FACM '14

FRONTIERS IN APPLIED AND COMPUTATIONAL MATHEMATICS

New Jersey Institute of Technology
Newark, New Jersey
May 22 – 23, 2014

Program Guide and Abstracts

Hosted by:
Department of Mathematical Sciences and
Center for Applied Mathematics and Statistics
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NJIT
New Jersey Institute of Technology

ORGANIZING COMMITTEE

FRONTIERS IN APPLIED AND COMPUTATIONAL MATHEMATICS
NEW JERSEY INSTITUTE OF TECHNOLOGY
NEWARK, NEW JERSEY
MAY 22 – 23, 2014

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FRONTIERS IN APPLIED AND COMPUTATIONAL MATHEMATICS

MESSAGE FROM THE ORGANIZING COMMITTEE

Welcome to Frontiers in Applied and Computational Mathematics (FACM'14), the eleventh in a series of annual conferences that have been organized by the Department of Mathematical Sciences and the Center for Applied Mathematics and Statistics at NJIT, and supported by the National Science Foundation.

In this year's conference, we recognize the fundamental contributions that our colleague Robert Miura has made to mathematics and its applications. There will be plenary talks and minisymposium sessions related to mathematical biology, non-linear waves, integrable systems and biostatistics, areas in which Robert has made important contributions. In addition, there will be a two-day poster session where work from more general areas of applied mathematics will be presented.

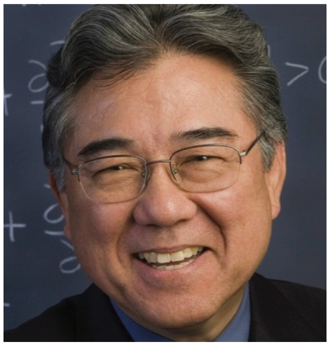
As in past FACM conferences, this year's conference continues to feature the presentation of contributed talks by graduate students and postdoctoral fellows. These talks were selected from numerous applications submitted by some of the nation's best young researchers working in applied and computational mathematics. We are happy to give these future leaders a chance to present their work.

The FACM conferences are indicative of the important role that Mathematical Sciences plays at NJIT. We hope you enjoy the meeting and return next year for another FACM conference to discuss your latest ideas and achievements.

We take this opportunity to thank the Administrative Staff of the Department of Mathematical Sciences: Eileen Michie, Fatima Ejallali, Alison Boldero and Nickcoy Findlater. We would also like to recognize and thank Susan Sutton, who was instrumental in the organization of the first ten FACM meetings and has just recently retired from NJIT.

FACM '14 Organizing Committee

IN HONOR OF ROBERT M. MIURA



In a career of nearly fifty years, Robert Miura has made ground-breaking and profound contributions to mathematics and the applications that arise from it. His work spans a variety of distinct fields, from the discovery of the inverse scattering method to applications in mathematical neuroscience. He has been a truly collaborative scientist who has led mathematics into areas of application that were formerly inconceivable. It is both a pleasure and an honor to recognize Robert's achievements.

In 1965 at the onset of his career, Robert began a postdoc with Martin Kruskal where they began trying to explain the wondrous behavior of solutions to the Korteweg-de Vries (KdV) equation. Solitary waves of this nonlinear PDE are able to pass through each other upon collision, emerging unscathed except for a finite shift in their positions. Clifford Gardener and John Greene soon joined the project. They discovered that KdV possesses an underlying linear structure which allowed them to construct the inverse scattering transform which leads to a Fourier-like method of solving the initial value problem. This deep and surprising result inspired others to look for similar structure in different systems and initiated the blossoming of a new field, "soliton theory." Their methods have subsequently been utilized to study other partial differential equations such as the non-linear Schrödinger and sine-Gordon equations, and to study Hamiltonian and integrable systems. The inverse scattering method has found application in fields such as nonlinear optics and plasma physics. For this work, Miura and his collaborators Gardner, Greene and Kruskal were awarded the prestigious Leroy P. Steele Prize for Seminal Contribution to Research in 2006 by the American Mathematical Society.

Miura's middle years were focused on differential-difference equations and their singular perturbations. He co-wrote a number of very fine papers with Charles Lange on the subject. Although these papers were very mathematical in nature, they were all motivated by physical applications in mathematical biology. The latter became a constant in his research career. Indeed, his contributions to the field of mathematical biology, and mathematical neurosciences in particular, will be one of his most enduring. He was uniquely capable of building realistic models from first principles and creatively solving them.

Miura's contribution to mathematical biology spans many different areas. Much of his research effort is devoted to the understanding and mathematical modeling of spreading cortical depression, a pathological phenomenon whereby a self-propagating wave of depolarization and elevated electrolyte concentration slowly spreads through mammalian neocortex, and is the basis of some forms of migraine pain and migraine aura. Robert has developed several novel models of this phenomenon over the years, and helped to clarify a more general, related problem of diffusion in cellular environments. His research interests extend far beyond this problem: he has published manuscripts on such diverse problems as insulin release in beta cells, cell calcium dynamics, and models of neuronal excitability in cortical, hippocampal and thalamocortical neurons. Robert has also contributed to the understanding of issues related to the manufacturing of glass electrodes that serve as the main experimental tool in neurophysiology.

In recognition of his complete body of work, Robert was named as an Inaugural Fellow of the Society for Industrial and Applied Mathematics in 2009 and of the American Mathematical Society in 2013. Previously he had been named a Fellow of the American Association for the Advancement of Science (2005), of the Royal Society of Canada (1995) and of the John Simon Guggenheim Memorial Foundation (1980-1981). Robert has received these awards with a degree of humility and grace, the same with which he has conducted his entire professional life. We, his colleagues, both here at NJIT and beyond, are fortunate to have had the opportunity to interact with Robert.

Amitabha Bose, Roy Goodman, Gregory Kriegsmann and Victor Matveev

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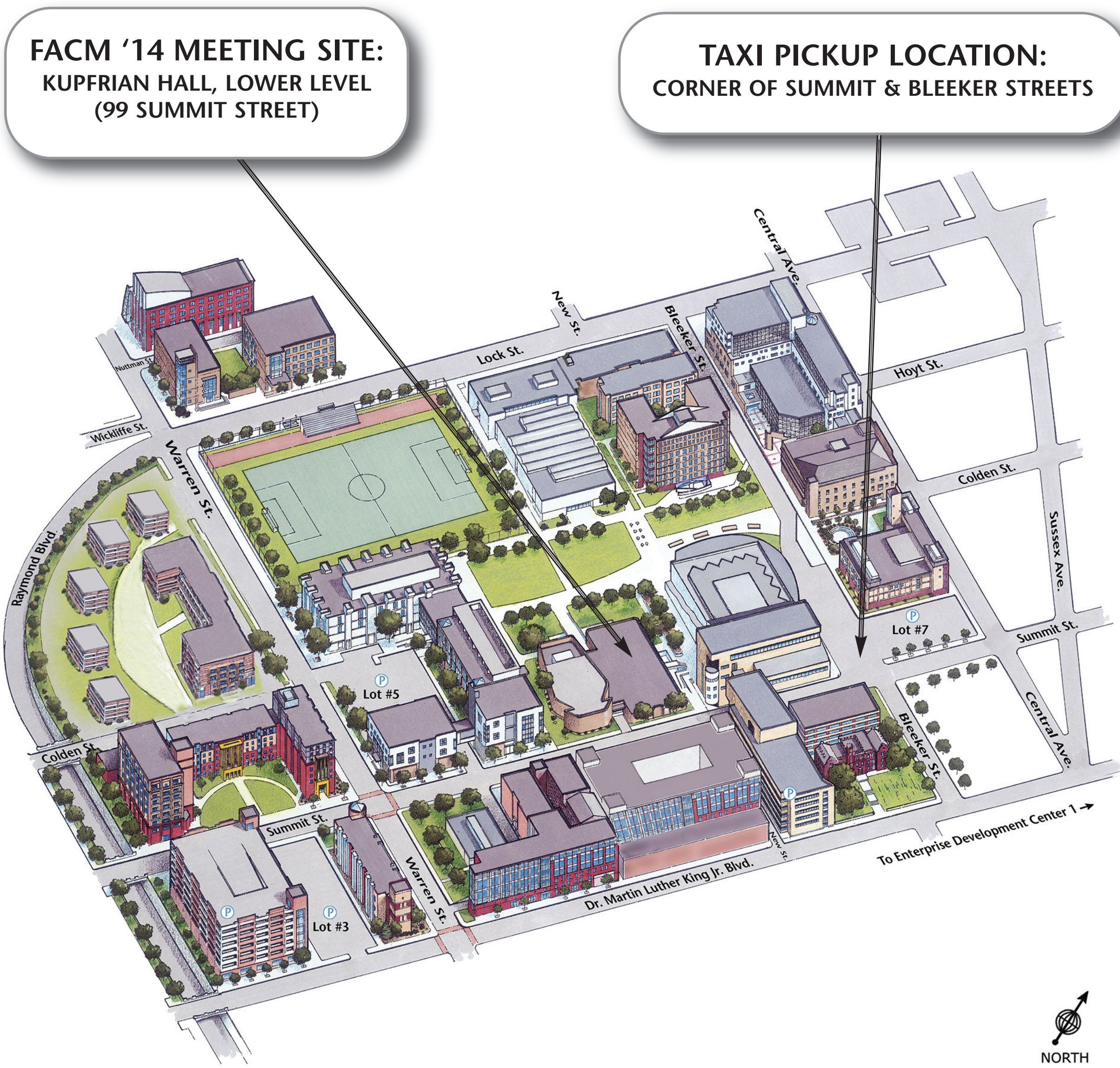

GUEST ACCESS TO THE NJIT NETWORK

MAY 22 - 23, 2014

Welcome to NJIT. Please make use of the wired and wireless connections available in the meeting area. To do so please follow these three steps:

1. *CONNECT* using either a wireless or wired connection. Addresses are assigned automatically.
   - **Wired:** Most wall plates are active in the meeting area and noted by a RED or YELLOW port on the wall plate.
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Password:	**fatigue42**

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3. *ACCESS* to the NJIT network should now be available. Your guest account will give you access for 6 hours. After that time you will be asked to authenticate again if you are using a web browser. If you are not using a web browser simply open one and repeat step 2.

Please note: these access credentials are only good until midnight of May 23, 2014.

PROGRAM SCHEDULE

THURSDAY, MAY 22

8:00 – 8:40 a.m.	Registration + Coffee/ Pastries	Kupfrian 1st Floor Lobby
	Set Up Posters	Kupfrian 2nd Floor Rotunda
8:45 – 9:00 a.m.	**Introductory Remarks**	Jim Wise Theater, Kupfrian Hall
	John Bechtold, Acting Chairperson, Department of Mathematical Sciences	
	Welcoming Remarks	
	Jonathan Luke, Interim Dean of CSLA	
9:00 – 10:00 a.m.	**Plenary Lecture I**	Jim Wise Theater, Kupfrian Hall
	John Rinzel, New York University	
	Neuronal Dynamics of Sound Localization	
10:00 – 10:30 a.m.	Coffee Break	Kupfrian 1st Floor Lobby
10:30 – 1:00 p.m.	**Minisymposia I, II, III**	
1:00 – 2:30 p.m.	Lunch	Kupfrian 1st Floor Lobby
	Poster Session	Kupfrian 2nd Floor Rotunda
2:30 – 3:30 p.m.	**Plenary Talk II**	Jim Wise Theater, Kupfrian Hall
	Huaxiong Huang, York University	
	Modelling Cortical Spreading Depression and Related Phenomena	
3:30 – 4:00 p.m.	**Coffee Break**	Kupfrian 1st Floor Lobby
4:00 – 6:00 p.m.	**Special Session in Honor of Robert Miura**	
6:00 – 9:00 p.m.	Banquet	Campus Center Atrium

THURSDAY MORNING

PLENARY TALK I

9:00 – 10:00 **John Rinzel,** New York University
Neuronal dynamics of sound localization
Location: Jim Wise Theater, Kupfrian Hall

MINISYMPOSIA I, II, III

	Minisymposia I	Minisymposia II	Minisymposia III
	Nonlinear Waves Location: Kupfrian 117 *Chair: Roy Goodman*	New Methods in Computational Biology Location: Kupfrian 106 *Chair: Ji Meng Loh*	Circadian Rhythms Location: Kupfrian 118 *Chair: Casey Diekman*
10:30 – 11:00	**Thomas Trogdon** Courant Institute *Oscillatory integrals and integrable systems*	**Vipul Periwal** LBM, NIDDK *The meaning of nothing: Applications of Empirical Bayes*	**Linda Petzold** UC Santa Barbara *Inference of Functional Circadian Networks*
11:00 – 11:30	**Gino Biondini** State University of New York at Buffalo *The integrable nature of modulational instability*	**Justin Kinney** Cold Spring Harbor Laboratory *Estimation of probability densities using scale-free field theories*	**Ron Anafi** University of Pennsylvania *Computationally assisted discovery of circadian clock components and output rhythms.*
11:30 – 12:00	**Christian Klein** Université de Bourgogne *Dipersive shocks in 2+1 dimensional systems*	**Mickey Atwal** Cold Spring Harbor Laboratory *Statistical Physics of Population Genetics and Complex Diseases*	**Tanya Leise** Amherst College *Wavelet-Based Analysis of Circadian Oscillators*
12:00-12:30	**Percy Deift** New York University *Universality in computations with random data: Case studies*	**Mona Singh** Princeton University *Data-driven approaches for uncovering and understanding biological networks*	**Adrian Granada** Harvard Medical School *Synchronization and coupling mechanisms of the mammalian circadian clock*
12:30 – 1:00	**Constance Schober** University of Central Florida *Numerical investigation of stability of breather-type solutions of the nonlinear Schrodinger equation*	**Cristiano Dias** New Jersey Institute of Technology *Driving peptides into fibril structures*	**Daniel DeWoskin** University of Michigan *Putting the circadian clock together: using high performance computing to investigate coupling in the suprachiasmatic nucleus*

