FACM '15

FRONTIERS IN APPLIED AND COMPUTATIONAL MATHEMATICS

New Jersey Institute of Technology
Newark, New Jersey
June 5 – 6, 2015

Program Guide and Abstracts

Hosted by:
Department of Mathematical Sciences and
Center for Applied Mathematics and Statistics
http://www.math.njit.edu

Supported by:
National Science Foundation

NJIT
New Jersey Institute
of Technology

ORGANIZING COMMITTEE

FRONTIERS IN APPLIED AND COMPUTATIONAL MATHEMATICS
NEW JERSEY INSTITUTE OF TECHNOLOGY
NEWARK, NEW JERSEY
JUNE 5 – 6, 2015

ORGANIZING COMMITTEE

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Fatima Ejallali

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Maria Laygo

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FRONTIERS IN APPLIED AND COMPUTATIONAL MATHEMATICS

MESSAGE FROM THE ORGANIZING COMMITTEE

Welcome to Frontiers in Applied and Computational Mathematics 2015 (FACM '15), the twelfth in a series of annual conferences organized by the Department of Mathematical Sciences and the Center for Applied Mathematics and Statistics at the New Jersey Institute of Technology, and supported by the National Science Foundation.

The main focus of FACM '15 is the application of mathematics to fluid dynamics, broadly interpreted to include: active fluids, biological fluids, classical fluid dynamics, complex fluids, flocking and swarming, numerical algorithms, and waves in fluids and media. The companion theme, applied and bio-statistics in big data, reflects NJIT's initiative and development in big data. In addition, a minisymposium is dedicated to recognizing our colleague Denis Blackmore's contributions in mathematical modeling of vortex dynamics.

As in past FACM conferences, FACM '15 continues to feature presentations by young researchers, selected from numerous applications submitted by some of the nation's best young applied mathematicians and statisticians. We are happy to give these future leaders in applied mathematics an opportunity to present their work among senior colleagues.

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 present and discuss your new ideas, research and achievements.

We take this opportunity to thank the Administrative Staff of the Department of Mathematical Sciences: Eileen Michie, Fatima Ejallali, Alison Boldero, Nickcoy Findlater and Maria Laygo.

FACM '15 Organizing Committee

DMS CHAIR'S MESSAGE

The Department of Mathematical Sciences, along with the Center for Applied Mathematics and Statistics (CAMS), is immensely pleased to welcome you to NJIT for our twelfth conference on Frontiers in Applied and Computational Mathematics (FACM). Our leading theme is all things fluids on scales ranging from the solar to the cellular. In line with the scope of the mission of CAMS, we have a substantial coverage of the frontiers of statistics with both academic and industrial perspectives. The emerging area of data science makes frequent appearances across both themes of the meeting. We are grateful for the continued support of the National Science Foundation in making this meeting possible.

We are particularly delighted to present a special session on Vortex Dynamics in honor of our colleague Denis Blackmore and his contributions to that classical but still current area of fluid mechanics. In addition to his scientific contributions, Denis is one of the primary movers who, more than three decades ago, planted the seeds that sprouted to become CAMS and brought a significant research agenda to the Department of Mathematical Sciences at NJIT.

The nature of a conference is to bring people together to share ideas and foster collaboration and new directions. Through FACM, we are pleased to include early-career scientists, statisticians, and applied mathematicians in these activities. To see the flourishing careers of so many past participants is immensely gratifying and encourages us to further expand these opportunities. All participants are especially encouraged to attend the poster sessions and minisymposia where early-career participants are presenting and to interact with these rising talents.

Jonathan H. C. Luke
Professor and Chair
Department of Mathematical Sciences

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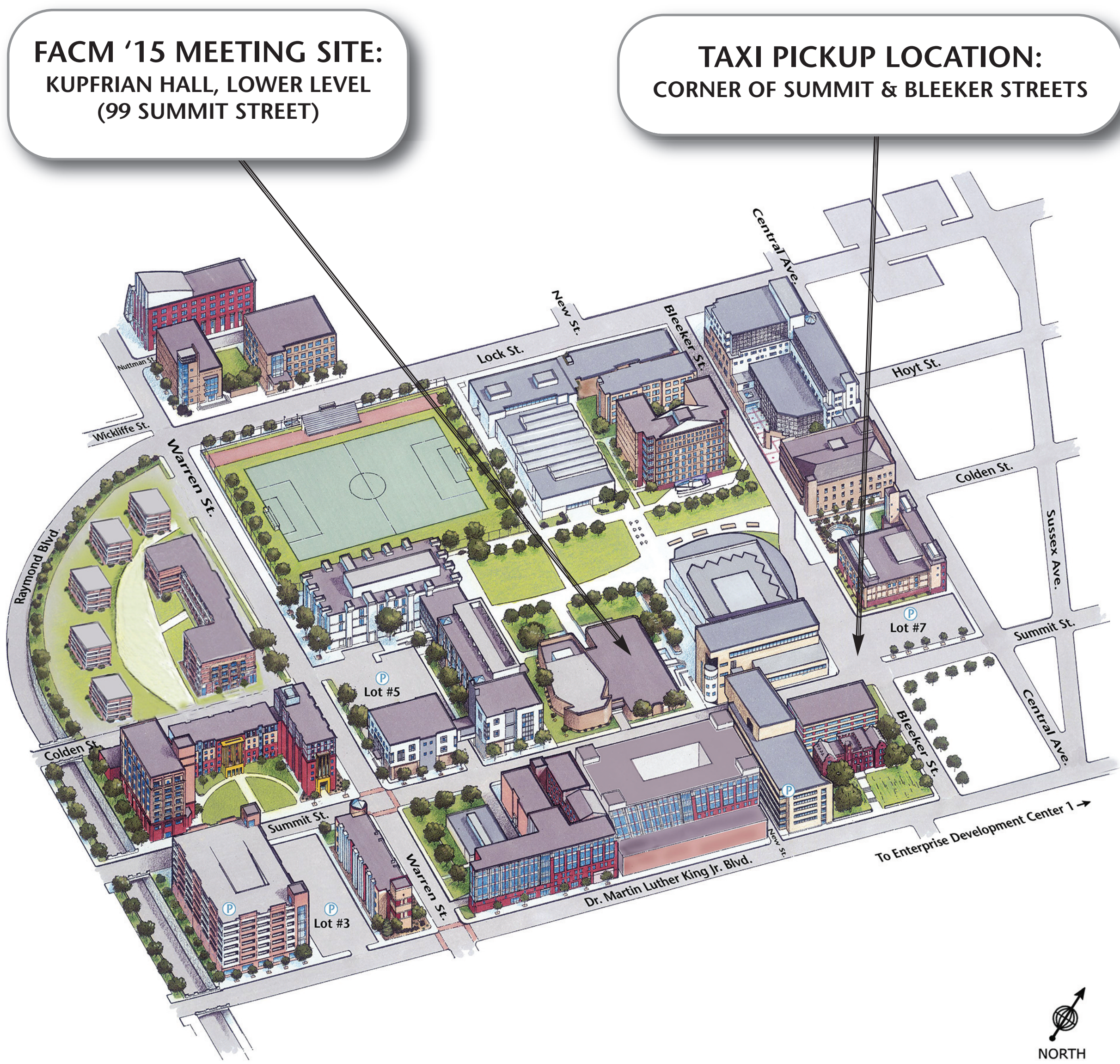

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JUNE 5 - 6, 2015

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Please note: these access credentials are only good until midnight of June 7, 2015.

