherent oceanic structures correspond to almost invariant sets. To detect these sets we numerically approximate a transfer operator and identify almost invariant sets from its eigenfunctions. In particular, we analyze the Southern Ocean and figure out significant coherent structures in the Ross and Weddell Seas. This is joint work with Gary Froyland and Kathrin Padberg.

Christian Horenkamp
Chair of Applied Mathematics
University of Paderborn
christian.horenkamp@math.upb.de

Michael Dellnitz
University of Paderborn, Germany
dellnitz@math.upb.de

PP0

Act-and-Wait Control Concept and the Number of Poles to Be Controlled

Control of systems with delay in the feedback loop is a complex task, since infinitely many poles should be controlled using only finite number of control parameters. Parametric switching of the feedback according to the act-and-wait concept is one possible way to reduce the number of the poles to be controlled. The main features of the method are outlined for general linear continuous-time systems, and case studies are presented for demonstrations.

Tamas Insperger, Gabor Stepan
Budapest University of Technology and Economics
Department of Applied Mechanics
inspi@mm.bme.hu, stepan@mm.bme.hu

PP0

Fast Reciprocal Inhibition Can Synchronize Bursting Neurons

We report the co-existence of stable in-phase and anti-phase synchronization in a half-center oscillator, formed by two bursting neurons with fast inhibitory connections. In contrast to the conventional belief, we show that the fast reciprocal inhibition can lead to synchronous bursting. Through the stability analysis, we reveal the hidden property of reciprocal inhibition to synchronize the neurons and describe its synchronization mechanism. We also discuss the implications of the analysis for larger inhibitory networks.

Sajiya Jalil, Igor Belykh
Department of Mathematics and Statistics
Georgia State University
sja_jalil@yahoo.com, ibelykh@gsu.edu

Andrey Shilnikov
Neuroscience Institute and Department of Mathematics
Georgia State University
ashilnikov@gsu.edu

PP0

Dynamics of Discrete Population Models: Higher Dimensional Pioneer-Climax Model

There are many population models in the literature for both continuous and discrete systems. We begin with a general discrete model that subsumes almost all of the discrete population models currently in use. Some results related to the existence of fixed points are proved. We then concentrate mainly on a 3-dimensional Pioneer-Climax model. Most of the previous studies of such models have been for 1-dimensional or 2-dimensional systems only. An extensive theoretical and computational investigation of the dynamics of discrete 3-dimension Pioneer-Climax models is conducted, including an analysis of fixed and periodic points, bifurcations and chaotic regimes.

Yogesh Joshi
New Jersey Institute of Technology
yj23@njit.edu

Denis Blackmore
New Jersey Institute of Technology
Newark, NJ 07102, USA
deblac@m.njit.edu

PP0

Effects of Synaptic Depression and Adaptation on Spatiotemporal Dynamics of an Excitatory Neuronal Network

We analyze the spatio-temporal dynamics of a system of integro-differential equations that describes an excitatory neuronal network with synaptic depression and adaptation. We first derive conditions for the existence of traveling fronts and pulses, showing they are relatively unaffected by adaptation. We then show stable standing bumps exist in the absence of adaptation. In the case of a piecewise linear firing rate function, we show that the network supports self-sustained oscillations between an Up state and a Down state, in which a spatially localized oscillating core periodically emits pulses each cycle.

Zachary Kilpatrick, Paul Bressloff
Department of Mathematics
University of Utah
kilpatri@math.utah.edu, bresslof@math.utah.edu

PP0

Intrinsic Localized Modes in Mechanically Coupled Cantilever Array with Tunable On-Site Potential

A macro-mechanical cantilever array is proposed for experimental manipulation of intrinsic localized mode (ILM). The array consists of cantilevers, electromagnets faced on the cantilevers, elastic rods for coupling between cantilevers, and a voice coil motor for external excitation. Nonlinearity appears in the magnetic interaction, that is, the restoring force of cantilever. In the array, ILMs are possibly generated by the sinusoidal excitation because of the on-site nonlinearity. The experimental observation will be reported in detail.