THURSDAY AFTERNOON

PLENARY TALK II

2:30 – 3:30 **Huaxiong Huang,** New York University
Modelling Cortical Spreading Depression and Related Phenomena
Location: Jim Wise Theater, Kupfrian Hall

SPECIAL SESSION IN HONOR OF ROBERT MIURA

CHAIR: AMITABHA BOSE

LOCATION: JIM WISE THEATER, KUPFRIAN HALL

4:00 – 4:30 **Mark Ablowitz**
University of Colorado
Nonlinear waves, solitons and applications

4:30 – 5:00 **Michael Ward**
University of British Columbia
Logarithmic Expansions and the Stability of Periodic Patterns of Localized Spots for Reaction-Diffusion Systems in Two Dimensions

5:00 – 5:30 **Gerda de Vries**
University of Alberta
Formation of Animal Groups: The Importance of Communication Mechanisms

5:30 – 6:00 **Yue Xian Li**
University of British Columbia
Working with Robert Miura on Clustering in Small Networks of Neuronal Oscillators

PROGRAM SCHEDULE

FRIDAY, MAY 23

8:30 – 9:00 a.m.	Registration + Coffee/ Pastries	Kupfrian 1st Floor Lobby
	Set Up Posters	Kupfrian 2nd Floor Rotunda
9:00 – 10:00 a.m.	**Plenary Lecture III**	Jim Wise Theater, Kupfrian Hall
	Peter Miller, University of Michigan	
	Universal Wave Patterns	
10:00 – 10:30 a.m.	Coffee Break	Kupfrian 1st Floor Lobby
10:30 – 12: 45 p.m.	Minisymposia IV, V, VI	
12:45 – 2:00 p.m.	Lunch	Kupfrian 1st Floor Lobby
	Poster Session	Kupfrian 2nd Floor Rotunda
2:00 – 3:00 p.m.	**Plenary Lecture IV**	Kupfrian 1st Floor Lobby
	Jonathan Wylie, City University of Hong Kong	
	Asymptotic Analysis of a Viscous Drop Falling Under Gravity	
3:00 – 3:15 p.m.	Coffee Break	Kupfrian 1st Floor Lobby
3:15 – 5:30 p.m.	Minisymposia VII, VIII, IX	

PROGRAM EVENTS

FRIDAY MORNING

PLENARY TALK III

9:00 – 10:00 **Peter Miller,** University of Michigan
Universal Wave Patterns
Location: Jim Wise Theater, Kupfrian Hall

MINISYMPOSIA IV, V, VI

	Minisymposia IV	Minisymposia V	Minisymposia VI
	Nonlinear Waves Location: Kupfrian 117 *Chair: Roy Goodman*	Dynamics of Brain Disorders Location: Kupfrian 118 *Chair: Jonathan Rubin*	Biostatistics I Location: Kupfrian 106 *Chair: Antai Wang*
10:30 – 11:00	**David Shirokoff** McGill University *A simple, efficient and accurate method for computing the order-disorder phase transition in double well energy functionals*	**Ernest Barreto** George Mason University *Ion Concentration Dynamics and its Effects on Neuronal Excitability*	**Song Yang** National Heart, Lung, and Blood Institute *Semiparametric Analysis of Summary Measures of Treatment Effect with Survival Data*
11:00 – 11:30	**Richard Moore** NJIT *Simulating exits in stochastic laser dynamics*	**Mark Kramer** Boston University *Seizure dynamics across spatial and temporal scales*	**Zhezhen Jin** Columbia University *Estimation and inference on semiparametric regression models*
11:30 – 12:00	**Demetrios Papageorgiou** Imperial College London *Nonlinear wave phenomena in viscous stratified multilayer flows*	**Jonathan Rubin** University of Pittsburgh *The healing power of (synaptic) depression*	**Yichuan Zhao** Georgia State University *Empirical likelihood for linear transformation models with interval-censored failure time data*
12:00-12:30	**Harvey Segur** University of Colorado *The nonlinear Schrödinger equation, dissipation and ocean swell*	**David Terman** Ohio State University *Spreading depolarization in a neuron/astrocyte network model*	**Guoqing Diao** George Mason University *New semiparametric regression method with applications to selection-bias sampling and missing data problems*
12:30 – 12:45	**Francisco Javier Martínez Farías** Universidad Nacional Autónoma de México *Weakly nonlinear localization for a 1-D FPU chain with clustering zones*	**José Fernando Bustamante Castañeda** Universidad Nacional Autónoma de México *Mathematical modeling of glioblastoma multiforme response to radiation therapy*	**Antai Wang** NJIT *Properties of the Marginal Survival Functions for Dependent Censored Data under an assumed Archimedean Copula*

FRIDAY AFTERNOON

PLENARY TALK IV

2:00 – 3:00	**Jonathan Wylie,** City University of Hong Kong *Asymptotic Analysis of a Viscous Drop Falling Under Gravity* Location: Jim Wise Theater, Kupfrian Hall

MINISYMPOSIA VII, VIII, IX

	Minisymposia VII	Minisymposia VIII	Minisymposia IX
	Applied Mathematics Location: Kupfrian 117 *Chair: Michael Siegel*	Modeling in Physiology Location: Kupfrian 118 *Chair: Victor Matveev*	Biostatistics II Location: Kupfrian 106 *Chair: Antai Wang*
3: 15 – 3:45	**Kenneth Ho** Stanford University *Efficient operator factorizations for integral and differential equations*	**Victoria Booth** University of Michigan *Modeling desynchronization of sleep and circadian rhythms in humans*	**Martin Lindquist** Johns Hopkins University *Functional Causal Mediation Analysis with an Application to Brain Connectivity*
3:45 – 4:15	**Fred Wan** University of California, Irvine *Feedback and Robust Biological Developments*	**Greg Smith** The College of William & Mary *Modeling the bidirectional coupling of localized calcium elevations and whole cell calcium responses*	**Yuanjia Wang** Columbia University *Statistical Learning Methods for Time-Sensitive Disease Classification and Prediction*
4:15 – 4:45	**Tong Li** University of Iowa *Traveling Waves of Chemotaxis Models*	**Richard Bertram** Florida State University *Synchronization of Pancreatic Islets*	**Yixin Fang** New York University School of Medicine *A model-free estimation for covariate-adjusted Youden index*
4:45 – 5:15	**Roy Malka** Harvard & MGH *In Vivo Volume and Hemoglobin Dynamics of Red Blood Cells*	**Qing Nie** University of California *Stem Cells and Regeneration: Feedback, Niche, and Epigenetic Regulation*	**Gavin Lynch** NJIT *A False Discovery Rate Controlling Procedure for Testing Hypotheses with Complex Structure*
5:15 – 5:30	**Joshua Chang** Mathematical Biosciences Institute *Regulation of calcium nanoparticle formation and precipitation in biological tissues: A Mathematical model*	**Patrick Fletcher** Florida State University *Real-Time Model Calibration and Prediction Testing with the GPU and Dynamic Clamp*	**Rianka Bhattacharya** NJIT *Two-sample location-scale estimation from semiparametric random censorship models*

HUAXIONG HUANG

York University

Modelling Cortical Spreading Depression and Related Phenomena

Cortical spreading depression (CSD) has been the focus of intensive experimental and theoretical study since its discovery by Leao in 1944. The connection between CSD waves and migraine with aura (MwA) and other pathological conditions has made the mathematical study of CSD even more compelling. The quantitative study of CSD has led to mathematical models that incorporate many of the mechanisms known to affect CSD speed, shape, and duration. CSD involves the movement of the major ions (potassium, sodium, chloride, and calcium) in the brain. These ions are transported by diffusion and can go through cell membranes as a result of ionic membrane channels and energy consuming pumps that restore the ionic concentrations to homeostasis. The massive variations in ion concentrations associated with CSD waves also give rise to significant osmotic effects and puts intense stress on the neurovascular coupling that regulates oxygen supply to the brain. In this talk, we will give an overview of the models that have been proposed with a focus on the models developed by Robert Miura and his colleagues.

PETER MILLER

University of Michigan

Universal Wave Patterns

A feature of solutions of a (generally nonlinear) field theory can be called "universal" if it is independent of side conditions like initial data. I will explain this phenomenon in some detail and then illustrate it in the context of the sine-Gordon equation, a fundamental relativistic nonlinear wave equation. In particular I will describe some recent results (joint work with R. Buckingham) concerning a universal wave pattern that appears for all initial data that crosses the separatrix in the phase portrait of the simple pendulum. The pattern is fantastically complex and beautiful to look at but not hard to describe in terms of elementary solutions of the sine-Gordon equation and the collection of rational solutions of the famous inhomogeneous Painlevé-II equation. As time permits, other recently studied examples of universal wave patterns will be highlighted.

JOHN RINZEL

New York University

Neuronal dynamics of sound localization

Sound localization involves neuronal computation in the auditory brain stem of interaural arrival time differences (ITDs) and intensity differences (IIDs). We will describe dynamical features that distinguish the neuronal populations for ITD and IID comparisons, including resonance as studied by Puil and Miura in several neural systems. ITDs are resolved with extraordinary precision (sub-ms range) using biophysical and dynamical specializations, making the coincidence-detecting neurons extraordinarily slope-sensitive, unresponsive to slow inputs.

JONATHAN WYLIE

City University of Hong Kong

Asymptotic Analysis of a Viscous Drop Falling Under Gravity

Despite extensive research on extensional flows, there is no complete explanation of why highly viscous fluids falling under gravity can form such persistent and stable filaments. We therefore investigate the motion of a slender axisymmetric viscous drop that is supported at its top by a fixed horizontal surface and extends downward under gravity. We consider the full initial-boundary-value problem for arbitrary initial shape of the drop in the case in which inertia and surface tension are initially negligible. We show that, eventually, the accelerations in the thread become sufficiently large that the inertial terms become important. We therefore keep the inertial terms and obtain asymptotic solutions for the full initial-boundary-value problem. The asymptotic procedure requires a number of novel techniques and the resulting solutions exhibit surprisingly rich behavior. The solution allows us to understand the mechanics that underlies highly persistent filaments.

MARK ABLOWITZ

University of Colorado

Nonlinear waves, solitons and applications

Motivated by the Fermi-Pasta-Ulam problem Zabusky and Kruskal numerically found that the solitary waves of the Korteweg-deVries (KdV) equation had special interaction properties; they termed them solitons. Subsequently, fundamentally based on the transformation Robert Miura found, the inverse scattering method and the concept of integrability for KdV was elucidated. Here solitons are special solutions. In shallow water waves the KdV equation and its generalization to 2+1 dimensions, the Kadomtsev-Petviashvili (KP) equation are integrable. KP admits line soliton solutions which are physically important. Their effect can be seen daily on shallow beaches. Other applications of nonlinear waves, solitary waves and solitons in physical applications will also be discussed.

RON ANAFI

University of Pennsylvania

Computationally assisted discovery of circadian clock components and output rhythms

Over the last decades, researchers have characterized a set of "clock genes" that drive daily rhythms in physiology and behavior. Here I will discuss our work in analyzing large scale data sets to answer two of the remaining challenges in circadian molecular biology. (1) Recent attempts to expand our understanding of circadian regulation have moved beyond the mutagenesis screens that identified the first clock components, employing higher throughput genomic and proteomic techniques. In order to further accelerate clock gene discovery, we utilize a computer-assisted approach to identify and prioritize candidate clock components. Using a simple form of probabilistic machine learning to integrate biologically relevant, genome-scale data, we rank genes on their similarity to known clock components. One candidate, Gene Model 129, functionally represses the key driver of molecular rhythms. Given these results, we have re-named the gene CHRONO (computationally highlighted repressor of the network oscillator). Importantly, CHRONO knockout mice display a prolonged free-running circadian period similar to, or more drastic than, six other clock components(2) There is increasing circumstantial evidence that circadian rhythms influence the susceptibility to various diseases and are, in turn, influenced by disease. However, the realities of dealing with human patients make traditional time course experiments practically impossible. Even in animal models, such time course collections can be daunting and expensive. On the other hand, there is a wealth of temporally unstructured data. I will present our preliminary work to develop theoretical tools to mine this data for high dimensional signatures of biological rhythms.