PROGRAM SCHEDULE

FRIDAY, JUNE 5

Time	Event	Location
8:15 – 8:45 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
	Atam P. Dhawan	
	Vice Provost for Research	
	Welcoming Remarks	
	Jonathan Luke, Chairperson,	
	Department of Mathematical Sciences	
9:00 – 10:00 a.m.	**Plenary Lecture I**	
	Jean-Luc Thiffeault, University of Wisconsin - Madison	Jim Wise Theater, Kupfrian Hall
	Particle Fluctuations Induced by Microswimmers	
10:00 – 10:30 a.m.	Coffee Break	Kupfrian 1st Floor Lobby
10:30 – 1:00 p.m.	**Minisymposia I, II, III, and IV**	
1:00 – 2:30 p.m.	Lunch	Kupfrian 1st Floor Lobb
	Poster Session	Kupfrian 2nd Floor Rotunda
2:30 – 3:30 p.m.	**Plenary Talk II**	Jim Wise Theater, Kupfrian Hall
	Anne Juel, University of Manchester	
	Interfacial Instabilities on the Pore Scale	
3:30 – 4:00 p.m.	Coffee Break	Kupfrian 1st Floor Lobby
4:00 – 6:15 p.m.	**Minisymposia V, VI, VII, and VIII**	
6:15 – 9:00 p.m.	Banquet	Campus Center Atrium

PROGRAM SCHEDULE

SATURDAY, JUNE 6

Time	Event	Location
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
	Randall J. LeVeque, University of Washington	
	Numerical Methods for Tsunami Modeling and Hazard Assessment	
10:00 – 10:30 a.m.	Coffee Break	Kupfrian 1st Floor Lobby
10:30 – 1:00 p.m.	**Minisymposia IX, X, XI, and XII**	
1:00 – 2:00 p.m.	Lunch	Kupfrian 1st Floor Lobby
	Poster Session	Kupfrian 2nd Floor Rotunda
2:00 – 3:00 p.m.	**Plenary Lecture IV**	
	Xiao-Li Meng, Harvard University	
	Is it a Computing Algorithm or a Statistical Procedure:	Kupfrian 1st Floor Lobby
	Can You Tell or Do You Care?	
3:00 – 3:15 p.m.	Coffee Break	Kupfrian 1st Floor Lobby
3:15 – 5:30 p.m.	**Minisymposia XIII, XIV, XV, XVI**	

PROGRAM EVENTS

FRIDAY MORNING

PLENARY TALK I

9:00 – 10:00 a.m.	**Jean-Luc Thiffeault,** University of Wisconsin - Madison *Particle Fluctuations Induced by Microswimmers* Location: Jim Wise Theater, Kupfrian Hall

MINISYMPOSIA I, II, III, IV

	Minisymposia I Data Info/Flocking Location: Kupfrian 118 Chair: David Shirokoff	**Minisymposia II** Numerical Methods I Location: Kupfrian 105 Chair: Yassine Boubendir	**Minisymposia III** Geophysical Fluid Location: Kupfrian 117 Chair: Ian Hewitt	**Minisymposia IV** Statistics Location: Kupfrian 106 Chair: Wenge Guo
10:30 – 11:00 a.m.	**Chad Topaz** Macalester College *Topological Data Analysis of Biological Aggregation Models*	**Marion Darbas** Université de Picardie Jules Verne *Analytical Preconditioners for the Solution of Three-dimensional Surface Scattering Problems*	**Daniel Rothman** MIT *Climate, Groundwater Flow, and the Geometry of River Networks*	**Zhi Wei** NJIT *An Empirical Bayes Change-point Model for Identifying 3' and 5' Alternative Splicing by Next-generation RNA Sequencing*
11:00 – 11:30 a.m.	**Enkeleida Lushi** Brown University *Self-organization of Confined Bacterial Suspensions*	**Zhen Peng** University of New Mexico *Boundary Integral Equation Domain Decomposition Methods for Time-harmonic Maxwell Equations*	**Ken Golden** University of Utah *Sea Ice, Climate, and Multiscale Composites*	**Usman Roshan** NJIT *A New Iterated Local Search Algorithm for NP-hard Linear Classification*
11:30 – 12:00 a.m.	**Themistoklis Sapsis** MIT *Quantification and Prediction of Rare Events in Nonlinear Water Waves*	**Matthew Causley** Kettering University *Higher Order Methods for PDE's Using Successive Convolution Algorithms*	**Stephen Morris** University of Toronto *Ripples on Icicles*	**Duan Lian** NJIT *Understanding Big Data through Correlation Analysis*

FRIDAY MORNING

MINISYMPOSIA I, II, III, IV

12:00-12:30 p.m.	**Dimitrios Giannakis** NYU, CIMS *Data-driven Methods for Nonparametric Forecasting of Dynamical Systems*	**Eldar Akhmetgaliyev** (12:00 – 12:15 p.m.) Caltech *Integral Equation Methods for Laplace Eigenvalue Problems* **Mohamed Riahi** (12:15 – 12:30 p.m.) NJIT *Parareal in Time Algorithm Face to 3D Simulation of the Time Dependent Neutron Diffusion Model*	**Ian Hewitt** University of Oxford *Glacial Stream Formation*	**Antai Wang** NJIT *The Analysis of Left Censored Bivariate Data Using Frailty Models*
12:30-1:00 p.m.	**Ummugul Bulut** (12:30 – 12:45 p.m.) Grand Valley State University *Derivation of Stochastic Biased and Correlated Random Walk Models*		**Kyle Mandli** Columbia University *Approaches to Forecasting Storm Surge More Quickly and Accurately*	

FRIDAY AFTERNOON

PLENARY TALK II

2:30 – 3:30 p.m **Anne Juel,** University of Manchester
Interfacial Instabilities on the Pore Scale
Location: Jim Wise Theater, Kupfrian Hall