Masayuki Kimura
Department of Electrical Engineering
Kyoto University
kimura@dove.kuee.kyoto-u.ac.jp

Takashi Hikihara
Kyoto University
Department of Electrical Engineering
hikihara@kuee.kyoto-u.ac.jp

PP0

Heat Damage of Cells with Application to Burn Injuries

Did you ever wondered how much you are going to burn yourself if you touch a hot plate? Or how long can a firefighter stay in an extremely hot environment wearing a protective gear? We propose a fundamentaly new mathematical model to investigate damage in living cells due to external heating particularly relevant to skin burns due to a contact with a hot surface but also applicable to other types of heat damage.

Richard Kollar
University of Michigan
Department of Mathematics
kollar@umich.edu

Sabino Pietrangelo
Lincoln Laboratory MIT
sabino@umich.edu

PP0

Multiple Time-Scales and the FitzHugh-Nagumo Equation

The FitzHugh-Nagumo equation has been investigated with a wide array of different methods in the last three decades. We use techniques from multiple time-scale dynamics to understand the structures of bounded global orbits and the bifurcation diagram. Numerical and analytical techniques can be used to compute homoclinic orbits and bifurcation curves which are inaccessible via continuation methods. The results of our analysis are summarized in a singular bifurcation diagram.

Christian Kuehn
Center for Applied Mathematics
Cornell University
ck274@cornell.edu

PP0

Oscillations in the Expression of a Self-Repressed Gene Induced by a Slow Transcriptional Dynamics

We revisit the dynamics of a gene repressed by its own protein in the case where the transcription rate does not adapt instantaneously to protein concentration. Analytical criteria for the appearance of sustained oscillations are derived. They show that oscillations require degradation mechanisms much less nonlinear than for infinitely fast regulation and that destabilization is maximal for a finite gene response time. Deterministic predictions are confirmed by stochastic simulations of this minimal genetic oscillator.

Pierre-Emmanuel Morant
PhLAM/Université Lille 1
France
morant@phlam.univ-lille1.fr

Quentin Thommen
PhLAM/Universit
'e de Lille I
France

thommen@phlam.univ-lille1.fr

Francois Lemaire
LIFL/Univ. de Lille 1
francois.lemaire@lifl.fr

Benjamin Parent
UGSF/Université de Lille 1
benjamin.parent@gmail.com

Constant Vandermoere
PhLAM/Université de Lille I
vander@phlam.univ-lille1.fr

Marc Lefranc
PhLAM/Université Lille I,
France
marc.lefranc@univ-lille1.fr

PP0

Two Modes of Theta-gamma Interaction in a Biophysical Model of the Hippocampus

The nervous system produces interacting rhythms of electrical activity believed to be functionally important. We analyze the interaction of the theta (4-12 Hz) and gamma (30-90 Hz) rhythms in a 2007 model of hippocampal oscillations. We show how the level of local excitation modulates network properties, and identify two different modes of interaction. We describe the properties of each mode and discuss their possible coordination at the network level.

Paola Malerba
Mathematics Department
Boston University
malerba@math.bu.edu

Nancy J. Kopell
Boston University
Department of Mathematics
nk@math.bu.edu

PP0

Chaotic Pattern Dynamics on Sun-Melted Snow

We present a comparison of time-lapse field observations of suncups on alpine snow with numerical simulations of a Kuramoto-Sivashinsky (KS)-like PDE in two dimensions. In addition to the traditional KS nonlinear term $|\nabla h|^2$, which causes a net recession in the mean, the PDE contains also a mean-conserving nonlinear term $\nabla^2|\nabla h|^2$. As the strength of the conservative term is increased with respect to the nonconservative term, the timescale of the chaotic dynamics increases.

Kevin A. Mitchell, Ralf W Wittenberg
Simon Fraser University
Department of Mathematics
kevmitch@math.sfu.ca, ralf@sfu.ca

Tom Tiedje
Faculty of Engineering
University of Victoria
ttiedje@uvic.ca

PP0

Approximation of Hodgkin-Huxley Models by Exponential Integrate-and-Fire Models

Effective strategies have been developed for finding the parameters in the recently proposed exponential integrate-and-fire point neuron model that best approximates the membrane potential and firing rate dynamics of a given, detailed Hodgkin-Huxley-type neuronal model. Efficient adaptive algorithms were developed for both systems, and the results of the computations compared. The same problem was also addressed in the presence of an adaptive current.