MICKEY ATWAL

Cold Spring Harbor Laboratory

Statistical Physics of Population Genetics and Complex Diseases

Population genetics enjoys an enviable role in the biological sciences. The understanding of evolutionary processes lends itself naturally to theory and computation, and the entire field of population genetics has benefitted greatly from the influx of methods from applied mathematics for almost 100 years. However, in spite of all this effort, there are a number of key dynamical models of evolution that have resisted analytical treatment. In addition, modern DNA sequencing technologies have magnified the amount of genetic data available, revealing challenges to previous mathematical approximations. Here I will show that methods from statistical physics can be used to understand the distribution of genetic variants and signatures of natural selection in human populations.

ERNEST BARRETO

George Mason University

Ion Concentration Dynamics and its Effects on Neuronal Excitability

I will describe a simple conductance-based model neuron that includes intra- and extracellular ion concentration dynamics and show that this model exhibits autonomous periodic bursting. The bursting arises as the fast-spiking behavior of the neuron is modulated by the slow oscillatory behavior in the ion concentration variables and vice versa. By separating these time scales and studying the bifurcation structure of the neuron, we catalog several qualitatively different bursting profiles that are strikingly similar to those seen in experimental preparations. Control of bursting by periodic stimulation will also be discussed.

RICHARD BERTRAM

Florida State University

Synchronization of Pancreatic Islets

Blood insulin levels in humans, dogs, rats, and mice are oscillatory, with periods of approximately five minutes. This pulsatility has recently been shown to facilitate the actions of the liver, which uptakes or releases glucose into the blood in response to insulin signaling. Insulin pulsatility is disrupted in type II diabetes, again demonstrating a role for rhythmicity in normal glucose homeostasis. It is well established that individual islets exhibit oscillatory activity, with periods similar to that of insulin measurements in the blood. There are roughly 1 million islets in the human pancreas. What synchronizes their activity? We use mathematical modeling to demonstrate one possible mechanism, and show the results of microfluidic experiments testing predictions of the model.

RIANKA BHATTACHARYA

New Jersey Institute of Technology

Two-sample location-scale estimation from semiparametric random censorship models

When two survival functions belong to a location-scale family of distributions, and the available two-sample data are each right censored, the location and scale parameters can be estimated using a minimum distance criterion combined with Kaplan--Meier quantiles. In this paper, it is shown that using the estimated quantiles from a semiparametric random censorship framework produces improved parameter estimates. The semiparametric framework was originally proposed for the one-sample case (Dikta, 1998), and uses a model for the conditional probability that an observation is uncensored given the observed minimum. The extension to the two-sample setting assumes the availability of good fitting models for the group-specific conditional probabilities. When the models are correctly specified for each group, the new location and scale estimators are shown to be asymptotically as or more efficient than the estimators obtained using the Kaplan--Meier based quantiles. Individual and joint confidence intervals for the parameters are developed. Simulation studies show that the proposed method produces confidence intervals that have correct empirical coverage and that are more informative. The proposed method is illustrated using two real data sets.

GINO BIONDINI

State University of New York at Buffalo

The integrable nature of modulational instability

Modulational instability (MI), known as Benjamin-Feir instability in the context of water waves, is a widespread phenomenon in nonlinear science. In many cases, the underlying dynamics is governed by the nonlinear Schrodinger (NLS) equation. The initial stage of MI can therefore be described by linearizing the NLS equation around a constant background. Once the perturbations have grown, however, the linearization ceases to be valid. On the other hand, the NLS equation is a completely integrable infinite-dimensional Hamiltonian system, and the initial-value problem is therefore amenable to solution via the inverse scattering transform (IST). In this talk I will describe how the recently-developed IST for the focusing NLS equation with non-zero boundary conditions can be used to characterize the nonlinear stage of the MI.

VICTORIA BOOTH

University of Michigan

Modeling desynchronization of sleep and circadian rhythms in humans

Using a physiologically based mathematical model of a putative sleep-wake regulatory network, we investigate the transition from typical human sleep patterns to spontaneous internal desynchrony behavior observed under temporal isolation conditions. The model sleep-wake regulatory network describes the neurotransmitter-mediated interactions among brainstem and hypothalamic neuronal populations that participate in the transitions between wake, rapid eye movement (REM) sleep, and non-REM (NREM) sleep. Physiologically based interactions among these sleep-wake centers and the suprachiasmatic nucleus (SCN), whose activity is driven by an established circadian oscillator model, mediate circadian modulation of sleep-wake behavior. In temporal isolation experiments, human subjects have exhibited different desynchronized sleep-wake behaviors. Our model can generate similar ranges of desynchronized behaviors by variations in the period of the sleep-wake cycle and the strength of interactions between the SCN and the sleep-wake centers. Analysis of the model suggests that similar mechanisms underlie several different desynchronized behaviors and that the phenomenon of phase trapping may be dependent on SCN modulation of REM sleep-promoting centers.

JOSÉ FERNANDO BUSTAMANTE CASTAÑEDA

Universidad Nacional Autónoma de México

Mathematical modeling of glioblastoma multiforme response to radiation therapy

Gliomas are highly invasive brain tumors. Their aggressive growth leads to short life expectancies, as well as an aggressive approach to treatment: surgical resection, radiation and chemo-therapy. Magnetic resonance imaging (MRI) has permitted the detection of tumors at much earlier stages in their development, as well as a better documentation of effects of treatments in individual patients in vivo. Founded on this documentation we present a model based on the Fischer equation to study the effect of radiotherapy on the gliomas.

JOSHUA CHANG

Mathematical Biosciences Institute

Regulation of calcium nanoparticle formation and precipitation in biological tissues: A Mathematical model

In this manuscript, we present a mathematical model for the formation of calcium precipitates in biological tissues and the regulation of such precipitates by mechanism of the ubiquitous serum protein fetuin-A. In the absence of fetuin-A, calcium orthophosphate salts under supersaturated conditions spontaneously nucleate into small clusters. These clusters grow and eventually precipitate. While desirable in bone, tissue calcification is typically undesirable and triggers inflammation which either causes or exacerbates many disorders like artherosclerosis, arthritis, or heart disease. Fetuin-A helps regulate calcification through the formation of nanoparticles of mineral-protein complexes which after aggregation, undergo a phase-change, and are efficiently cleared om the system. Our model looks at the coupling behind the two separate nucleation processes involved and sheds insight of some of the rich behavior of this system.

GERDA de VRIES

University of Alberta

Formation of Animal Groups: The Importance of Communication Mechanisms

We investigate the formation and movement of self-organizing collectives of individuals in homogeneous environments. We review a hyperbolic system of conservation laws based on the assumption that the interactions governing movement depend not only on distance between individuals, but also on whether neighbours move towards or away from the reference individual. The inclusion of direction-dependent communication mechanisms significantly enriches the model behavior; the model exhibits classical patterns such as stationary pulses and traveling trains, but also novel patterns such as zigzag pulses, breathers, and feathers. The same enrichment of model behavior is observed when we include direction-dependent communication mechanisms in individual-based models.

PERCY DEIFT

New York University

Universality in numerical computations with random data: Case studies

Universal fluctuations are shown to exist when well-known and widely used numerical algorithms are applied with random data. Similar universal behavior is shown in stochastic algorithms and algorithms that model neural computation. The question of whether universality is present in all, or nearly all, computation is raised.

DANIEL DEWOSKIN

University of Michigan

Putting the circadian clock together: using high performance computing to investigate coupling in the suprachiasmatic nucleus

Circadian rhythms are endogenous oscillations seen in many physiological processes with periods of approximately 24 hours. In mammals, the circadian clock is controlled by the roughly twenty thousand neurons of the suprachiasmatic nucleus (SCN). While much is known about the transcription-translation feedback loop and electrophysiological activities of SCN neurons that form the basis of the cellular clock, many open questions remain about how coupling between cells creates a robust tissue-level rhythm out of noisy, weak cellular oscillators. To explore this, we develop a detailed, multi-scale model of the SCN, able to simulate both the electrical activity, at the scale of individual ionic currents and action potentials, and molecular clock rhythms, at the level of individual protein and complex concentrations, in every cell of the SCN. This model is a powerful tool for investigating the connections between the molecular oscillations and electrical activity rhythms in individual cells, as well as the role of coupling between individual SCN neurons, two of the largest open questions in the circadian field. Here we present the multi-scale numerical methods used for solving this complex model, aided by computation on graphics processing units, as well as model predictions showing how synaptic signaling between neurons on a millisecond timescale can affect synchrony of protein rhythms on a circadian timescale, demonstrating the importance of a multi-scale approach.

GUOQING DIAO

George Mason University

New semiparametric regression method with applications to selection-bias sampling and missing data problems

We propose a new method to estimate a regression function based on the semiparametric density ratio model, which can be viewed as a generalized linear model with a canonical link function and an unspecified baseline distribution function. Under the density ratio model, the distribution of the observed data retains the same structure in the presence of selection-bias 15 sampling or when the predictors are missing at random. Particularly, in the latter case, the new method utilizes all the available information and does not need to specify the distribution of the predictors or the missing probability. We establish large sample properties of the proposed regression estimators. Simulation studies demonstrate that the proposed estimators perform well in practical situations. An application to a real example is provided. This is joint work with Jing Qin.

CRISTIANO DIAS

New Jersey Institute of Technology

Driving peptides into fibril structures

The hierarchical organization of building blocks into complex supra-structures is a recurrent theme in biology. The assembly of proteins into cross-beta or fibril structures is a simple case of hierarchical organization in which building blocks are identical. These protein conformations have received a lot of attention recently as they have been linked to diseases like Alzheimer's and Parkinson's. Despite these studies, it is still not clear what are the molecular forces driving peptides into fibrils and how they differ from the ones driving protein folding. Here, I will discuss our efforts to understand molecular driving forces and energetic principles of fibrillization using all-atom molecular dynamics simulations. The role played by the solvent and how small molecules like urea can be used in fibril dissociation will also be discussed.

YIXIN FANG

New York University School of Medicine

A model-free estimation for covariate-adjusted Youden index

In medical research, continuous markers are widely employed in diagnostic tests to distinguish diseased and non-diseased subjects. The accuracy of such diagnostic tests is commonly assessed using the receiver operating characteristic (ROC) curve. To summarize an ROC curve and determine its optimal cut-point, the Youden index is popularly used. In literature, estimation of the Youden index has been widely studied via various statistical modeling strategies on the conditional density. This paper proposes a new model-free estimation method, which directly estimates the covariate-adjusted cut-point without estimating the conditional density. Consequently, covariate-adjusted Youden index can be estimated based on the estimated cutpoint. The proposed method formulates the estimation problem in a large margin classification framework, which allows flexible modeling of the covariate-adjusted Youden index through kernel machines. The advantage of the proposed method is demonstrated in a variety of simulated experiments as well as a real application to Pima Indians diabetes study.

PATRICK FLETCHER

Florida State University

Real-Time Model Calibration and Prediction Testing with the GPU and Dynamic Clamp

Electrical activity of anterior pituitary cells is heterogeneous, motivating model fitting to individual cells. We use the parallel computational power of the GPU to find parameters of a biophysical model with similar bifurcation structure to live individual cells. The optimization is iteratively improved by making model predictions that induce a qualitative change in electrical activity, testing the predictions with dynamic clamp on the same cell, then adding the results to the set of optimization constraints.

ADRIAN GRANADA

Harvard Medical School

Synchronization and coupling mechanisms of the mammalian circadian clock

Circadian clocks are endogenous oscillators driving daily rhythms in physiology and behavior, such as sleep-wake and temperature cycles. In mammals, these rhythms are centrally controlled by a tiny neuronal nucleus located in the hypothalamus, the suprachiasmatic nucleus (SCN). SCN cells synchronize with each other and generate a robust around 24 h self-sustained oscillation that drives locomotor and hormonal daily rhythms. In this talk I will discuss several puzzling features of this network of coupled oscillators: robust synchronization, phase of entrainment, jet-lag associated transients, coupling mechanisms, limits of entrainment and heterogeneity. I will give an overview of the combined theoretical and experimental efforts we have made to unveil properties of the mammalian circadian system.

KENNETH HO

Stanford University

Efficient operator factorizations for integral and differential equations

Fast algorithms for elliptic PDEs are central to modern scientific computing. In this talk, we consider the efficient factorization of matrices associated with elliptic problems in both integral and differential form. A key starting point is the nested dissection multifrontal method for PDEs, which can be viewed as an LU factorization with a cost which grows with the spatial dimension. Our primary contributions are twofold: (1) a reformulation of previous fast direct solvers for integral equations as multifrontal-like generalized LU decompositions; and (2) a recursive dimensional reduction strategy to achieve optimal linear or nearly linear complexity in 2D and 3D. Our method is fully adaptive and can handle both boundary and volume problems, and furthermore reveals the close connection between structured dense matrices and sparse ones. This is joint work with Lexing Ying.