MINISYMPOSIA V, VI, VII, AND VIII

	Minisymposia V	Minisymposia VI	Minisymposia VII	Minisymposia VIII
	Vortex Dynamics; Special Session in Honor of Denis Blackmore Location: Kupfrian 117 Chair: Stefan Llewellyn Smith	Numerical Methods II Location: Kupfrian 118 Chair: Brittany Froese	Biofluid Dynamics Location: Kupfrian 105 Chair: Yuan-Nan Young	Statistics Location: Kupfrian 106 Chair: Ji Meng Loh
4:00 – 4:30 p.m.	**Stefan Llewellyn Smith** UCSD *Hollow Vortices*	**William Henshaw** RPI *Over-coming the Fluid-structure Added-mass Instability for Incompressible Flows*	**David Salac** University at Buffalo, SUNY *Vesicles in Electric Fields: A Numerical Investigation*	**Howard Karloff** Yahoo! Labs *Variable Selection is Hard*
4:30 – 5:00 p.m.	**Morten Brons** Technical University of Denmark *On Conservation of Vorticity and Generation of Vortices*	**Jean-Christophe Nave** McGill University *Evolution of Curves, Surfaces, and Arbitrary Sets*	**Zhangli Peng** University of Notre Dame *Combining Dissipative Particle Dynamics, Finite Element Method and Boundary Element Method to Study Red Blood Cell Diseases*	**Kenneth Shirley** AT&T Labs-Research *Text Mining on Domain Names*
5:00 – 5:30 p.m.	**Scott David Kelly** The University of North Carolina at Charlotte	**Benjamin Seibold** Temple University *High-Order Methods for Incompressible Flows via Pressure Poisson Equation Reformulations*	**Alessandro Veneziani** Emory University *Cardiovascular Mathematics - from the Computer Lab to the Bedside: Perspectives and Challenges*	**Souvik Ghosh** LinkedIn *Bid Suggestions for Online Ad Auction at LinkedIn*

MINISYMPOSIA V, VI, VII, AND VIII

5:30 – 6:00 p.m.	**Chjan Lim** RPI *Negative Effects in Vortex Dynamics*	**Brittany Froese** University of Texas at Austin *Fast Sweeping Methods for Hyperbolic Systems of Conservation Laws*	**Bin Liu** University of California, Merced *Swimming with Wobbling Bodies: The Effect of Cell Body on Motility of Flagellated Bacteria*	**Yixin Fang** New York University *Tuning Parameter Selection in Regularized Estimations of Large Covariance Matrices*
6:00 – 6:15 p.m.	**Diego Ayala Rodriguez** University of Michigan *Extreme Vortex States and Growth of Enstrophy*	**Longfei Li** RPI *Overcoming the Added Mass Instability for Coupling Incompressible Flows and Elastic Beams*	**Nguyenho Ho** WPI *Rods with Bend and Twist in a Brinkman Fluid*	

PROGRAM EVENTS

SATURDAY MORNING

PLENARY TALK III

9:00 – 10:00 a.m.	**Randall J. LeVeque,** University of Washington *Numerical Methods for Tsunami Modeling and Hazard Assessment* Location: Jim Wise Theater, Kupfrian Hall

MINISYMPOSIA IX, X, XI, AND XII

	Minisymposia IX Active Fluids Location: Kupfrian 117 Chair: Lou Kondic	**Minisymposia X** Numerical Methods III Location: Kupfrian 105 Chair: Shahriar Afkhami	**Minisymposia XI** Fluid Dynamics of the Eye Location: Kupfrian 118 Chair: Linda Cummings	**Minisymposia XII** Statistics Location: Kupfrian 106 Chair: Sundar Subramanian
10:30 – 11:00 a.m.	**Jérémie Palacci** New York University *Emergent Properties in Experiments with Synthetic Micro-swimmers*	**Xiaolin Li** SUNY at Stony Brook *Simulation of Parachute FSI Using the Front Tracking Method*	**Rich Braun** University of Delaware *Mathematical Models for Tear Film Dynamics*	**Yijian (Eugene) Huang** Emory University *Quantile Regression with Randomly Censored Data*
11:00 – 11:30 a.m.	**Michael Shelley** NYU, CIMS *The Dynamics of Microtubule/Motor-protein Assemblies and Structures*	**Olivier Desjardins** Cornell University *Conservative and Accurate Geometric Transport Methods for Discontinuous Variables in Turbulent Multi-physics Two-phase Flows*	**Christiaan Ketelaar** University of Delaware *Stability of Electrolyte Films on Solid and Structured Surfaces*	**Limin Peng** Emory University *Generalizing Quantile Regression for Counting Processes with Applications to Recurrent Events*
11:30 – 12:00 p.m.	**Arezoo Ardekani** Purdue University *Near-wall Motion of Microorganisms in Viscoelastic Fluids*	**Christopher Batty** University of Waterloo *Multimaterial Front Tracking for Soap Bubbles and Multiphase Flow*	**Kara Maki** RPI *The Mechanics of a Contact Lens*	**Yu Cheng** University of Pittsburgh *Association Analysis of Successive Events Data in the Presence of Competing Risks*

SATURDAY MORNING

MINISYMPOSIA IX, X, XI, AND XII

12:00 – 12:30 p.m.	**Alexander Petroff** The Rockefeller University *Fast-Moving Bacteria Self-Organize into Active Two-Dimensional Crystals of Rotating Cells*	**Anna-Karin Tornberg** KTH, Royal Institute of Technology *Accelerated Boundary Integral Methods for Interactions of Drops and Solids in Micro-fluidics.*	**Dan Anderson** George Mason University *Tear Film Models with Evaporation and a Contact Lens*	**Jun Yan** University of Connecticut *A Bivariate Two-Part Model*
12:30 – 1:00 p.m.	**Shiyan Wang** (12:30 – 12:45 p.m.) Purdue University; University of Notre Dame *Biogenic Mixing in a Stratified Fluid*	**Ludvig Klinteberg** KTH, Royal Institute of Technology *A Fast and Accurate Integral Equation Method for Particles in Viscous Flow Using QBX*		**Howard Bondell** North Carolina State University *Efficient Robust Estimation via Two-Stage Generalized Empirical Likelihood*

SATURDAY AFTERNOON

PLENARY TALK IV

2:00 – 3:00 p.m.	**Xiao-Li Meng**, Harvard University *Is it a Computing Algorithm or a Statistical Procedure: Can You Tell or Do You Care?* Location: Jim Wise Theater, Kupfrian Hall