Jennifer L. Moyher
Rensselaer Polytechnic Institute
RPI
moyhej@rpi.edu

Daniel Johnson, Joshua P. Sauppe
Rensselaer Polytechnic Institute
johnsd2@rpi.edu, sauppj@rpi.edu

PP0

Robust Unbounded Attractors for Vector Fields in R^3

We construct unbounded non-singular strange attractors for vector fields in R^3, which are robust under uniformly small perturbations. The construction is based on the geometric Lorenz attractor.

Blaz Mramor
VU University Amsterdam
bmramor@few.vu.nl

PP0

Stable States of An Ice-Ocean Coupled Cell Model

We present a diffusively coupled cell model to investigate the ice-albedo feedback system of the Arctic Ocean and pattern formation during melting season. The current model is two-dimensional; it includes inter-cellular heat transfer, a solid-liquid phase transition in water, elements of phase field theory, and radiative energy exchange in the form of an idealized spatiotemporal drive. We introduce the model and show transient and asymptotic spatiotemporal dynamics, including stable steady states of sea-ice volume.

Marc Mueller-Stoffels, Renate A. Wackerbauer
University of Alaska Fairbanks
Department of Physics
ftmm2@uaf.edu, ffraw1@uaf.edu

PP0

The Saint-Venant System for Shallow Waters: Derivation of the Model and Global Solution of the Riemann Problem

We derive a model with a non-flat bottom from the Euler equation and discuss global weak solutions to the Riemann problem.

Simone Munao
VU University Amsterdam
smunao@few.vu.nl

PP0

Fourier Spectral Computing on the Sphere

Although spherical coordinates arise naturally in many applications, numerical routines for computing PDEs on a spherical surface are not yet commonplace tools for the relatively uninitiated. While spherical harmonics and finite-element methods are well-developed approaches, neither possesses the essential simplicity of computing on the 2D periodic domain with FFT-based spectral methods. It is little appreciated that fast Fourier transforms for the spherical surface have been implemented using the fact that longitude-latitude coordinates can be double-mapped to the torus. Combining this idea with a choice of Fourier basis for which the Laplacian is a sparse matrix operation, implicit time-stepping for diffusion can be implemented in a spectrally-fast manner. This simple FFT-based approach is demonstrated for a reaction-diffusion system.

David J. Muraki
Department of Mathematics
Simon Fraser University
muraki@math.sfu.ca

Kevin A. Mitchell
Simon Fraser University
Department of Mathematics
kevmitch@math.sfu.ca

Andrea Blazenko
Department of Mathematics
Simon Fraser University
ablazenk@sfu.ca

PP0

A Search Method of Multiple Local Optimal Solutions Based on the Bifurcations

This paper presents optimization for obtaining multiple local optimal solutions using bifurcation theories. The method consists of two steps. The first step is a local search step, and the second step is for escaping from the convergence region of the local optimal solution. In this paper, bifurcation theory is applied for escaping from the convergence region. For the purpose of illustrating the method, the numerical results show the effectiveness of the proposed method.

Chikashi Nakazawa, Akihiro Oi, Tetsuro Matsui
Fuji Electric Advanced Technology Co., Ltd.
nakazawa-chikashi@fujielectric.co.jp, oi-akihiro@fujielectric.co.jp, matsui-tetsuro@fujielectric.co.jp

PP0

Intermittent Search Strategies for Delivering Mrna to Synaptic Targets

We model the motor–driven transport of an mRNA containing granule along a dendrite in terms of a random intermittent search for a synaptic target. The granule is injected at one end of a one–dimensional track with an absorbing boundary at the other end. The particle switches between a stationary phase and a mobile phase that is biased in the anterograde direction. A single hidden target is located at a fixed but unknown location on the track. We calculate the hitting probability and conditional mean first passage time for finding the target, and determine conditions for an optimal search strategy.

Jay Newby, Paul C. Bressloff
University of Utah
Department of Mathematics
newby@math.utah.edu, bressloff@math.utah.edu

PP0

The Vsc Model, Existence, Uniqueness and Stability of Solutions

The Vesicl Supply Center (VSC) model is a model from heoretical biology to describe the morphology and growth of fungal hyphae. Traveling wave solutions for this model are analyzed and existence, uniqueness and linear stability of these solutions can be shown.