ZHEZHEN JIN

Columbia University

Estimation and inference on semiparametric regression models

For regression models, it is challenging to obtain point and variance estimates of regression parameters if the corresponding estimating functions are nonregular, such as non-smooth and non-monotone. We discuss the issues and present recently developed new approaches based on a natural self-induced smoothing method. We show general theory, implementation, simulation studies and demonstrate the methods with censored linear regression models and general semiparametric transformation models.

JUSTIN KINNEY

Cold Spring Harbor Laboratory

Estimation of probability densities using scale-free field theories

The question of how best to estimate continuous probability distributions from finite data remains an intriguing open problem, even in low dimensions. Here I describe a field-theoretic approach to this problem that, in low dimensions, can be computed rapidly enough to be used in day-to-day data analysis. First, a Bayesian prior on possible data-generating distributions is defined using a scale-free mixture of scalar field theories. A Laplace approximation for the Bayesian posterior is then computed using a deterministic homotopy method. Importantly, this approach does not impose a privileged length scale for smoothness of the inferred distribution, but rather learns a natural length scale from the data.

CHRISTIAN KLEIN

Université de Bourgogne

Dipersive shocks in 2+1 dimensional systems

We present a numerical study of dispersive shocks and blow-up in solutions to 2+1 dimensional systems. In particular we discuss the Kadotsev-Petviashvili, the Davey-Stewartson and the Toda equations.

MARK KRAMER

Boston University

Seizure dynamics across spatial and temporal scales

Epilepsy - the condition of recurrent, unprovoked seizures - is a common brain disease, affecting 1% of the world's population. Seizures are typically identified as abnormal patterns in brain voltage activity. Many open questions surround epilepsy and seizures, and identifying the associated answers promises new insights for treatment and prevention. In this talk, we will consider brain voltage activity during seizure as observed at multiple spatial scales. We will show how techniques from mathematics and statistics can be used to characterize these data, identify common features, and connect observed brain activity to mechanisms. We will focus on a specific, open question in epileptology: including, how do seizures start and spread across the brain, and how do seizures spontaneously terminate? Through analysis of human brain electrical activity at various spatial scales, we will propose biophysical and dynamical answers to these questions.

TANYA LEISE

Amherst College

Wavelet-Based Analysis of Circadian Oscillators

Time-frequency methods involving both discrete and continuous wavelet transforms can be useful in quantifying circadian and ultradian patterns occurring in the typically non-stationary time series of biological oscillators. The discrete Fourier transform and other types of periodograms can estimate the period of a circadian rhythm, but they can fail to correctly assess ultradian periods and cannot detect changes in the period over time. Time-frequency methods that can localize frequency estimates in time are more appropriate for analysis of patterns occurring within each day and of fluctuations in the period. In particular, the analytic wavelet transform offers a method for determining instantaneous frequency with good resolution in both time and frequency, capable of detecting changes in circadian period over the course of several days and in ultradian period within a given day. This method can also measure the phase relationship between two rhythms, e.g., in temperature and activity, and how it changes following a disruption, yielding insight into how such rhythms may be coupled.

TONG LI

University of Iowa

Traveling Waves of Chemotaxis Models

We investigate local and global existence, blowup criterion and longtime behavior of classical solutions for a hyperbolic-parabolic system derived from the Keller-Segel model describing chemotaxis. Moreover, we establish the existence and the nonlinear stability of large-amplitude traveling wave solutions to the system.

YUE-XIAN LI

University of British Columbia

Working with Robert Miura on Clustering in Small Networks of Neuronal Oscillators

In this presentation, I will bring back some memories of the experience during the period when Robert Miura, a post-doc Yuqing Wang, and myself worked together on clustering in small networks of coupled neuronal oscillators and discuss the results we have achieved together in that work.

MARTIN LINDQUIST

Johns Hopkins University

Functional Causal Mediation Analysis with an Application to Brain Connectivity

Mediation analysis is often used in the behavioral sciences to investigate the role of intermediate variables that lie on the causal path between a randomized treatment and an outcome variable. Typically, mediation is assessed using structural equation models (SEMs) with model coefficients interpreted as effects. In this paper we present an extension of SEMs to the functional data analysis (FDA) setting that allows the mediating variable to be a continuous function rather than a single scalar measure, thus providing the opportunity to study the functional effects of the mediator on the outcome. We provide sufficient conditions for identifying the average causal effects of the functional mediators using the extended SEM. The method is applied to data from a functional magnetic resonance imaging (fMRI) study of thermal pain that sought to determine whether activation in certain brain regions mediated the effect of applied temperature on self-reported pain.

GAVIN LYNCH

New Jersey Institute of Technology

A False Discovery Rate Controlling Procedure for Testing Hypotheses with Complex Structure

Large-scale studies can often involve testing multiple hypotheses with complex underlying structures, such as those related to Gene Ontology. However, most false discovery rate (FDR) controlling procedures do not account for the underlying structure of the hypotheses, even though doing so can lead to improved power and enhanced interpretation of the rejected hypotheses. Furthermore, among the few procedures that do account for the underlying structure, proving their FDR control has turned out to be theoretically complex. In this presentation, I will describe a novel approach which greatly facilitates the development of procedures that control complex error rates, such as the FDR. I will show how this approach can be used to create a new procedure controlling the FDR for testing hypotheses organized into a directed acyclic graph structure. Simulation studies show that the new procedure can outperform the standard Benjamini-Hochberg procedure in terms of power.

ROY MALKA

Harvard & MGH

In Vivo Volume and Hemoglobin Dynamics of Red Blood Cells

Human red blood cells (RBCs) lose 30% of their volume and 20% of their protein during their 100-day lifespan in the bloodstream. We combine theory with single-cell characteristics to investigate the impact of vesiculation on the reduction in volume and hemoglobin. We show that vesicle shedding alone is sufficient to explain membrane loses but not volume or hemoglobin losses. We use dry mass measurements of human RBCs to validate the models and to propose that unknown mechanisms are controlling volume and hemoglobin reduction and they are responsible for 90% of the observed reduction.

FRANCISCO JAVIER MARTÍNEZ FARÍAS

Universidad Nacional Autónoma de Mexico

Weakly nonlinear localization for a 1-D FPU chain with clustering zones

We study weakly nonlinear localized oscillations in an quartic elastic network model. Elastic network models describe sets of particles interacting through pairwise elastic potentials of finite range and have been used as phenomenological models for protein vibrations. We use a small displacement assumption to derive a quartic FPU-type model in which the number of interacting neighbors depends on the site. The derivation holds in arbitrary dimension, and we examine in more detail some 1-D toy examples, and some 3-D examples obtained from proteins. The spatial inhomogeneity of the interaction, specifically the presence of clusters of particles that interact with many neighbors, leads to the existence localized linear modes. Additionally we show examples where the properties of the linear spectrum, and the nonlinear mode interaction coefficients allow us to bring the system into a normal form that has invariant subspaces with additional symmetries and periodic orbits that represent spatially localized motions.

RICHARD MOORE

New Jersey Institute of Technology

Simulating exits in stochastic laser dynamics

Importance sampling using open-loop feedback based on maximum likelihood paths has been demonstrated to improve the efficiency of Monte Carlo estimation of rare event probabilities by several orders of magnitude, even when the maximum likelihood paths are determined from an approximate model of low dimension. When calculating the expected first exit time of a domain, however, the optimal path is often one that takes infinite time, and open-loop feedback is often unable to drive the dynamics to the critical exit events for finite noise strength. At the same time, computing the closed-loop feedback for problems of even moderate dimension is computationally intractable. An intermediate approach is to derive an approximate closed-loop feedback using perturbation theory performed about the optimal path. We apply this method to the loss-of-lock problem, including the calculation of phase slips, in mode-locked (pulsed) lasers.

QING NIE

University of California

Stem Cells and Regeneration: Feedback, Niche, and Epigenetic Regulation

In developing and renewing tissues, terminally differentiated cell types are typically specified through the actions of multistage cell lineages. Such lineages commonly include a stem cell and multiple progenitor cell stages, which ultimately give rise to terminally differentiated cells. In this talk, I will present several modeling frameworks with different complexity on multistage cell lineages driven by stem cells, which account for diffusive signaling molecules, regulatory networks, individual cells, mechanics, and evolution. Questions of our interest include role of feedbacks in regeneration, stem cell niche for tissue spatial organization, crosstalk between epigenetic and genetic regulations. In several cases, we will also present direct comparisons between our modeling outputs and some existing and new in-vivo and in-vitro data.

DEMETRIOS PAPAGEORGIOU

Imperial College London

Nonlinear wave phenomena in viscous stratified multilayer flows

Viscous multilayer flows consisting of at least three stratified layers, can become unstable to longwave instabilities even at zero Reynolds numbers. Such phenomena are important in microfluidic applications and the interest of this work is in modelling and analyzing the instabilities into the nonlinear regime. Coupled systems of PDEs are derived that in general contain flux function nonlinearities of mixed hyperbolic-elliptic type and high order diffusion (2nd or 4th order). Of particular interest is the zero diffusion limit of such systems and this is studied through extensive numerical computations for a range of diffusion operators. It is shown that in the case of homogeneous flux functions the solutions are unbounded in the limit (steady states with unbounded max-norm or solutions encountering finite-time singularities). For inhomogeneous flux functions the solutions are bounded in the limit (they become measure valued) and can be characterized by the fractal dimension of the distribution of shrinking domains where ellipticity is supported. The fractal dimension is observed to depend on the diffusion operator and decreases as the order of the operator is decreased.

VIPUL PERIWAL

LBM, NIDDK

The meaning of nothing: Applications of Empirical Bayes

Bayesian inference is founded on a rigorous statement of probability theory. Nevertheless, it excites a great deal of controversy because there is nothing canonical about applications of Bayes' theorem. What is the origin of the hypotheses that Bayesian inference tests against data? We propose a simple calculus for canonically associating null models with data. We show, based in part on techniques from theoretical physics, that this calculus is computationally effective and efficient at deducing relationships present in the data by applying our methods to diverse biological datasets.

LINDA PETZOLD

UC Santa Barbara

Inference of Functional Circadian Networks

In mammals, the Suprachiasmatic Nucleus (SCN), a brain region of about 20,000 neurons, serves as the master circadian clock, coordinating timing throughout the body and entraining the body to daily light cycles. The extent to which cells in the SCN can synchronize and entrain depends on the communication network between individual cell oscillators. Characterization of that network is challenging, due to the dynamics of the circadian oscillators and the stochastic noise inherent in discrete molecular chemical reactions. Statistical models based on information theoretic measures are well-suited for the analysis of stochastic information flow across networks. We have developed a methodology that uses information-theoretic measures on time course data to infer network structure, and tested its performance on data from computational models of networks of stochastic circadian oscillators with known connectivity.

JONATHAN RUBIN

University of Pittsburgh

The healing power of (synaptic) depression

Several changes in basal ganglia activity patterns are associated with parkinsonism, including increased prevalence of bursting, changes in oscillatory features, and altered correlations within and between areas. I will discuss how short term synaptic depression can alter transfer of oscillations as well as how related effects, combined with other forms of short term depression, may contribute to the efficacy of deep brain stimulation as a therapy for Parkinson's disease.

CONSTANCE SCHOBER

University of Central Florida

Numerical investigation of stability of breather-type solutions of the nonlinear Schrodinger equation

In this talk we discuss the results of a broad numerical investigation of stability of breather-type solutions of the nonlinear Schrödinger (NLS) equation, a widely used model of rogue wave generation and dynamics in deep water. NLS breathers rising over an unstable background state are frequently used to model rogue waves. However, the issue of whether these solutions are robust with respect to the kind of random perturbations occurring in physical settings and laboratory experiments has just recently begun to be addressed. Numerical experiments for spatially periodic breathers with one or two modes involving large ensembles of perturbed initial data for six typical random perturbations suggest interesting conclusions. Breathers over an unstable background with N unstable modes are generally unstable to small perturbations in the initial data unless they are "maximal breathers" (i.e. they have N spatial modes). Additionally, among the maximal breathers with two spatial modes, the one of highest amplitude due to coalescence of the modes appears to be the most robust. The numerical observations support and extend to more realistic settings the results of our previous stability analysis, which we hope will provide a useful tool for identifying physically realizable wave forms in experimental and observational studies of rogue waves.

HARVEY SEGUR

University of Colorado

The nonlinear Schrödinger equation, dissipation and ocean swell

The nonlinear Schrödinger equation (NLS) has been among the most studied equations in mathematical physics in the past half-century, both because of its mathematical structure and because of its physical applications. One prominent physical application is to describe the evolution of waves on the ocean's surface, as they propagate over long distances. A paradox in that context is that ocean swell is known to propagate over thousands of kilometers, while NLS theory predicts that these waves should disintegrate because of the modulational (or Benjamin-Feir) instability. This talk discusses and partially resolves this paradox.