MINISYMPOSIA XIII, XIV, XV, XVI

	Minisymposia XIII	Minisymposia XIV	Minisymposia XV	Minisymposia XVI
	Complex Flows Location: Kupfrian 118 Chair: Arezoo Ardekani	Modeling and Experiments Location: Kupfrian 117 Chair: Shilpa Khatri	Fluid Dynamics Location: Kupfrian 105 Chair: Michael Booty	Statistics Location: Kupfrian 106 Chair: Antai Wang
3:15 – 3:45 p.m.	**Prosenjit Bagchi** Rutgers University *Computational Modeling of Red Blood Cells: From Single Cell Mechanics to Microvascular Stenosis*	**Shilpa Khatri** University of California, Merced *Modeling of Pulsating Soft Coral*	**Alexander Kosovichev** NJIT *Observation and Numerical Simulations of MHD Convection in the Sun*	**Shuangge (Steven) Ma** Yale University *Promoting Similarity of Sparsity Structures in Integrative Analysis*
3:45 – 4:15 p.m.	**Paulo Arratia** University of Pennsylvania *Pulling & Pushing in Complex Fluids*	**Mark Hoefer** University of Colorado, Boulder *Dispersive Hydrodynamics of Viscous Fluid Conduit Interfacial Waves*	**Aloknath Chakrabarti** Indian Institute of Science *Integral Equation Methods in Water Wave Problems*	**Lan Xue** Oregon State University *Estimation and Model Selection in Generalized Additive Partial Linear Models For Correlated Data With Diverging Number of Covariates*
4:15 – 4:45 p .m.	**Thomas Powers** Brown University *Mechanics of Swimming in Complex Fluids*	**Saverio Spagnolie** University of Wisconsin–Madison *The Sedimentation of Flexible Filaments in Viscous Fluids*	**Hansong Tang** CUNY *Domain Decomposition for Simulation of Small-Scale Coastal Ocean Flows*	**Rabi Bhattacharya** University of Arizona *Statistical Analysis of Non-Euclidean Data: Examples and Applications*

SATURDAY AFTERNOON

MINISYMPOSIA XIII, XIV, XV, XVI

4:45 – 5:15 p .m.	**Shashi Thutupalli** Princeton University *The Non-equilibrium Dynamics of Active Droplets and Their Collectives*	**Anand Oza** NYU, CIMS *A Dynamical System for Interacting Flapping Swimmers*	**Marko Budisic** (4:45 – 5:00 p .m.) University of Wisconsin–Madison *Finite-Time Braiding Exponents* **Peter Mueller** (5:00 – 5:15 p .m.) University of Wisconsin–Madison *Fluid Transport by an Unsteady Microswimmer*
5:15 – 5:30 p.m.	**Minghao Rostami** WPI *Efficient Simulation of Fluid-Structure Interactions Using Fast Multipole Method*	**Gaojin Li** University of Notre Dame *Dynamics of Particle Migration in a Channel Flow of Viscoelastic Fluids*	**Peter Wills** University of Colorado, Boulder *Stochastic Perturbation of the Magnetic Droplet Soliton*

ANNE JUEL

University of Manchester

Modelling Cortical Spreading of Depression and Related Phenomena

What links a baby's first breath to adhesive debonding, enhanced oil recovery, or even drop-on-demand devices? All these processes involve moving or expanding bubbles displacing fluid in a confined space, bounded by either rigid or elastic walls. In this talk, we show how spatial confinement may either induce or suppress interfacial instabilities and pattern formation in such flows.

We demonstrate that a simple change in the bounding geometry can radically alter the behaviour of a fluid-displacing air finger both in rigid and elastic vessels. A rich array of propagation modes, including symmetric, asymmetric and localised fingers, is uncovered when air displaces oil from axially uniform tubes that have local variations in flow resistance within their cross-sections. An unexpected and novel propagation mode exhibits spatial oscillations formed by periodic sideways motion of the interface at a fixed relative distance behind the moving finger-tip. The presence of multiple steady and unsteady modes is in contrast to the single, symmetric mode observed in tubes of regular cross-section, e.g. circular, elliptical, rectangular and polygonal. Moreover, we show that the experimentally observed states are all captured by a two-dimensional depth-averaged model for bubble propagation through wide channels with a smooth occlusion, which is similar to a model describing viscous fingering, but with a spatially varying channel height.

Viscous fingering in Hele-Shaw cells is a classical and widely studied fluid-mechanical instability: when air is injected into the narrow, liquid-filled gap between parallel rigid plates, the axisymmetrically expanding air-liquid interface tends to be unstable to non-axisymmetric disturbances. We show how the introduction of wall elasticity (via the replacement of the upper bounding plate by an elastic membrane) can weaken or even suppress the fingering instability by allowing changes in cell confinement through the flow-induced deflection of the boundary. The presence of a deformable boundary also makes the system to additional solid-mechanical instabilities, so that in elastic-walled Hele-Shaw cells that are bounded by sufficiently thin and elastic sheets, the (fluid-based) viscous fingering instability can arise concurrently with a (solid-based) wrinkling instability. We study the interaction between these distinct instabilities, using a theoretical model that couples the depth-averaged lubrication equations for the fluid flow to the Föppl-von Kármán equations, which describe the deformation of the thin elastic sheet.

RANDALL J. LEVEQUE

University of Washington, Seattle

Numerical Methods for Tsunami Modeling and Hazard Assessment

Many geophysical flows over topography can be modeled by two-dimensional depth-averaged fluid dynamics equations. The shallow water equations are the simplest example of this type, and are often sufficiently accurate for simulating tsunamis and other large-scale flows such as storm surge. These hyperbolic partial differential equations can be modeled using high-resolution finite volume methods. However, several features of these flows lead to new algorithmic challenges, e.g. the need for well-balanced methods to capture small perturbations to the ocean at rest, the desire to model inundation and flooding, and that vastly differing spatial scales that must often be modeled, making adaptive mesh refinement essential. I will discuss some of the algorithms implemented in the open source software GeoClaw that is aimed at solving real-world geophysical flow problems over topography. I will also discuss several applications of tsunami modeling -- real-time warning and probabilistic hazard assessment in addition to scientific studies of past earthquakes

XIAO-LI MENG

Harvard University

Is it a Computing Algorithm or a Statistical Procedure: Can You Tell or Do You Care?