Robert Nolet
Vrije Universiteit Amsterdam
rwnolet@few.vu.nl

PP0

Time Evolution of Epidemics on Complex Networks

We study neighbour-to-neighbour dynamical propagation on complex networks with an analytical time evolution approach. The finite size of the system is taken into account and results are compared to numerical simulations. The new formalism has multiple applications in a wide range of domains from epidemiology in human populations to propagation of rumours and computer viruses.

Pierre-André Nol, Antoine Allard
Université Laval, Québec, Canada
pierre-andre.noel.1@ulaval.ca, antoine.allard.1@ulaval.ca

Louis J. Dubé
Université Laval
Departement de Physique
ljd@phy.ulaval.ca

PP0

Dynamical Impurities Increase the Lifetime of Transient Spatiotemporal Chaos

Spatiotemporal chaos on a regular ring network of excitable Gray-Scott dynamical elements collapses to a stable asymptotic state, with the average lifetime increasing exponentially with the network size. We introduce few dynamical impurities into the regular network by slightly changing the parameters in few of the network elements. These impurities drastically change the lifetime of spatiotemporal chaos - more than an order of magnitude - although the maximum Lyapunov exponent stays rather constant.

Renate A. Wackerbauer, Justin Oldham
University of Alaska Fairbanks
Department of Physics
ffraw1@uaf.edu, fsjjo3@uaf.edu

PP0

Neural Dynamics of Odor Encoding in a Network Model of the Olfactory Bulb

We use analyses of optical recordings in the rat olfactory bulb from to investigate how the results and prediction of existing network models of odor encoding may change when real data traces are used as input. The model considered here focuses on the mitral cell layer as the output of the olfactory bulb processing network, where synchronization of a subset of the mitral cells during specific phases of an underlying gamma rhythm constitutes a code for recognition of a specific odor. Our results suggest that the neural codes used in this model are sensitive to the variation in the real data.

Remus Osan, Nancy J. Kopell
Boston University
Department of Mathematics
osan@bu.edu, nk@math.bu.edu

PP0

Phase Space As An Optical Engineering Tool in Open Microcavity Designs

Optical microcavities have received much attention in the last decade from many different research fields ranging from fundamental aspects (quantum chaos) to specific applications in biosciences (molecular detection). In most cases, it would be desirable to combine high energy densities AND emission directionality in the near/far field. We propose to modify the refractive index of the medium with a careful monitoring of the corresponding phase space to achieve an optimal combination of these characteristics.

Guillaume Painchaud-April, Julien Poirier
Université Laval
Department of Physics, Physics Engineering and Optics
guillaume.painchaud-april.1@ulaval.ca,
julien.poirier.1@ulaval.ca

Louis J. Dubé
Université Laval
Departement de Physique
ljd@phy.ulaval.ca

PP0

First Poincar Returns, Natural Measure, Upo's and Kolmogorov-Sinai Entropy

Observing how long a dynamical system takes to return to some state is one of the most simple ways to model and quantify its dynamics from data series. In this work we show how to calculate the probability of the first Poincar returns (FPRs) of chaotic trajectories, using the unstable eigenvalues of a set of only a few (often only one) unstable periodic orbits. The FPRs of a chaotic trajectory is the time a trajectory takes to make two consecutive returns to a region, and can be simply and quickly accessible in experiments. This approach allows for analytical and semi-analytical estimations of relevant quantities in dynamical systems, as the Kolmogorov-Sinai entropy, the decay of correlations and the Lyapunov exponents.

Paulo Pinto
Centro de Matematica da Universidade do Porto
R. do Campo Alegre 687, Zip 4169-007, Porto, Portugal
paulo.pinto@fc.up.pt

Murilo S. Baptista
Centro de Matem
'atica da Universidade do Porto
murilo.baptista@fc.up.pt

PP0

Controlling Transport Properties in Dielectric Billiards

The classical ray dynamics of dielectric billiards (cavity + medium) has generically a mixed regular-chaotic phase space. The correspondence with the wave description (resonant cavity modes) exhibits a dynamical transport phenomenon known as chaos-assisted-tunnelling (CAT). However, this mechanism is still not well understood. We have constructed a novel billiard (an integrable cavity geometry with an inhomogeneous refractive index) that displays CAT and allows for its parametric control. This ability is important in the context of optical microcavities.