DAVID SHIROKOFF

McGill University

A simple, efficient and accurate method for computing the order-disorder phase transition in double well energy functionals

A wide variety of materials that exhibit energy driven pattern formation are governed by an underlying non-convex energy functional. Although numerically finding and verifying local minima to these functionals is relatively straight-forward, the non-convex nature of the functionals makes the computation and verification of global minimizers much more difficult. Here the verification of the global minimizers is important for understanding the material phase diagram. In this talk I will focus on mass-constrained global minimizers for a class of double well energy functionals: including Ohta-Kawasaki and phase-field crystals. I will derive sufficient conditions to show that a candidate minimizer is a global minimizer, and using convex optimization techniques show that the approach works very well when the minimizer is the constant (disordered) state. I will then extend the discussion to non-constant states and show that in certain cases the approach may work if one handles the symmetries in the functional.

MONA SINGH

Princeton University

Data-driven approaches for uncovering and understanding biological networks

High-throughput experimental technologies have generated, and continue to generate, large and complex biological data sets: from the genomes of numerous organisms and individuals to 3D structures for tens of thousands of proteins to large-scale molecular networks for many model organisms. My group aims to harness these data to obtain a predictive understanding of protein interactions and the relationship between molecular networks and cellular functioning. In this talk, I will overview a number of data-driven approaches we have developed over the years for the complementary problems of predicting interactions and analyzing interaction networks.

GREG SMITH

The College of William & Mary

Modeling the bidirectional coupling of localized calcium elevations and whole cell calcium responses

The stochastic dynamics of calcium signaling is an important aspect of excitation-contraction coupling in cardiac myocytes, where sarcoplasmic reticulum calcium-induced calcium release is locally controlled by trigger calcium influx via L-type channels of the plasma membrane. A recently developed whole cell modeling approach is able to avoid the computationally demanding task of resolving spatial aspects of global calcium signaling by using probability densities and associated moment equations to representing heterogeneous local calcium signals in a population of calcium release units. This new class of whole cell models of calcium handling facilitates simulation and analysis of the bidirectional coupling of localized calcium elevations and whole cell calcium responses in cardiac myocytes.

DAVID TERMAN

Ohio State University

Spreading depolarization in a neuron/astrocyte network model

We present a detailed network model for key processes involved in ischemic stroke. The model incorporates interactions between neurons and astrocytes and integrates the dynamics of cell membrane potential, ion homeostasis, mitochondrial ATP production, mitochondrial and ER Ca2+ handling, and IP3 production. Stroke-like conditions are initiated by decreasing parameter corresponding to either glucose or oxygen input. The model is used to help understand conditions, under which low glucose and/or oxygen levels lead to waves of spreading depolarizations, while high glucose and oxygen levels do not.

THOMAS TROGDON

New York University

Oscillatory integrals and integrable systems

High oscillation is an important conservative phenomenon in the theory of integrable systems. For integrable PDEs, two competing forces are in balance. First, the flow regularizes and prevents the formation of discontinuities. Second, an infinite number of quantities are conserved. In the necessary absence of dissipation, oscillations must be responsible for regularization. These oscillations are seen to be a direct consequence of oscillatory Fourier symbols. Furthermore, properties of these symbols are used for detailed asymptotic and numerical studies of many problems. In this talk, I will discuss recent asymptotic and numerical progress on integrable PDEs that exploits the structure of oscillatory integrals.

FRED WAN

University of California, Irvine

University of California, Irvine

Developing tissue patterns are orchestrated by gradients of morphogens bound to signaling receptors. An important requirement for such signaling morphogen gradients is that they should not be easily altered by genetic or environmental perturbations that stimulate enhanced morphogen synthesis rates. Various inhibitors to enhanced signaling morphogen concentrations are known to exist. However their level of activities needs to be adjusted in a way commensurate with the synthesis rate enhancement in order to maintain robust signaling gradients. It is naturals to expect one or more kinds of feedback mechanisms to be available for this purpose. This talk reports some existing negative results on this expectation and describes some empirically based feedback models that would theoretically accomplish the task of maintaining robust biological developments.

ANTAI WANG

New Jersey Institute of Technology

Properties of the Marginal Survival Functions for Dependent Censored Data under an assumed Archimedean Copula

Given a dependent censored data $(X, \delta) = (\min(T,C), I(T < C))$ from an Archimedean copula model, we give general formulas for possible marginal survival functions of T and C. Based on our formulas, we can easily establish the relationship between all these survival functions and derive some useful identifiability results. Also based on our formulas, we propose a new estimator of the marginal survival function when the Archimedean copula model is assumed to be known. We derive bias formulas for our estimator and other existing estimators. Simulation studies have shown that our estimator is comparable with the copula-graphic estimator proposed by Zheng and Klein (1995) and Rivest and Wells (2001) and Zheng and Klein's estimator (1994) under the Archimedean copula assumption. We end our paper with some discussions.

YUANJIA WANG

Columbia University

Efficient Estimation of Nonparametric Genetic Risk Function with Censored Data

With an increasing number of causal genes discovered for Mendelian and complex human disorders, it is important to assess the genetic risk distribution functions of disease onset for subjects who are carriers of these causal mutations and compare them with the disease distribution in non-carriers. In many genetic epidemiological studies of the genetic risk functions, the disease onset information is subject to censoring. In addition, subjects' mutation carrier or non-carrier status is unknown due to the cost of ascertaining subjects to collect DNA samples or due to death in older subjects (especially for late onset disease). Instead, the probability of subjects' genetic marker or mutation status can be obtained from various sources. When genetic status is missing, the available data takes the form of mixture censored data. Recently, various methods have been proposed in the literature using parametric, semiparametric, and nonparametric models to estimate the genetic risk distribution functions from such data. However, none of the existing approach is efficient in the presence of censoring and mixture, and the computation for some methods is demanding. In this paper, we propose a sieve maximum likelihood estimation which is fully efficient to infer genetic risk distribution functions nonparametrically. Specifically, we estimate the logarithm of hazards ratios between genetic risk groups using B-splines, while applying the nonparametric maximum likelihood estimation (NPMLE) for the reference baseline hazard function. Our estimator can be calculated via an EM algorithm and the computation is much faster than the existing methods. Furthermore, we establish the asymptotic distribution of the obtained estimator and show that it is consistent and semiparametric efficient, and thus the optimal estimator in this framework. The asymptotic theory on our sieve estimator sheds light on the optimal estimation for censored mixture data. Simulation studies demonstrate superior performance of the proposed method in small finite samples. The method is applied to estimate the distribution of Parkinson¡¯s disease (PD) age at onset for carriers of mutations in the leucine-rich repeat kinase 2 (LRRK2) G2019S gene, using the data from the Michael J. Fox Foundation Ashkenazi Jewish LRRK2 consortium. This estimation is important for genetic counseling purposes since this test is commercially available yet genetic risk (penetrance) estimates have been variable.

MICHAEL WARD

University of British Columbia

Logarithmic Expansions and the Stability of Periodic Patterns of Localized Spots for Reaction-Diffusion Systems in Two Dimensions

We determine the stability threshold for a periodic arrangment of localized spots for some singularly perturbed two-component reaction-diffusion systems including the Gierer-Meihardt, Schnakenburg, and Gray-Scott models, in R^2. In the semi-strong interaction asymptotic limit where only one of the components has an asymptotically small diffusivity, the leading order stability threshold governing amplitude instabilities of the spots, as derived by Wei-Winter (2001, 2003), is independent of the arrangement of the spots in the lattice. By combining a spectral approach based on Floquet-Bloch theory together with the method of matched asymptotic expansions and appropriate Fredholm solvability conditions, we calculate the next order term in the expansion of the stability threshold in terms of the regular parts of certain Green's functions. In this way, we derive an asymptotic result for the location of a real-valued band of continuous spectrum for the linearized operator near the origin in the spectral plane when a stability parameter is close to its critical value. This result depends on an objective function defined in terms of both the Bloch wave vector and the particular lattice arrangement. From a numerical min-max optimization of this objective function it is shown that a regular hexagonal lattice of localized spots is the most stable. Joint work with Juncheng Wei (UBC), David Iron (Dalhousie) and John Rumsey (Dalhousie).

SONG YANG

National Heart, Lung, and Blood Institute

Semiparametric Analysis of Summary Measures of Treatment Effect with Survival Data

For clinical trials with survival data, the hazard ratio has been the most widely used measure for describing the treatment effect. The short-term and long-term hazard ratio model of Yang and Prentice (2005) contains the proportional hazards model and the proportional odds model as sub-models, and provides sufficient flexibility when there is possibly a treatment by time interaction. We investigate various measures under this model. Point estimates, point-wise confidence intervals and simultaneous confidence bands of the hazard ratio and a few other measures are established. These results can be used to capture and to graphically present the treatment effect. We also investigate extension of the model to allow covariate adjusted analysis. We illustrate these visual tools and discuss their merits and limitations in applications to clinical trials including the Women's Health Initiative.

YICHUAN ZHAO

Georgia State University

Empirical likelihood for linear transformation models with interval-censored failure time data

For regression analysis of interval-censored failure time data, Zhang et al. (2005) proposed an estimating equation approach to fit linear transformation models. In this paper, we develop two empirical likelihood (EL) inference approaches for the regression parameters based on the generalized estimating equations. The limiting distributions of log-empirical likelihood ratios are derived and empirical likelihood confidence intervals for any specified component of regression parameters are obtained. We carry out extensive simulation studies to compare the proposed methods with the method discussed by Zhang et al. (2005). The simulation results demonstrate that the EL and jackknife EL methods for linear transformation models have better performance than the existing normal approximation method based on coverage probability of confidence intervals in most cases, and they enable us to overcome an under-coverage problem for the confidence intervals of the regression parameters using a normal approximation when sample sizes are small and right censoring is heavy. Two real data examples are provided to illustrate our procedures.

ZEYNEP AKCAY

New Jersey Institute of Technology

Creation of bistable phase locking solutions in recurrent neuronal networks through short-term synaptic depression

Bistability is observed in many neuronal systems, such as the voltage activity of individual neurons, the activity of the neuronal networks or the period of network oscillations. It is associated with various roles in the perception of visual and audial stimuli and is required for the normal functioning of the human brain. We use discrete maps derived from the phase response curves of the individual neurons and the plasticity properties of the synapses to study phase locking in a recurrent network of two oscillatory neurons. Fixed points of these maps correspond to the phase locked modes of the network. We show that short-term synaptic plasticity acts as a mechanism for bistable phase locking solutions in such a network. We analyze the dependence of the stability of phase locked solutions and the existence of bistability on the parameters of depressing synapses.

THOMAS ANDERSON

New Jersey Institute of Technology

Long-term Behavior of Solutions to a Wave Equation with Degenerate Damping

The model of interest is a semilinear wave equation with degenerate damping. That is, there is an additional term in the standard homogeneous wave equation which consists of local nonlinear damping of the form of wave amplitude multiplied by time- rate of change. In addition, the sought after function u satisfies fixed-boundary values, e.g. homogeneous Dirichlet conditions. The well-posedness of this problem has been studied; however, little is known to date about the energy dissipation rates of its solutions. The primary challenge is that it is not clear how to estimate the kinetic energy of a state in terms of the dissipation feedback that deteriorates at small amplitudes. We present an alternate proof of existence and uniqueness using a contraction mapping argument. In addition, we establish local existence of regular solutions. Then, a numerical simulation of this model will be presented employing a combination of a finite-element scheme and the fixed point method. Some results concerning the asymptotic energy decay rates and their uniformity will be discussed. Examples of these energy decay rates will also be presented. This work was done as a part of an REU project at the University of Nebraska-Lincoln.

HAROON ANWAR

New Jersey Institute of Technology

Dendritic diameters affect the spatial variability of intracellular calcium dynamics in computer models

There is growing interest in understanding calcium dynamics in dendrites, both experimentally and computationally. Many processes influence these dynamics, but in dendrites there is a strong contribution of morphology because the peak calcium levels are strongly determined by the surface to volume ratio of each branch, which is inversely related to branch diameter. In this study we explore the predicted variance of dendritic calcium concentrations due to local changes in dendrite diameter and how this is affected by the modeling approach used. We investigate this in a model of dendritic calcium spiking in different reconstructions of cerebellar Purkinje cells and in morphological analysis of neocortical and hippocampal pyramidal neurons. We report that many published models neglect diameter-dependent effects on calcium concentration and show how to implement this correctly in the NEURON simulator, both for phenomenological pool based models and for implementations using radial 1D diffusion. More detailed modeling requires simulation of 3D diffusion and we demonstrate that this does not dissipate the local concentration variance due to changes of dendritic diameter. In many cases 1D diffusion of models of calcium buffering give a good approximation provided an increased morphological resolution is implemented.

SONIA BANDHA

New Jersey Institute of Technology

Copula-based modeling and Computational Solutions of Warranty Cost Management Problems

Much recent research on modeling and optimization of servicing costs for Non-Renewing Free Replacement Warranties (NR-FRW) assumes that a consumer's usage profile is constant and known. Such an assumption is unrealistic for moderately high value consumer durables. In such cases, it would be pragmatic to assume that the manufacturer/seller is uncertain about any customer's xed usage rate of the product; the usage rate is modeled by a probability distribution of the usage for target customers. This research seeks to model and minimize the expected costs of pragmatic servicing strategies for NR- FRW warranties, using a Copula based approach to capture the adverse impact of increasing product usage rate on its time-to-failure. Since exact analytical solutions to these models are typically not obtainable, numerical methods using MATLAB and the Simulated Annealing algorithm for globally optimal cost minimization are used for computational solution. These methods and results are compared with those obtained from a well know benchmark numerical example and then new results are derived.