For years, it irritated me whenever someone called the EM algorithm an ``estimation'''' procedure. I'd argue passionately that EM merely is an algorithm designed to compute a maximum likelihood estimator (MLE), which can be computed by many other methods. Therefore the estimation principle/procedure is MLE, not EM, and it is dangerous to mix the two, for example by introducing modifications to EM steps without understanding how they would alter MLE as a statistical procedure. The reality, however, is that the line between computing algorithms and statistical procedures is becoming increasingly blurred. As a matter of the fact, practitioners are now typically given a black box, which turns data into an ""answer"". Is such a black box a computing algorithm or a statistical procedure? Does it matter that we know which is which? Should I continue to be irritated by the mixing of the two? This talk reports my contemplations of these questions that originated in my taking part in a team that investigated the self-consistency principle introduced by Efron (1967). We will start with a simple regression problem to illustrate a self-consistency method that apparently can accomplish something that seems impossible at first sight, and the audience will be invited to contemplate whether it is a magical computing algorithm or a powerful statistical procedure. We will then discuss how such contemplations have played critical roles in developing the self-consistency principle into a full bloom generalization of EM for semi/non-parametric estimation with incomplete data and under an arbitrary loss function, capable of addressing wavelets de-noising with irregularly spaced data as well as variable selection via LASSO-type of methods with incomplete data. Throughout the talk, the audience will also be invited to contemplate a widely open problem: how to formulate in general the trade-off between statistical efficiency and computational efficiency?

This talk is based on joint work with Thomas Lee and Zhan Li.

JEAN-LUC THIFFEAULT

University of Wisconsin

Particle Fluctuations Induced by Microswimmers

The experiments of Leptos et al. show that the displacements of small particles affected by swimming microorganisms achieve a non-Gaussian distribution, which nevertheless scales diffusively --- the 'diffusive scaling.' We use a simple model where the particles undergo repeated `kicks' due to the swimmers to explain the shape of the distribution as a function of the volume fraction of swimmers. The net displacement is determined by the inverse Fourier transform of a single-swimmer characteristic function. The only adjustable parameter is the strength of the stresslet term in our spherical squirmer model. We give a criterion for convergence to a Gaussian distribution in terms of moments of the drift function, and show that the experimentally-observed diffusive scaling is a transient related to the slow crossover of the fourth moment from a ballistic to a linear regime with path length.

ELDAR AKHMETGALIYEV

California Institute of Technology

Integral Equation Methods for Laplace Eigenvalue Problems

In this talk we present a range of numerical methods which, based on use of Green functions and integral equations, can be applied to produce solution of Laplace eignvalue problems with arbitrary boundary conditions (including, e.g., Dirichlet/Neumann mixed boundary conditions) and in arbitrary domains (including e.g. do- mains with corners). As part of our presentation we present newly obtained characterizations of the singularities of solutions and eigenfunctions which arise at transition points where Dirichlet and Neumann boundary condi- tions meet; the numerical methods mentioned above rely on use of these characterizations in conjunction with the novel Fourier Continuation technique to produce solutions with a high order of accuracy. In particular, the resulting method exhibits spectral convergence for smooth domains (in spite of the solution singularities at Dirich- let/Neumann junctions) and prescribed high-order convergence for non-smooth domains. A point of interest concerns the search algorithm in our eigensolver, which proceeds by searching for fre- quencies for which the integral equations of the problem admit non-trivial kernels. As it happens, the "minimum- singular-value" objective function gives rise to a challenging nonlinear optimization problem. To tackle this dif-ficulty we put forth an improved objective functional which can be optimized by means of standard root-finding methods.

The methods above were also applied to modal analysis problems in electromagnetics: our calculation of TE and TM modes (eigenfunctions) of the cross sections of specifically designed quadruple-ridged flare horn microwave (astrophysical) antenna have been applied to the problem of optimization of the antenna parameters. The resulting eigensolutions are produced with such high accuracy that it becomes possible to track the eigen- value/eigenfunction evolution with shape changes even as eigenvalues cross—a capability that is necessary for the antenna-design application, and which existing commercial software packages were not able to deliver. Other applications will also be mentioned, including methods for evaluation of transmission eigenvalues that arise in the field of inverse problems and computation of Laplace eigenfunctions as a basis for spectral decomposi- tion of functions in the space of square integrable functions—with application to, e.g., highly accurate separation- of-variables solution of time-dependent problems (including diffusion and wave-propagation) in arbitrary, possibly singular spatial domains and with possibly mixed boundary conditions.

Certain aspects of this work have benefited from collaborations with various colleagues, including Ahmed Akgiray, Nilima Nigam and Carlos Perez-Arancibia.

DANIEL ANDERSON

George Mason University

Tear Film Models with Evaporation and a Contact Lens

The human tear film is a complex bio-fluid system. A stable tear film whose thickness is on the order of microns is established after each blink in a healthy eye. A contact lens separates the tear film into a pre-lens tear film (PrLTF), the fluid layer between the CL and the outside environment, and a post-lens tear film (PoLTF), the fluid layer between the CL and the cornea. A modern contact lens is permeable and allows fluid transfer between the PrLTF and the PoLTF. Evaporation of the tear film thins the pre-lens tear film and consequently may also lead to depletion of the PoLTF. We discuss mathematical models, expressed in terms of ordinary and partial differential equations, of the pre-lens tear film, the contact lens and the post-lens tear film. Solutions methods and predictions of these models will be discussed.

AREZOO ARDEKANI

Purdue University

Near-wall Motion of Microorganisms in Viscoelastic Fluids

Near-surface motion of microorganisms, such as bacteria, algae and spermatozoa, is ubiquitous and has important significance in biofilm formation, biofouling and fertilization. Even though, most biological materials, like biofilm, mucus layer and tissue, are characterized as complex fluids, the effects of viscoelasticity and shear-thinning behavior of the surrounding fluid on the near-surface accumulation of microorganisms are poorly understood. We investigate bio-locomotion of a Squirmer and an undulatory flagellum in a Giesekus fluid using fully resolved, direct numerical simulations. We found that viscoelasticity effects can enhance the wall attraction of swimmers, depending on the swimmers' type. Enhanced swimming performance, in terms of increased swimming speed and efficiency, can also be achieved near a wall in a shear-thinning viscoelastic fluid.

PAULO ARRATIA

University of Pennsylvania

Pulling & Pushing in Complex Fluids

Many microorganisms evolve in media that contain (bio)-polymers and/or solids; examples include cervical mucus, intestinal fluid, wet soil, and tissues. These so-called complex fluids often exhibit non-Newtonian rheological behavior such as shear-thinning viscosity and elasticity. In this talk, I will discuss recent experiments on the effects of fluid elasticity on the swimming behavior of microorganisms. Two main microorganisms are used, the green algae C. reinhardtii (a puller-type swimmer) and the bacterium E. coli (a pusher-type swimmer). For the case of pullers (C. reinhardtii), we find that fluid elasticity hinders the cell's overall swimming speed but leads to an increase in the cell's flagellum beating frequency. The beating kinematics and flagellum waveforms are also significantly modified by fluid elasticity. For the case of pushers (E. coli), the presence of even small amount of polymers in the medium suppresses the bacteria run-and-tumble mechanism. The bacteria spend more time in ballistic mode and swim faster as well. Single molecule experiments using fluorescently labeled DNA show that the flow fields generated by E. coli are able to stretch initially coiled polymer molecules and thus induce elastic stresses in fluid. These results demonstrate the intimate link between swimming kinematics and fluid rheology and that one can control the spreading and motility of microorganisms by tuning fluid properties.