Julien Poirier, Guillaume Painchaud-April
Université Laval
Department of Physics, Physics Engineering and Optics
julien.poirier.1@ulaval.ca,
guillaume.painchaud-april.1@ulaval.ca

Louis J. Dubé
Université Laval
Departement de Physique
ljd@phy.ulaval.ca

PP0

Modeling and Construction of a Synthetic Toggle Switch in Mammalian Cells

We model and construct a gene regulatory network acting as a toggle switch which is to be used for in vivo delivery of mRNA/protein. The mathematical model captures well the qualitative behavior observed in the experiments. Additionally, we use bifurcation and continuation analysis to design and provide robust bistability in the network. This system can also be used as a device with applications for gene therapy.

Athanasios Polynikis
University of Bristol
Th.Polynikis@bristol.ac.uk

Giulia Cuccato, Velia Siciliano, Lucia Marucci
Telethon Institute of Genetics and Medicine, Naples, Italy
cuccato@tigem.it, siciliano@tigem.it, marucci@tigem.it

Stephen J. Hogan
University of Bristol
Dept of Engineering Math
s.j.hogan@bristol.ac.uk

Mario Di Bernardo
University of Bristol
Dept of Engineering Mathematic
m.dibernardo@bristol.ac.uk

Diego di Bernardo
Telethon Institute of Genetics and Medicine, Naples, Italy
dibernardo@tigem.it

PP0

On Mri Pulse Sequence Design with Pseudospectral (ps) Methods

PS methods have been shown to reduce continuous time optimal control (OC) problems to finite dimensional nonlinear programming problems. Non-uniform node spacing and orthogonal polynomial basis functions reduce the computational complexity and time for solving challenging OC problems. Pulse sequence design in MRI forms OC problems of (dissipative) bilinear systems. We take PS methods as a general toolkit for this class of problems. Applications include compensating pulses and presaturation pulses for cancer and cardiovascular imaging.

Justin A. Ruths
Washington University In Saint Louis
jruths@ese.wustl.edu

Jr-Shin Li
Washington University in St. Louis
jsli@seas.wustl.edu

PP0

Continuation of Invariant Tori in Large-Scale Dissipative Systems

We present a numerical algorithm for the continuation of invariant tori of high-dimensional dissipative dynamical systems. It is based on the computation of fixed points of a generalized Poincaré map by Newton-Krylov methods. The fast convergence of the linear solvers used in the algorithm can be easily explained. The method has been applied to the thermal convection of a binary mixture in a rectangular geometry. A branch of invariant tori has been found which includes a supercritical pitchfork bifurcation. The stable emerging branches end at a breakdown of the tori after two period doublings. We have also followed a small portion of the unstable branch. In addition, some details on the computations to follow the periodic orbits inside an Arnold's tongue of rotation number 1/8 will be shown. In this case, due to the symmetries of the problem, two stable and two unstable periodic orbits are found on the invariant torus.

Marta Net
Departament Fsica Aplicada
Universitat Politècnica de Catalunya
marta@fa.upc.edu

Juan Sánchez UmbríA
Dept. Fisica Aplicada
Universitat Politecnica de Catalunya
sanchez@fa.upc.edu

Carles SimÓ
Dept. Matematica Aplicada i Analisi
Universitat de Barcelona
carles@maia.ub.es

PP0

Bifurcations of Mixed-Mode Oscillations in a Three-Dimensional Autocatalator Model

Mixed-mode oscillations, a common phenomenon in fast-slow systems, occur in the three-dimensional chemical system considered here. A nice choice of cross-section allows us to reduce the full dynamics to a one-dimensional induced return map. Bifurcations of the map, which correspond to bifurcations of mixed-mode oscillations, are analyzed with symbolic dynamics.

Christopher J. Scheper
Center for Applied Mathematics
Cornell University
cjs73@cornell.edu

PP0

Constructing Freerunnable Models from Observed Data

Because of noise, it is sometimes hard to find, from observed datasets, models that behave similarly as the dynamics generating them. We call such models freerunnable. When observational noise is large, the extreme values of models obtained using a simple least square method are often underestimated. We propose a method to find freerunnable models from noisy data. The proposed method can reconstruct the extreme values of models better and thus the underlying dynamics.