Simulating Golf Handicaps Using Empirical and Fitted Data

Previous studies in golf have analyzed and compared the performances of individual golfers based on their handicaps and the nature of a tournament. The purpose of USGA Handicap System is to allow golfers of varying skill levels to compete fairly. The goal of this research is to study the effectiveness of the current handicapping system. To accomplish this, a golf handicap index is viewed as a moving average of moving order statistics. Simulation is used to obtain the handicap scores and their corresponding average handicap indices in order to observe how changes and trends in the scores affect the average handicap indices. Statistical fitting on the data set indicates that the generalized extreme value distribution is an appropriate fit whereas the normal distribution is not an appropriate fit. Results are in qualitative agreement for fitted and empirical; filtering reduces the variance in all cases.

VALERIA BARRA

New Jersey Institute of Technology

Linear stability analysis of thin viscoelastic liquid of Jeffreys type with van der Waals interaction

We study the linear instability of a thin viscoelastic liquid film under the influence of van der Waals interaction. The Jeffreys model is used to describe the viscoelasticity with a relaxation time and a retardation time. We use the thin film equation that governs the nonlinear evolution of the interface and study the linear stability of the interface in the long-wave limit. We include the dewetting effect through van der Waals attractive-repulsive force. The analysis is also carried out considering the fluid in different regimes: strong-slip and weak-slip. In each regime, the role of the liquid viscoelasticity as well as the contact angle are studied. We also study the influence of the slippage on the length scale and time scale of the instability and the transitions of weak to moderate to strong slip regimes.

ERNEST BARRETO

George Mason University

Complete Classification of the Macroscopic Behavior of a Heterogeneous Network of Theta Neurons

We design and analyze the dynamics of a large network of theta neurons, which are idealized Type-I neurons. The network is heterogeneous in that it includes both inherently spiking and excitable neurons. The coupling is global, via pulse-like synapses of adjustable sharpness. Using recently developed analytical methods, we identify all possible asymptotic states that can be exhibited by a mean field variable that captures the network's macroscopic state. These consist of two equilibrium states that reflect partial synchronization in the network, and a limit cycle state in which the degree of network synchronization oscillates in time. Our approach also permits a complete bifurcation analysis, which we carry out with respect to parameters that capture the degree of excitability of the neurons, the heterogeneity in the population, and the coupling strength (which can be excitatory or inhibitory). We find that the network typically tends toward the two macroscopic equilibrium states when the neuron's intrinsic dynamics and the network interactions reinforce one another. In contrast, the limit cycle state, bifurcations, and multistability tend to occur when there is competition among these network features. Finally, we show that our results are exhibited by finite network realizations of reasonable size.

CASAYNDRA BASARAB

New Jersey Institute of Technology

Hamiltonian Hopf Bifurcations in Schrödinger Trimers

Understanding the dynamics of nonlinear waves is quite a difficult task. In our case, we study the Discrete Nonlinear Schrödinger equation. Thankfully, the dynamics of an ODE mimic the PDE. The discreteness of the problem allows us to study an ODE rather than a PDE, which is significantly simpler. We find that Hamiltonian-Hopf Bifurcations arise. We analytically find the locations of the two bifurcations and compute how the families of periodic orbits are configured in a neighborhood of these periodic orbits. To do this, we reduce the degrees of freedom from three to two using Nöther's Theorem, and find that the norm N is a conserved quantity. We then take the extracted linear part of the Hamiltonian and use the Burgoyne's Algorithm, a tool which allows us to compute the normal form of our Hamiltonian. We find that there is a three parameter family of periodic solutions, i.e. a two family of periodic orbits).

LAKE BOOKMAN

North Carolina State University

Perturbations of Magnetic Solitons

The symmetries in integrable systems give rise to conserved quantities, which in turn induce free parameters in the general solution. When such systems are perturbed, and made slightly nonintegrable, it is natural to consider the slow time dynamics of a base solution confined to the soliton solution manifold. One standard approach is to leverage the conserved quantities of the integrable system to determine the evolution of soliton parameters. However, the evolution of the symmetry parameters containing higher order, but often very important information, is not as clear, requiring ad hoc combinations of balance laws. In this work, we use a singular perturbation theory approach to determine modulation equations for the (2+1) Landau-Lifshitz equation which models the magnetization of a thin, ferromagnetic material. The Landau-Liftshitz equation is Hamiltonian and the derivation employed here highlights the underlying structure necessary to perform this analysis in other Hamiltonian systems. Particular focus will be given to perturbations governing damping and forcing which model recent experimental observations of magnetic solitons.

YINBO CHEN

New Jersey Institute of Technology

Neuronal membrane resonance influences network frequency through electrical coupling

Neural oscillations arise from the coordinated activity of a population of neurons. Neurons often exhibit membrane resonance, a maximal response at one frequency in response to sinusoidal current input. Membrane resonance of neurons in oscillating networks has been implicated as a major influence in determining the network frequency. We examine the hypothesis that the membrane resonance properties of neurons can bias the network frequency through gap junction (electrical) synapses. We test this hypothesis in a two-cell model network consisting of an oscillator, electrically coupled to a linear biophysical resonator. When coupled, the baseline potential of the linear resonator can be adjusted to set the steady-state network frequency. We find that shifting the preferred frequency of the linear resonator positively influences the network frequency and that this effect is enhanced by increasing resonance power. Additionally, this effect is independent of the oscillator type. These results validate our hypothesis and show an important role for membrane resonance in shaping the output of electrically coupled networks.

ALBERT DICANZIO

Webster University

Cluster Analysis in Metric Spaces Defined on Hamming Distance Function

Experience in the physical sciences has shown that when events cluster in metric spaces, an otherwise unobserved relationship between the variables representing dimensions of the metric space can become apparent. More recently, the present researcher encountered a need for detecting and mapping clusters in a natural-historical binary data set so as to discover dynamics and strategy in its event space. The research problem was to formulate a method capable of re-discovering a known variable relationship in the physical sciences and then to transpose a variation of that method to data-mining and discovery in organizational dynamics. An early example of data clustering in the physical sciences is the Herzsprung-Russell diagram from which it is observed that in a space whose dimensions are stellar luminosity and surface temperature, stars reveal a distinctive complex pattern consisting of a mainstream sequence from hot bright stars to cool dim ones, with two isolated non-mainstream colonies inhabited by the red giants and white dwarfs. Since H-R clustering follows a predetermined pattern, this researcher formulated a clustering method used in the experimental phase (phase 1 of his project) by analogy to an agglomerative method that he used on raw data of 100 stars to produce a clustered pattern fitting the known H-R relationship. An event category matrix, the principal discovery mechanism he created for phase 2 this project, then permitted the analysis of event historical data along (1) the longitudinal dimension of time-ordered events and associated dynamic attractors, and (2) the logical dimension of event categories and combinations thereof. Because the event matrix contained the population of historical events under study, and to the extent that each of these properties was defined as a binary decision on the question that defines the event property, any pair of events within clusters, or any pair of event properties, was susceptible of being correlated by a function of Hamming distance. The proposed presentation describes the method of analysis and elements of the learning, produced by interpreting the mined data on which it was used, about dynamics and strategy found in the targeted natural history event sequence.

NANYI DONG

New Jersey Institute of Technology

Formation of drops from structured metal geometries on nanoscale

Instabilities of liquid metals on nanoscale are relevant to a number of problems in nanofluidics and more generally materials science on nanoscale, where such instabilities may lead to formation of particles with applications to plasmonics and related fields. Our project is motivated by recent experiments which involve structured metal geometries liquified by laser irradiation, which have been shown to lead to formation of nano particles. In order to model this physical phenomenon, Navier-Stokes equations are simplified by implementing long-wave asymptotic expansion to model the evolution. The model includes the capillary effects as well as liquid-solid interaction. We carry out fully nonlinear simulations of the derived model, which provide additional insight into the film evolution on very fast time scale. We find that computational results are fully consistent with the experimental ones, thus confirmed that the main feature of the experiment could be captured by a simplified hydrodynamic model. In addition, our simulations suggest that for certain choice of parameters, stochastic effects may play important role in the experiments.

DAVID FOX

New Jersey Institute of Technology

Using multi-objective evolutionary algorithms to predict the parameters that determine membrane resonance in a biophysical model of bursting neurons

Neurons exhibit membrane potential resonance (MPR), a peak in the membrane impedance amplitude (|Z|) in response to oscillatory inputs at a nonzero frequency (fmax). Pacemaker PD neurons of the crab pyloric network show MPR whose fmax is correlated with the network frequency (~ 1Hz). In contrast, the LP follower neuron shows a higher fmax of ~ 1.4 Hz. MPR in PD neurons is sensitive to blockers of ICa and Ih. Furthermore, shifts in fmax are positively correlated with shifts in Vlow or Vhigh of a ZAP function in voltage clamp. However, LP fmax is only sensitive to Vhigh. We used a genetic algorithm to fit a model of PD MPR to find different combinations of ICa and Ih parameters. The parameter distributions, correlations and their effect on MPR suggest that Ica window conductance and activation and inactivation rates shape MPR. Fitting fmax shifts with changes in ZAP Vlow and Vhigh suggest that LP does not shift fmax with Vlow changes because its Ih activation rate is too fast; a result which we aim to test experimentally.

SZU-PEI FU

New Jersey Institute of Technology

A Fast Multipole Method for Coarse-grained Brownian Dynamics Simulations of a DNA with Hydrodynamic Interactions

The coarse-grained molecular dynamics (MD) or Brownian dynamics (BD) modeling is a particle-based approach that has been applied to a wide range of biological problems that involve meso-scale dynamics over a long period of time. In biologically relevant problems the non-local hydrodynamic interactions (HIs) of macromolecules in water are essential to the underlying physics for their dynamics. A lot of water molecules need to be included to capture the non-local HIs. As a result the simulations become numerically expensive even for the coarse-grained dynamics of a small system over a short time. The particular focuses are on validating the improved coarse-grained BD schemes for a DNA macromolecule and the kernel-free fast multipole method for computing the non-local hydrodynamic interactions.

ANJANA GRANDHI

New Jersey Institute of Technology

Control of mdFDR in Testing Hierarchically Structured Families of Hypotheses

We develop a mixed directional false discovery rate (mdFDR) controlling procedure in the context of Uterine Fibroid gene expression data (Davis et. al, 2013). The main question of interest that arises in the research related to uterine fibroids is to find out which genes are associated with onset, growth and size of tumor and find the trends in mean gene expressions across several categories of size or tumor, location etc. To answer these questions we formulate a three-stage testing problem and propose a general procedure that can be used with any mixed directional family wise error rate (mdFWER) controlling procedure for each gene, while controlling mdFDR as the overall error rate. We prove that our procedure controls mdFDR when the underlying test statistics are independent across the genes. We report the results of a simulation study evaluating the performance of the procedure under independence and dependence of the underlying test statistics relative to the procedure in Guo et. al (2010). We then develop methodology based on the general procedure in the context of uterine fibroid gene expression data and compare the results with the results of Davis et. al (2013).

HOLLY GRANT

Virginia Tech

A viscoelastic constitutive model that displays the behavior of a thixotropic yield stress fluid

We investigate the extensional flow of a viscoelastic fluid, with no built-in assumptions about yield stress. We combine Larson's partially extending strand convection model with a large relaxation time and a Newtonian solvent to address initial value problems for a prescribed tensile stress. The stages of evolution from equilibrium are characterized using multiscale asymptotic analysis, together with numerical simulations, of the original equations. The results reveal several features associated with thixotropic yield stress fluids, such as delayed yielding and hysteresis.

JOON HA

Laboratory of Biological Modeling, NIDDK, NIH

Exploration of pathways to diabetes with a mathematical model

We have extended our mathematical model for compensation and failure of beta-cell mass and function in response to insulin resistance and pre-existing genetic defects. The previous version was limited to simulating average daily glucose and average daily insulin secretion, but the model can now simulate Oral Glucose Tolerance Test (OGTT), Intravenous Glucose Tolerance Test (IVGTT) and the large excursions of glucose, insulin and hepatic glucose production (HGP) due to meals. We have incorporated the dynamics of exocytosis of insulin granules. These enhancements allow us to look at the mechanistic defects that underlie observed pathologies such as impaired fasting glucose (IFG) and impaired glucose tolerance (IGT). The model supports associations in experiments between IFG and excess HGP and between IGT and peripheral insulin resistance. We analyze the model structure in a phase plane along with a bifurcation diagram.