DIEGO AYALA

University of Michigan

Extreme Vortex States and Growth of Enstrophy

We analyze a family of extreme vortex states which maximize the instantaneous production of enstrophy under Navier-Stokes dynamics on 3D periodic domains. They are found by numerically solving suitably constrained optimization problems and include other well-known flows, such as the Taylor-Green vortex and the ABC flow, as special cases. Initially discovered by Lu \& Doering (2008), these vortex states saturate an analytic upper bound on the rate of growth of enstrophy, indicating that this estimate is in fact sharp. We provide a numerical characterization of the set of initial data for which smooth solutions are guaranteed to exist for all times, thereby offering a physical interpretation of a well-known result of mathematical analysis. The results from high-resolution direct numerical simulations indicate that the flows triggered by these optimal fields produce a larger finite-time growth of enstrophy than the flows obtained from other widely-used initial conditions, such as the Taylor-Green vortex, Lamb dipoles and perturbed anti-parallel vortex tubes. Although numerical in nature, these results illustrate a systematic approach to finding a worst-case initial condition which could lead to the potential formation of a singularity in finite-time.

PROSENJIT BAGCHI

Rutgers University

Computational Modeling of Red Blood Cells: From Single Cell Mechanics to Microvascular Stenosis

This talk will present some recent findings in red blood cell dynamics as revealed in a 3D multiscale computational model of fully deformable cells. In the first part of the talk, we present the first computational evidence of the chaotic dynamics of isolated red blood cells subjected to steady and oscillatory shear flows; the evidence of chaos is obtained via deterministic simulations of fully deformable cells without the introduction of any stochastic noise. We then consider semi-dense suspension of cells in shear flow, and study the transport, margination and adhesion of platelets and other nonspherical microparticles. We show that particle diffusion is anisotropic and it leads to a cluster formation near the wall which, in case of platelets, could act as a hydrodynamic precursor to blood clot formation. The role of particles' shape on their transport through the cell suspension and adhesion to the wall is quantified. We then consider the flow of red blood cells through a microvascular stenosis, and show that the flow physics and its physiological consequences are significantly different from what is known in case of a macrovascular stenosis.

CHRISTOPHER BATTY

University of Waterloo

Multimaterial Front Tracking for Soap Bubbles and Multiphase Flow

Front tracking is a classic method to simulate the evolution of material interfaces through the use of a deforming triangle mesh representation. I will discuss some recent work in which we extend this technique to the case of more than two distinct materials. This necessitates the development of new remeshing operations to robustly support elaborate topological changes that arise in applications such as foams, soap bubbles, and multiphase flows, while preserving watertight, collision-free geometry.

RABI BHATTACHARYA

University of Arizona

Statistical Analysis of Non-Euclidean Data: Examples and Applications

How does one analyze data valued in a non-Euclidean space M? For parametric inference one may create a parametric model for the distribution Q of the data : f(x; ⊠), x ⊠ M, ⊠⊠⊠, obtain the MLE of ⊠, or construct a two-sample likelihood ratio test for H0: ⊠⊠= ⊠⊠. It is a difficult, or even impossible, task to find the correct parametric model on such spaces M. We therefore consider a non-parametric methodology. On a metric space M, define the Fre̕chet mean ⊠ of Q as the minimizer of the expected squared distance Er2(p, X) from a point p, where X has distribution Q. One may then distinguish different distributions by their Fre̕chet means. When the distance is chosen appropriately, this methodology works well. We provide a number of examples and applications when the non-Euclidean data is manifold-valued, and contrast the results wherever possible with inference arrived at earlier by parametric methods.

Applications are provided to paleomagnetism, to the detection of certain diseases from the deformation of certain organs, to the classification of subjects based on shapes, etc.

One may think of the subject matter of the talk as part of a rather new nonparametric way of looking at a class of problems in image analysis.

HOWARD BONDELL

North Carolina State University

Efficient Robust Estimation via Two-Stage Generalized Empirical Likelihood

The triumvirate of outlier resistance, distributional robustness, and efficiency in both small and large samples, constitute the Holy Grail of robust statistics. We show that a two-stage procedure based on an initial robust estimate of scale followed by an application of generalized empirical likelihood comes very close to attaining that goal. The resulting estimators are able to attain full asymptotic efficiency at the Normal distribution, while simulations point to the ability to maintain this efficiency down to small sample sizes. Additionally, the estimators are shown to have the maximum attainable finite-sample replacement breakdown point, and thus remain stable in the presence of heavy-tailed distributions and outliers. Although previous proposals with full asymptotic efficiency exist in the literature, their finite sample efficiency can often be low. The method is discussed in detail for linear regression, but can be naturally extended to other areas, such as multivariate estimation of location and covariance.

RICHARD BRAUN

University of Delaware

Mathematical Models for Tear Film Dynamics

The tear film is the liquid layer that is formed on the front of the eye after each blink. The tear film consists of aqueous and lipid layers, with the lipid layer between the aqueous layer and the surrounding environment. The tear film is only a few microns thick extending over centimeter-sized eye openings, and it is part of a very sensitive system; direct measurements can be difficult. We survey several mathematical models and imaging methods and closely compare the results. The mathematical models, based on lubrication theory, help explain why some experimental methods give different results for the tear film thickness, and help pinpoint relevant effects driving healthy and unhealthy dynamics. We also discuss situations where the math models are ahead of experimental methods; an example is the distribution of salts inside the aqueous layer of the tear film. Limitations of the models will be discussed as well.

MORTEN BRONS

Technical University of Denmark

On Conservation of Vorticity and Generation of Vortices

Vorticity is a key quantity in fluid dynamics. It is well known that vorticity cannot be generated in the interior of an incompressible fluid, but only at the boundaries, from where it may diffuse into the fluid. Nevertheless, it is possible to formulate a theorem on the conservation of vorticity which takes the sources at the boundaries into account. I will show how this can give a simple explanation of some surprising phenomena in vorticity dynamics.

Once inside the fluid, the vorticity may distribute itself into vortices. I will show how bifurcation theory can be used to describe the formation and interaction of vortices in wakes and boundary layer separation.