Masanori Shiro
University of Tokyo
shiro@sat.t.u-tokyo.ac.jp

Yoshito Hirata
Aihara Complexity Modelling Project, ERATO, JST
Institute of Industrial Science, The University of Tokyo
yoshito@sat.t.u-tokyo.ac.jp

Kazuyuki Aihara
JST/University of Tokyo, Japan
Dept of Mathematical Sciences
aihara@sat.t.u-tokyo.ac.jp

PP0

Investigating the Dynamics of the Neural Substrates Taking Part in Goal-Directed Behaviour

A previously proposed discrete time dynamical system has been shown to be versatile in modelling cortex-thalamus-basal ganglia loop taking part in cognitive processes as goal-directed behaviour. In order to extract analogy between the cognitive processes and the dynamics of the model, a computational analysis including bifurcation diagrams for the parameters taking role in goal-directed behaviour will be given. Thus, the aim is to benefit from the computational analysis to comprehend the considered cognitive process better.

Cihan Soylu
istanbul technical university
cihansoylu@gmail.com

Ozkan Karabacak
School of Engineering, Computing and mathematics,
University of Exeter
ok213k@ex.ac.uk

Neslihan Sengor
Istanbul technical University
Electrics and Electronics Faculty
sengorn@itu.edu.tr

PP0

Local Collapse of Spatiotemporal Chaos

Reaction-diffusion systems can exhibit both small scale and systemic collapse of spatiotemporal chaos. The frequency of larger scale collapses decreases exponentially with size but the frequency of small scale collapses follows a power law. The presence of non-local shortcuts can introduce a sinusoidal component to extinction frequency. In all cases we find that spatiotemporal chaos is extensive during the transient dynamics, i.e. the Kaplan-Yorke dimension increases linearly with system size.

Dan Stahlke, Renate A. Wackerbauer
University of Alaska Fairbanks
Department of Physics
dan@gina.alaska.edu, ffraw1@uaf.edu

PP0

Imprinting Patterns in Relativistic Electron Bunches of Storage Rings

We show that it is possible to imprint periodic structures inside the phase-space of electron bunches using interactions with a laser. Perturbative studies of the electron transport equations, and of the Vlasov-Fokker-Planck equation allows to calculate the efficiency of the process, as well as damping times versus wavenumber. Experimentally the structure results in the emission of a narrowband terahertz radiation. Beside practical use, this opens the way to new tests of electron bunch spatio-temporal dynamics.

Christophe Szwaj
Lab. PhLAM/Univ. Lille1 (France)
christophe.szwaj@univ-lille1.fr

PP0

Revisiting the Slice Selection Problem in Magnetic Resonance Imaging

Through rewriting the dynamics of a spin system in spherical coordinates, a novel framework is introduced that can be used in magnetic resonance imaging (MRI) for designing pulses with better slice selectivity. The problem formulation shows that the order of the system will be reduced without using spinors. Moreover, a lower order of approximation is required in solving the slice selection problem compared to the classical methods available in the Cartesian coordinates.

Bahman Tahayori
PhD Student of Electrical Engineerin University of Melbourne
and NICTA Victoria Research Laboratory
b.tahayori@ee.unimelb.edu.au

Leigh Johnston, Iven Mareels, Peter Farrell
EEE Department, The University of Melbourne
NICTA Victoria Research Laboratory
leigh.johnston@florey.edu.au, i.mareels@unimelb.edu.au, pfarrell@unimelb.edu.au

PP0

Bifurcation Analysis of Shimmy in An Aircraft Nose Landing Gear

We present a mathematical model of an aircraft nose landing gear that describes the interaction between different vibrational modes via the interaction of an elastic tyre with the ground. In contrast to almost all previous studies, nonlinearities arising from the nose gear geometry are fully incorporated. Bifurcation diagrams in the forward velocity and downward force on the landing gear identify regions where different types of shimmy oscillations can be found in practice.

Phanikrishna Thota, Bernd Krauskopf
University of Bristol
Phani.Thota@bris.ac.uk, b.krauskopf @ bristol.ac.uk

Mark Lowenberg
Dept. of Aerospace Engineering
University of Bristol
m.lowenberg@bristol.ac.uk

PP0

Singular Dynamics in the Willmore Flow

The Willmore flow is a model for the bending energy of embranes and has its origin in conformal geometry. It is an open question whether the Willmore flow can produce a singularity in finite time on a smooth surface. We use the method of matched asymptotics and numerical methods to investigate this problem.