YOGESH JOSHI

Kingsborough Community College

Strange Attractors for Asymptotically Zero Maps

A discrete dynamical system in Euclidean m-space generated by the iterates of an asymptotically zero map f, satisfying |f(x)| --> 0 as |x| --> infinity, must have a compact global attracting set A. The question of what additional hypotheses are sufficient to guarantee that A has a minimal (invariant) subset U that is a chaotic strange attractor is answered in detail for a few types of asymptotically zero maps. These special cases happen to have many applications (especially as mathematical models for a variety of processes in ecological and population dynamics), some of which are presented as examples and analyzed in considerable detail.

DONGWOOK KIM

Paine College

The mechansim generating oscillations in local-diffusive and global coupling system

We investigate the effects of competition between local-diffusive and global coupling in the generation of localized and phase-locked oscillatory patterns in fast-slow piecewise-linear (PWL) models of FitzHugh-Nagumo (FHN) type. It has been previously shown that these models are able to capture several important aspects of the behavior of the classical (smooth) FHN model. We consider two types of inhibitor nullclines: linear and sigmoidal-like. We analyze the patterns obtained for different ratios between the diffusive and global coupling coefficients and compare the effects of these two types of nullclines for representative values of these ratios. We show that diffusive coupling contributes to the spatial aggregation of the out-of-phase clusters generated by the presence of global coupling.

LENKA KOVALCINOVA

New Jersey Institute of Technology

Properties of force networks of slowly compressed granular matter

Force chains in granular material have been studied extensively by the scientific community over the years. Statistical approaches have been used to give some insights on the forces distribution inside the granular medium. They offer a quantitative perspective on the forces but no spatial information is being contained. We consider a set of circular particles confined in a square domain with rough walls composed of monodisperse particles and slowly compress the system. Using the numerical tools, we analyze our system around the jamming transition and for higher volume fractions. We look at the influence of various parameters on our system - such as system size, compression speed, polydispersity, etc. Statistical physics and recent results suggest the universality and scaling laws of the mean cluster size, with several critical exponents. We study these parameters numerically using different approaches.

MICHAEL LAM

New Jersey Institute of Technology

Hele-Shaw Instabilities of Newtonian and Non-Newtonian Two-Phase flow

We present the results of semester long project focusing on the instabilities that develop in two-phase flow in Hele-Shaw geometry. Experimentally, we have considered few different fluid combinations: water-glycerol, water-PEO (polyethylene oxide), and water-5CB (4-Cyano-4'-pentylbiphenyl). The last two combinations are known to exhibit non-Newtonian behavior that influences the pattern formation process. Theoretically, we have carried out linear stability analysis and compared the predictions with the experimental results. Computationally, we have carried out Monte-Carlo type of simulations based on the so-called diffusion limited aggregation (DLA) approach. We have computed various measures of the emerging patterns, including fractal dimension forboth experimental and computational results, and we discuss to which degree non-Newtonian behavior of the considered fluids influences these measures. This work was conducted as part of the Undergraduate Capstone Course taught by Lou Kondic. Authors: Michael Lam, Ronald Anazco, Thomas Anderson, Timothy Barnes, Ivonne Lastra, Scott Lieberman, Stephanie Maruca, Lucy Moulton, Joseph Zaleski, Erich Zinssmeister, Lou Kondic

Instabilities in the flow of nematic liquid crystal films down an incline in three spatial dimensions

The flow of nematic liquid crystals down an inclined substrate is studied. Under the usual long wave approximation, a fourth order nonlinear parabolic partial differential equation of diffusion type is derived for the free surface height. The model accounts for elastic stresses due to distortions in the orientation of liquid crystal molecules (director field) as well as the nematic-substrate and nematic-free surface interactions (anchoring conditions). The partial differential equation we derive admits 2D traveling-wave solutions, which may translate stably or exhibit instabilities in the flat film behind the traveling front. These streamwise instabilities are distinct from the usual transverse instability of downslope flow. Linear stability analysis shows that in the regime where a traveling front is streamwise stable, the anchoring condition on the substrate may enhance or weaken transverse instabilities. These results may explain the intricate patterns observed in simulations of the nonlinear long wave model in the presence of transverse and streamwise instabilities.

RANDOLPH LEISER

New Jersey Institute of Technology

Periodic forcing of insulin-secreting glycolytic oscillators: entrainment and synchronization properties

Glycolytic oscillations have been proposed to underlie the pulsatile release of insulin from pancreatic beta cells. Several studies have addressed the mechanisms of synchronization of beta cells across Langerhans islets. Because of their dynamic nature, these phenomena invariably involve the oscillatory communication among beta cells. Periodic forcing of glycolytic oscillators is thus an important step in the investigation of the underlying mechanisms and hence has been studied both theoretically and experimentally. The effects of periodic forcing on glycolytic oscillators can be studied at different levels of organization including (i) the entrainment of existing oscillations, (ii) the generation of oscillatory behavior in otherwise silent cells, and (iii) the synchronization of oscillations in coupled or uncoupled oscillators. In this work we investigate these phenomena in minimal models of glycolytic oscillations leading to the pulsatile secretion of insulin. We show that both synchronized in-phase and out-of-phase oscillatory patterns emerge as a result of the interplay of the model's nonlinearities, time scales, and the properties of the periodic inputs.

KYLE MAHADY

New Jersey Institute of Technology

Contact angles and thin film rupture: Volume of Fluid based simulations of the van der Waals interaction in three-phase systems

The van der Waals' (vdW) interaction between molecules is of fundamental importance in determining the behavior of three phase systems in fluid mechanics. This interaction gives rise to interfacial energies and thus the contact angle for a sessile droplet on a solid surface, and additionally leads to instability of very thin liquid films. We develop a hybrid method for including a Lennard-Jones type vdW interaction in a finite volume, Volume of Fluid (VoF) based solver for the full two-phase Navier-Stokes equations. This method includes the full interaction between each fluid phase and the solid substrate via a finite-volume approximation of the vdW body force. Our work is distinguished from conventional VoF based implementations in that the contact angle arises from simulation of the underlying physics, as well as successfully treating vdW induced film rupture. At the same time, it avoids the simplifications of calculations based on disjoining-pressure, where the vdW interaction is included as a pressure jump across the interface which is derived under the assumption of a flat film. This is especially relevant in the simulation of nanoscale film ruptures involving large contact angles, which have been studied recently in the context of bottom-up nanoparticle fabrication.

ENSELA MEMA

New Jersey Institute of Technology

Substrate induced gliding effect in a nematic liquid crystal layer

The interaction between nematic liquid crystals (NLC) and substrates is of great industrial importance due to the increase in use of portable electronic devices, many of which use NLC-based display technology, in everyday life. Traditional liquid crystal display (LCD) devices use glass bounding surfaces, at which the anchoring (the preferred orientation of the NLC molecules at the surface) may be precisely controlled. Motivated by recent interest in the development of flexible LCD devices, we focus our attention on a flexible polymer-NLC-polymer sandwich, in which there is less precise control of anchoring, and interesting phenomena such as "director gliding" occur. Director gliding refers to a slow drift in the anchoring angle (or easy axis) at the bounding surface, due to the interaction between the polymeric substrate and the NLC. In this poster, we develop a mathematical model consisting of a NLC layer sandwiched between two parallel bounding plates. We introduce two gliding models, and study the effect of each on the director. In addition, for a system that is initially bistable, we investigate how director gliding can affect the bistability.

MICHAEL MIKUCKI

Colorado State University

Fast algorithms for dynamics of vesicle membranes

Lipid bilayer membranes appear ubiquitously in biological systems. The fluidity of the membrane allows for large deformations, permitting a myriad of possible structures. The mechanics of bilayer membranes play a central role in many cellular functions, including budding, binding, fusion, endocytosis, and exocytosis, among many others. These processes are often regulated by curvature-inducing proteins. Therefore, defining and computing the forces on the membrane is critical to understanding the dynamics of these systems. First, the dynamics of bilayer vesicle membranes under its own mechanical energy will be computed using the spontaneous curvature model. Surface harmonics are used to parameterize the membrane surface, drastically reducing the degrees of freedom when compared to surface triangulations for finite element and finite difference methods. Next, a fast algorithm for including the dynamics of membrane-protein interactions will be discussed. The presentation will conclude with some equilibrium membrane shapes including those exhibited by red blood cells and conformations which are non-axisymmetric.

HOANG-NGAN NGUYEN

University of California, Merced

Computation of doubly-periodic Green's functions of Stokes flow in the presence of a plane wall

We develop an Ewald-like summation method to compute the periodic Green's functions of Stokes flow in the presence of a plane wall. The idea is to use the method of image for regularized Stokeslet with suitable blobs. The advantage of our method is that the computed Green's functions are exactly zero on the plane wall independent of the number of the periodic copies used. This method will then be used in modeling cilia and swimming microorganisms near the wall.

CHOONGSEOK PARK

North Carolina A&T State University

Neuronal network with voltage-sensitive piecewise smooth coupling

In this study, we present an analysis of activity patterns in a neuronal network, which consists of three mutually inhibitory cells with voltage-sensitive piecewise smooth coupling. This network model was motivated by recent development of respiratory neuronal network model in the mammalian brainstem and is able to exhibit various activity patterns including the bistable relaxation oscillation solutions with different order of activations. A reversed order of activations, which is observed in one of the bistable solutions, is contrary to the network architecture and characterized by a sudden "turn-around" during transitions (fast jumps) between states. Standard fast-slow analysis provides the set of fixed points of fast subsystem and transition surfaces parameterized by slow variables but due to the voltage-sensitive nature of coupling it fails to describe the mechanism underlying the sudden "turn-around" during fast jumps. To determine where fast jumps actually go, we consider the structure of fast subsystem which is modulated by slow dynamics as well as fast dynamics. Piecewise smoothness of coupling enables us to consider a sequence of fast subsystems in piecewise way. Our analysis shows that there are three possible scenarios during fast jumps, which incorporate the fast dynamics and slow dynamics. First, the fast dynamics succeeds to equilibrate at (or near) a presumed fixed point manifold and then the slow dynamics relaxes to its own fixed point, pulling the slaved, fast variables along the fixed point manifold. Second, while the fast dynamics tries to equilibrate at a fixed point manifold, the slow dynamics pushes the fast system through a bifurcation, which forces a second fast jump to a new fixed point manifold and then the slow relaxation follows. Third, the presumed fixed point manifold is either already lost by the slow dynamics or blocked by the structure of the fast subsystem, thus the fast dynamics is forced to approach a new fixed point manifold directly. In the second and third cases, we observe the sudden "turn-around" during fast jumps.

JURI RAPPOPORT

Institute for Computer Aided Design of the Russian Academy of Sciences

Some corneal applications and computation of modified Bessel functions

Methods are elaborated and computational procedures are constructed for modified Bessel functions of order zero, one, integer, pure imaginary and complex. New realization of the Lanczos Tau method with minimal residue is proposed for the numerical solution of the second order differential equations with polynomial coefficients. The approximating scheme of Tau method is extended for the systems of hypergeometric type differential equations. The morphometry analysis of endothelial cells is investigated in the different periods of time after the keratoplasty.

AMINUR RAHMAN

New Jersey Institute of Technology

A Scheme for Analyzing the Dynamics of Logical Circuits

It is shown how logical circuits can be modeled by discrete dynamical systems that preserve the qualitative behavior observed in physical realizations. While continuous dynamical systems provide quite accurate mechanistic models, they can become extremely computationally expensive to simulate. In contrast, simulating discrete dynamical systems is relatively inexpensive. A systematic-algorithmic-first principles based approach is developed in order for such dynamical models to reflect observed behavior and facilitate further investigation. Also, it is demonstrated how this fundamental algorithmic approach can, with similar ease, be used to obtain discrete dynamical models of other more complicated logical circuits.

MOHAMED KAMEL RIAHI

CMAP: X-Ecole Polytechnique and INRIA Saclay

3D direct and inverse solver for Eddy current testing in steam generator

We consider the inverse problem of estimating the shape profile of an unknown deposit on the exterior of stream generator tubes from a set of eddy current impedance measurements due to coils located in the interior of the tubes. We shall address the problem in a 3D setting to treat the case where the deposits are located in the vicinity of the support plates. Numerical validating experiments on synthetic deposits with different shapes will be presented.

IVANA SERIC

Interfacial instability in thin ferrofluid films under a magnetic field

3D direct and inverse solver for Eddy current testing in steam generator

We consider a thin layer of viscous and non-conducting ferrofluid film subjected to an applied uniform magnetic field and covered by non-magnetizable passive gas. The dynamics is governed by coupled static Maxwell equations and incompressible Navier-Stokes equations. We derive a thin film equation that governs the non-linear evolution of the interface and study the linear stability of the interface in the long-wave limit. The contact angle is imposed through a disjoining pressure model. The thin film equation is solved numerically and the results are compared with the linear stability analysis. Unstable modes grow in time and the film breaks up into droplets. Satellite droplets are also found to appear depending on the strength of the magnetic field relative to the van der Waals interaction.