MARKO BUDISIC

University of Wisconsin, Madison

Finite-Time Braiding Exponents

Kinematics of fluid flows are often studied through using flow velocity fields. If the flow can be measured only sparsely, e.g., in oceanography, by floating sensors, its velocity field cannot be accessed. In those situations, groups of Lagrangian trajectories can be represented by braids, symbolic models capturing only topological information, i.e., relative positions of trajectories. We introduce the Finite-Time Braiding Exponent (FTBE), which quantifies the amount of complexity of the braid sampled over a finite time interval. Numerical results suggest that FTBE approaches topological entropy as flow is sampled more accurately, i.e., by increasing length and density of sampled trajectories. Additionally, we discuss theoretical results supporting convergence of FTBE for mixing flows.

UMMUGUL BULUT

Grand Valley State University

Derivation of Stochastic Biased and Correlated Random Walk Models

In biased and correlated random walk (BCRW) models, the transport is characterized by correlated successive step orientations with a local directional bias as well as a consistent bias in the globally preferred direction. These models are useful, for example, in animal movement studies. Deterministic BCWR models may be used to estimate mean animal densities. In the present investigation, stochastic versions of BCRW models are derived for one, two, and three dimensions which have the form of stochastic partial differential equations (SPDEs). Discrete time stochastic models are first developed by determining the possible changes in direction for a small time interval. As the time interval decreases, the discrete stochastic models lead to systems of Ito stochastic differential equations. As the position intervals decrease, stochastic partial differential equations are derived to model BCRW in one, two, and three dimensions. Comparisons between numerical solutions of the stochastic partial differential equations and independently formulated Monte Carlo calculations support the accuracy of the derivations.

MATTHEW CAUSLEY

Kettering University

Higher Order Methods for PDE's Using Successive Convolution Algorithms

PDE's are often solved using the method of lines (MOL), wherein a spatial discretization is chosen, and the quantities of interest are updated using time integration. Using the method of lines transpose (MOL^T), time discretization is first performed, and all spatial quantities are solved at a fixed time to perform the update, usually with boundary integral methods.

A recent method, successive convolution, combines a fast O(N) boundary solver with higher order Taylor expansions, to achieve new high order schemes for solving PDEs. The novelty is that higher order partial derivatives are approximated with stable convolution integrals.

Examples include hyperbolic and parabolic problems, on smooth geometries.

ALOKNATH CHAKRABARTI

Indian Institute of Science

Integral Equation Methods in Water Wave Problems

Integral Equation methods to solve boundary value problems of mathematical physics with special reference to water wave problems will be presented and the questions of uniqueness of solutions will be examined. Certain specific water wave scattering problems will be taken up as illustrative examples.

YU CHENG

University of Pittsburgh

Association Analysis of Successive Events Data in the Presence of Competing Risks

We aim to close a methodological gap in analyzing durations of successive events that are subject to induced dependent censoring as well as competing-risk censoring. In the Bipolar Disorder Center for Pennsylvanians (BDCP) study, some patients who managed to recover from their symptomatic entry later developed a new depressive or manic episode. It is of great clinical interest to quantify the association between time to recovery and time to recurrence in patients with bipolar disorder. The estimation of the bivariate distribution of the gap times with independent censoring has been well studied. However, the existing methods cannot be applied to failure times that are censored by competing causes such as in the BDCP study. Bivariate cumulative incidence function (CIF) has been used to describe the joint distribution of parallel event times that involve multiple causes. To the best of our knowledge, however, there is no method available for successive events with competing-risk censoring. Therefore, we extend the bivariate CIF to successive events data, and propose nonparametric estimators of the bivariate CIF and the related conditional CIF. Moreover, an odds ratio measure is proposed to describe the cause-specific dependence, leading to the development of a formal test for independence of successive events. Simulation studies demonstrate that the estimators and tests perform well for realistic sample sizes, and our methods can be readily applied to the BDCP study.

MARION DARBAS

Université de Picardie Jules Verne

Analytical Preconditioners for the Solution of Three-dimensional Surface Scattering Problems

The numerical solution of time-harmonic scattering problems remains challenging in the high frequency regime due to its specific computational bottlenecks. The techniques based on integral equations lead to the resolution of linear systems where the involved matrices are dense and usually badly conditioned. Several studies have been managed for years and years to overcome these disadvantages. Two main directions focus on the application of iterative solutions, usually Krylov solvers: Preconditioning techniques to speed up the convergence of the solver and fast methods for the computation of matrix-vector products. We propose an analytical preconditioner taking inspiration of On-Surface Radiation Condition techniques. This preconditioner is an accurate approximation to the Dirichlet-to-Neumann map. The associated integral equations are of the second kind. Moreover, the proposed preconditioner shows highly desirable advantages: sparse structure, ease of implementation and low additional computational cost.

In this talk, we present first the principle of the method in the acoustic case. We show numerical simulations for various configurations. Next, we explain how to extend the approach to other types of waves, namely elastic waves.

OLIVIER DESJARDINS

Cornell University

Conservative and Accurate Geometric Transport Methods for Discontinuous Variables in Turbulent Multi-physics Two-phase Flows

Simulating multiphase flows presents significant challenges: flow variables exhibit discontinuities across the phase interface, complex microscale dynamics arise due to surface tension, and the interface develops highly complex corrugations. Fluid turbulence and multi-physics processes such as electro-hydrodynamics exacerbate these difficulties. We will discuss recently advanced geometric techniques capable of addressing these challenges conservatively and with second order accuracy. Applications ranging from interface-turbulence interaction in homogeneous flows to electro-hydrodynamic fuel atomization will be presented.

YIXIN FANG

New York University

Tuning Parameter Selection in Regularized Estimations of Large Covariance Matrices

Recently many regularized estimators of large covariance matrices have been proposed, and the tuning parameters in these estimators are usually selected via cross-validation. However, there is no guideline on the number of folds for conducting cross-validation and there is no comparison between cross-validation and the methods based on bootstrap. Through extensive simulations, we suggest 10-fold cross-validation (nine-tenths for training and one-tenth for validation) be appropriate when the estimation accuracy is measured in the Frobenius norm, while 2-fold cross-validation (half for training and half for validation) or reverse 3-fold cross-validation (one-third for training and two-thirds for validation) be appropriate in the operator norm. We also suggest the ""optimal"" cross-validation be more appropriate than the methods based on bootstrap for both types of norm.