Michelangelo Vargas Rivera
Vrije Universiteit Amsterdam
mvargas@few.vu.nl

PP0

A New Conserved Quantity for the Kermack-McKendrick Epidemic Model

We show that the Kermack-McKendrick nonlinear Volterra integral equation has a conserved quantity that generalizes the well-known conserved quantity of the three-dimensional SIR model. We show that "all' multi-stage SIR-type models have this conserved quantity, because they are reductions of the Kermack-McKendrick equation corresponding to specific choices of the "infectiousness kernel'. We derive new formulas for the basic reproduction number in a large class of multi-stage SIR models with arbitrary infectiousness kernels.

Warren Weckesser
Enthought, Inc
warren.weckesser@gmail.com

Daniel Schult
Colgate University
dschult@mail.colgate.edu

PP0

An Adaptive Method for Computing Invariant Manifolds of 2-D Maps

We present a method for computing invariant manifolds of planar maps. Such manifolds can have large variations in curvature hence must be calculated adaptively. Some of the current well known schemes are based on piecewise-linear interpolation. We improve this by using higher-order methods from geometric modeling. We base our scheme on Catmull-Rom splines, taking advantage of the properties of Bézier curves. Finally, we show the method to be more accurate and efficient than the existing methods.

Jacek Wrobel, Roy H. Goodman
New Jersey Institute of Technology
Department of Mathematical Sciences
jkw3@njit.edu, goodman@njit.edu

PP0

Experimental Study on Chaos Control in Dynamic-Mode Atomic Force Microscopy

The dynamic-mode atomic force microscopy (AFM) has realized high resolution imaging by utilizing a micromechanical cantilever resonator. However, recent studies have em-

phasized that a cantilever interacting to a sample surface may exhibit various nonlinear phenomena. The resulting chaotic oscillation may reduce force sensitivity of dynamic-mode AFM. In this paper, we present the application of the time-delayed feedback control to the dynamic-mode AFM. We experimentally demonstrate irregular oscillation can be stabilized by perturbation to excitation signal.

Kohei Yamasue, Kei Kobayashi, Hirofumi Yamada,
Kazumi Matsushige
Kyoto University
kohei.yamasue@ky7.ecs.kyoto-u.ac.jp,
keicoba@icc.kyoto-u.ac.jp, h-yamada@kuee.kyoto-u.ac.jp,
matusige@kuee.kyoto-u.ac.jp

Takashi Hikihara
Kyoto University
Department of Electrical Engineering
hikihara@kuee.kyoto-u.ac.jp

PP0

Synchrony Between Scattered Gnrh Neurons Through a Diffusive Mediator

A mechanism for GnRH pulsatility involving autocrine regulation of GnRH neurons in a well-stirred medium has been revealed experimentally and modeled mathematically. We extend this model to the situation of scattered GnRH neurons in the hypothalamus coupled only by diffusion of GnRH without stirring. We explore the significance of the number of neurons and the average inter-neuronal distance on synchronization. Both regularly and randomly distributed networks of GnRH neurons are explored.

Atsushi Yokoyama
Department of Bioscience and Bioinformatics,
Ritsumeikan University, Kusatsu Shiga, Japan
rs025010@se.ritsumei.ac.jp

Patrick Fletcher
Department of Mathematics,
University of British Columbia
fletcher@math.ubc.ca

Yue-Xian Li
University of British Columbia
Department of Mathematics
yxli@math.ubc.ca

PP0

Modelling of Osmotic Cell Swelling

Absorption of water by a cell is caused by osmotic force and pressure differences. The exact mechanism of water absorption is not completely clear, probably this is by receptor-like entities. We present a gradient-flow model which might answer the question.

Martijn Zaal
VU University Amsterdam
mzl400@few.vu.nl

PP0

Interaction of Solitary Pulses and Periodic Waves in Excitable Systems

Excitable systems of reaction-diffusion equations are used to model many biophysical processes, including changes of calcium concentration in various cell types. Understanding the interaction between solitary and periodic travelling waves is important in these systems. By moving to travelling wave coordinates and using ideas from geometric singular perturbation theory, we show how complicated bifurcations associated with this interaction arise from a singular limit. We illustrate the method with models of intracellular calcium dynamics and the FitzHugh-Nagumo equations.

Wenjun Zhang
University of Auckland
wzha122@math.auckland.ac.nz