MALIK ZAKA ULLAH

King Abdulaziz University

An Efficient Method for Nonlinear Dynamic Deflection Analysis of an Infinite Beam on a Nonlinear Elastic Foundation with variable Beam Cross-section

The dynamic response of an infinite Euler-Bernoulli beam, resting on a nonlinear elastic foundation, has been investigated. The problem is treated in a general sense by defining the flexural rigidity and coefficients in nonlinear power law as a function of spatial variable which runs along the length of infinite beam. The flexural rigidity and coefficients in nonlinear power law could be discontinuous. We implemented quasilinear method (QLM) to deal with the nonlinearity of the problem which is due to the inclusion of nonlinear elastic foundation. The QLM translates the nonlinear problem in a linear associated problem that satisfies the boundary conditions defined for the nonlinear fourth-order partial differential equation (PDE). The quasilinear form (QL) is iterated until the approximate solutions converge to real solution within some tolerance. The QL-PDE is solved using Chebyshev spectral collocation method in space and time. The spatial and temporal discretization converts the QL-PDE in to system of linear algebraic equations. The validity and accuracy of proposed iterative scheme is checked by number of designed problems. The proposed iterative method has second-order convergence which is implied from QLM and shows rapid convergence in few number of iterations.

OLEKSIY VARFOLOMIYEV

New Jersey Institute of Technology

A non-stiff numerical method for 3D interfacial flow of inviscid fluids

We formulate the initial value problem to model the evolution of the interface between two fluids of different density in three spatial dimensions. The evolution equations account for the action of gravity on the fluids, surface tension in the fluids and a prescribed far-field conditions. The flow in each fluid is incompressible and irrotational, so the classical potential theory applies and allows for a boundary integral of dipoles representation. This representation satisfies the kinematic condition of continuous normal velocity and the Laplace-Young condition for the pressure. The dipole strength is related to the jump in potential across the interface. The model of the exact nonlinear three-dimensional motion of the interface is formulated and includes expressions for integral invariants of the motion, the mean height of the interface and the total energy per wavelength. We develop the numerical method that employs a special generalized isothermal interface parameterization. It enables the use of implicit non-stiff time-integration methods via a small-scale decomposition. Our method includes the efficient algorithms for the generation of initial data with the generalized isothermal parameterization by evolving a flat interface toward a prescribed initial surface shape or by the appropriate choice of the tangential velocities. The method is used to efficiently compute the nonlinear evolution of a doubly periodic interface separating two fluids in the Rayleigh-Taylor instability and internal waves with surface tension.

SHAOBO WANG

New Jersey Institute of Technology

Efficient sum-of-exponentials approximations for the heat kernel and their applications

Efficient separated sum-of-exponentials approximations can be constructed for the heat kernel in any dimension. These approximations can be used to accelerate integral equation-based methods for boundary value problems governed by the heat equation in complex geometry. The resulting algorithms are nearly optimal. For Ns points in the spatial discretization and Nt time steps, the cost is O(NsNt log(z))in terms of both memory and CPU time for fixed accuracy epsilon, where z is T over delta and t is from delta to T. The algorithms can be parallelized in a straightforward manner. Several numerical examples are presented to illustrate the accuracy and stability of these approximations.

HAO WU

New Jersey Institute of Technology

Investigation of Infinite-dimensional Dynamical Systems Models Applicable to Granular Flow

Recently Blackmore, Samulyak and Rosato developed a class of infinite-dimensional dynamical systems in the form of integro-partial differential equations, which have been called the BSR models. The BSR models were originally derived to model granular flows, but they actually have many additional applications in a variety of fields. We prove that dynamical systems of the BSR type are well posed under mild auxiliary conditions, and have interesting properties. In addition, a novel semi-discrete numerical scheme for obtaining approximate solutions has been developed and this can be used to help demonstrate the value of these models for predicting the evolution of granular flows and other flow field related phenomena.

YEONA KANG

Brookhaven National Lab

QSPR/PET Imaging Predicts Blood-Brain barrier Transport and Efflux of Benzamides

The failure of many CNS radiotracer candidates to show appropriate brain uptake, pharmacokinetics and specificity has created the need to develop and validate tools with predictive value. Here we report the design and development of a series of structurally well-defined benzamides labeled them with carbon-11 (20.4 min), as a model for the development and evaluation of a quantitative structure-property relationship tool for predicting brain pharmacokinetics using in silico/in vitro data (QSPR). Twenty one C-11 labeled benzamides with varying molecular volume (MV) and polar surface area (PSA) were designed and synthesized by N-methylation using [11C]methyl iodide. Brain time-activity data was analyzed and calculate plasma-to-brain influx (K1) and model parameter using a 1-tissue-compartiment model. MOE and Schrodinger were used to generate and refine Quantitative Structure Property relationship (QSAR). K1 ranged between 0.1 (not BBB permeable) to 0.3 (BBB permeable). The R2 value between predicted and experimental values of K1 was 0.77. The main criteria driving QSPR were PSA and MV with brain entry rate (K1) being highly correlated with PSA. We demonstrate, for the first time an experimentally validated K1 prediction model for PET radiotracers. Even though it is limited to structurally well-defined benzamides we suggest that it will be generalizable to other structural motifs and could also be used to predict brain uptake and pharmacokinetics for CNS drug candidates administrated acutely by inhalation and intravenous routes.

ANTHONY ZALESKI

Rutgers University

On an isoperimetric problem with a competing non-local term: Quantitative results

This paper provides a quantitative version of the recent result of Knüpfer and Muratov (Commun. Pure Appl. Math. 66 (2013), 1129-1162) concerning the solutions of an extension of the classical isoperimetric problem in which a non-local repulsive term involving Riesz potential is present. There it was shown that in two space dimensions the minimizer of the considered problem is either a ball or does not exist, depending on whether or not the volume constraint lies in an explicit interval around zero, provided that the Riesz kernel decays sufficiently slowly. Here we give an explicit estimate for the exponents of the Riesz kernel for which the result holds.

ANNA ZEMLYANOVA

Kansas State University

Frictionless contact problem for a rigid stamp in the presence of curvature-dependent surface tension

In this talk I will discuss the two-dimensional problem of a frictionless contact of a rigid stamp with an elastic semi-plane. A curvature-dependent surface tension acts on the boundary of the semi-plane. With the help of Muskhelishvili's complex potentials, the problem is reduced to the system of singular integro-differential equations. By using Fourier transform it is possible to further reduce this system to a single Fredholm equation of the second kind on the contact interval. The numerical results are presented and the comparison with a classical contact problem in the absence of surface tension is made.

YANG ZHANG

New Jersey Institute of Technology

An empirical equation for predicting the history-dependence of conduction delay in axons

Conduction delay (d) of action potentials is a function of axon length, passive membrane properties, voltage-gated ion channels, and the Na+/K+ pump. Although d is often assumed to be relatively stable, it can drastically change dependent on both short- and long-term history of activity. Recent experiments on a lobster motor axon show that such changes can substantially alter temporal patterns during propagation to distal synaptic targets (Ballo & Bucher, 2009; Ballo et al., 2012). We have built a biophysical model of this axon which successfully captures the short- and long-term history dependence. To develop an equation that accurately predicts history-dependence, we investigated the relationships between d and different ionic currents and found that d is mostly determined by the opening rate of the Na+ activation variable prior to the action potential (αm(VT)), and the closing rate of its inactivation variable at the peak (βh(VP)). Furthermore, we observed that in our model data both αm and βh are almost linear functions of their respective voltage variables (VT and VP) in the voltage ranges observed. We therefore developed our empirical equation d=A/VT+B/VP+C. We found that this equation can accurately predict the history dependence of d in the model. More importantly, it provided accurate predictions of d from experimental measurements of action potential voltage trajectories in the motor axon. This equation can therefore be used to describe the history-dependence of d in experiments without any need for computational modeling.

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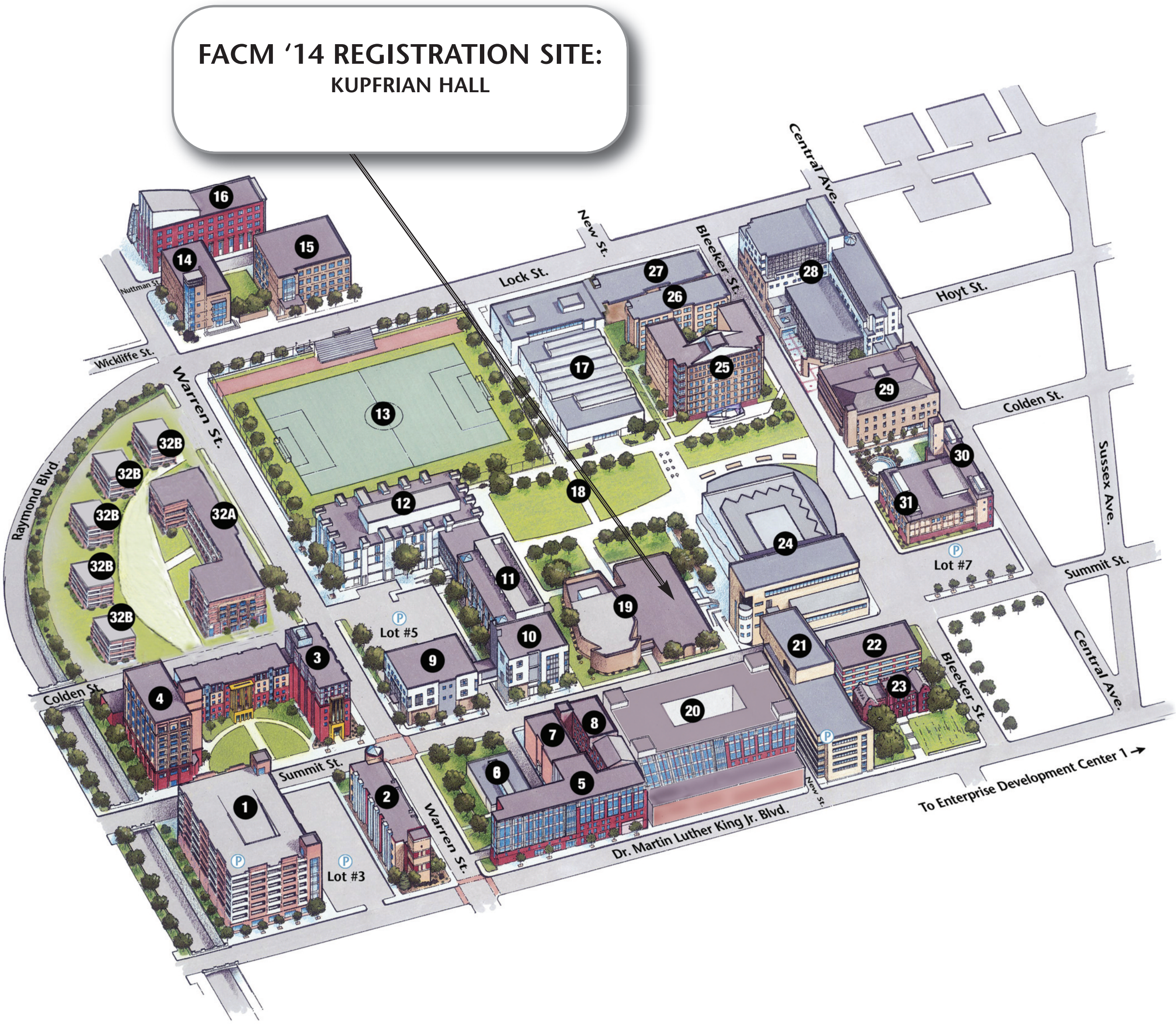
NJIT CAMPUS MAP



1	CAMPBELL HALL/STUDENT SERVICES	17	ESTELLE AND ZOOM FLEISHER ATHLETIC CENTER
2	YORK CENTER FOR ENVIRONMENTAL ENGINEERING AND SCIENCE	18	THE GREEN:
3	LAUREL RESIDENCE HALL	19	KUPFRIAN HALL
4	OAK RESIDENCE HALL	20	CENTRAL KING BUILDING:
5	COLLEGE OF ARCHITECTURE AND DESIGN	21	FENSTER HALL
6	SPECHT BUILDING	22	CULLIMORE HALL:
7	COLTON HALL	23	EBERHARDT HALL/ALUMNI CENTER:
8	CAMPBELL HALL	24	CAMPUS CENTER
9	ECE BUILDING	25	CYPRESS RESIDENCE HALL:
10	MICROELECTRONICS CENTER	26	REDWOOD RESIDENCE HALLS
11	FACULTY MEMORIAL HALL	27	NAIMOLI FAMILY ATHLETIC AND RECREATIONAL FACILITY
12	TIERNAN HALL	28	GUTTENBERG INFORMATION TECHNOLOGIES CENTER
13	LUBETKIN FIELD AT J. MALCOLM SIMON STADIUM	29	MECHANICAL ENGINEERING CENTER
14	CHEN BUILDING	30	CENTRAL AVENUE BUILDING
15	ENTERPRISE DEVELOPMENT CENTER 2	31	VAN HOUTEN LIBRARY
16	ENTERPRISE DEVELOPMENT CENTER 3	32A	ALBERT DORMAN HONORS COLLEGE
		32B	GREEK HOUSES

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