BRITTANY FROESE

University of Texas at Austin

Fast Sweeping Methods for Hyperbolic Systems of Conservation Laws

Fast sweeping methods have become a useful tool for computing the solutions of static Hamilton-Jacobi equations. By adapting the main idea behind these methods, we describe a new approach for computing steady state solutions to systems of conservation laws. Because they exploit the flow of information along characteristics, these fast sweeping methods can compute solutions very efficiently. Furthermore, the methods capture shocks sharply by directly imposing the Rankine-Hugoniot shock conditions. We present numerics for several examples to illustrate the use and advantages of this approach.

SOUVIK GHOSH

LinkedIn

Bid Suggestions for Online Ad Auction at LinkedIn

Online advertising at LinkedIn is based on an auction mechanism. An advertiser sets up ad campaigns and can target various segments of members based on their LinkedIn profile. For any opportunity of an ad impression an auction is used to choose the ad among the competing campaigns. To take part in the auctions the advertiser must also specify a bid value while setting up a campaign. Providing information about the bid landscapes to the advertiser specific to the target segment at the time of campaign setup is important as that helps the advertiser understand how much to bid. This is also a very challenging problem because the target segments can be arbitrary and are not known a priori. We describe how we solved this problem and the benefits we derived from this.

DIMITRIOS GIANNAKIS

Courant Institute of Mathematical Sciences, New York University

Data-driven Methods for Nonparametric Forecasting of Dynamical Systems

We discuss two data-driven techniques for nonparametric forecasting of dynamical systems. In the first approach (which can be viewed as a generalization of Lorenz's method of analogs), local kernels on manifolds are used to generate weighted ensemble forecasts from historical training data. The second approach uses the shift map of time series to approximate the solution semigroup of stochastic differential equations on manifolds in a smooth basis acquired through the diffusion maps algorithm. We present applications in atmosphere ocean science.

KEN GOLDEN

University of Utah

Sea Ice, Climate, and Multiscale Composites

The precipitous loss of Arctic sea ice has far outpaced expert predictions. In this lecture we will explore the mathematical underpinnings of this mystery, and show how we are using the mathematics of multiscale composites and statistical physics to study key sea ice processes. Our models are developed in close conjunction with measurements of sea ice properties that we have made during recent polar expeditions. This research is helping to represent sea ice more rigorously in climate models and improve projections of the fate of Earth's ice packs.

WILLIAM HENSHAW

Rensselaer Polytechnic Institute

Over-coming the Fluid-structure Added-mass Instability for Incompressible Flows

The added-mass instability has, for decades, plagued partitioned fluid-structure interaction (FSI) simulations of incompressible flows coupled to light solids and structures. Many current approaches require tens or hundreds of expensive sub-iterations per time-step. In this talk two new stable partitioned algorithms for coupling incompressible flows with both compressible elastic bulk solids and thin structural shells are described. These added-mass partitioned (AMP) schemes require no sub-iterations, can be made fully second- or higher-order accurate, and remain stable even in the presence of strong added-mass effects. Extensions of the schemes to treat large solid motions using deforming overlapping grids and the Overture framework will also be described.

IAN HEWITT

University of Oxford

Glacial Stream Formation

The flow of a fluid over its solid phase leads to heating driven by viscous dissipation. Such heating causes melting of the solid surface, and can lead to an instability of a uniform flow that eventually results in stream formation. In this context, I discuss a linear stability problem for a free stream flowing over a glacier surface, and explore the processes that control the preferred wavelengths leading to channel growth. There is much in common with other erosive flows, in particular the formation of rills on a hillslope.

I go on to examine the formation of sub-glacial streams, which emerge from a similar instability of a uniform thin-film flow between ice and underlying bedrock. Such streams are not open to the air, which gives the problem a slightly different character. Starting with the linear stability problem, I move on to examine the nonlinear evolution of subglacial streams, and finally discuss computational efforts to understand the formation and dynamics of stream networks.

NGUYENHO HO

Worcester Polytechnic Institute

Rods with Bend and Twist in a Brinkman Fluid

We develop a Lagrangian algorithm to model an elastic rod in a porous medium. The 3-D fluid is governed by the incompressible Brinkman equation and the Kirchhoff rod model captures bend and twist of the rod. Regularized solutions are derived and we compare numerical results to asymptotics for swimming speeds in a Brinkman fluid.

MARK HOEFER

University of Colorado, Boulder

Dispersive Hydrodynamics of Viscous Fluid Conduit Interfacial Waves

Hyperbolic equations regularized by dispersion can give rise to coherent structures including solitary waves and dispersive shock waves. More recently, incoherent collections of these structures have been studied as a soliton gas. In this talk, nonlinear dispersive wave excitations at the interface between two Stokes fluids are shown to exhibit dispersive hydrodynamic features. Solitons, dispersive shock waves, and their interactions are examined theoretically in the context of a long wavelength asymptotic reduction of the Stokes dynamics. Additionally, the latest experiments involving viscous fluid conduits from CU Boulder's Dispersive Hydrodynamics Laboratory will be presented and compared with the theoretical investigations.

YIJIAN (EUGENE) HUANG

Emory University, Rollins School of Public Health

Quantile Regression with Randomly Censored Data

Quantile regression has been advocated in survival analysis to assess evolving covariate effects. The model naturally extends the accelerated failure time (AFT) model to allow for varying coefficients. I will review a censored quantile regression procedure developed on the basis of quantile calculus and estimating integral equation. The method is accompanied with a numerically reliable and efficient algorithm for the computation. The procedure reduces exactly to the inverse of the Kaplan-Meier estimator in the k-sample problem, and to standard uncensored quantile regression in the absence of censoring. New developments will be discussed on issues concerning model identifiability and quantile crossing. Illustration with a clinical study will be provided.

HOWARD KARLOFF

Yahoo! Labs

Variable Selection is Hard

Consider the task of a machine-learning system faced with voluminous data on m individuals. While there may be p=10^6 features describing each individual, how can the algorithm find a small set of features that ""best"" describes the individuals? People usually seek small feature sets both because models with small feature sets are understandable and because simple models usually generalize better.

We study the simple case of linear regression, in which a user has an m x p matrix B and a vector y, and seeks a p-vector x *with as few nonzeroes as possible* such that Bx is approximately equal to y, and we call it SPARSE REGRESSION. There are numerous algorithms in the statistical literature for SPARSE REGRESSION, such as Forward Selection, Backward Elimination, LASSO, and Ridge Regression.

We give a general hardness proof that (subject to a complexity assumption) no polynomial-time algorithm can give good performance (in the worst case) for SPARSE REGRESSION, even if it is allowed to include more variables than necessary, and even if it need only find an x such that Bx is relatively far from y.

This is joint work with Justin Thaler of Yahoo Labs and Dean Foster.

CHRISTIAAN KETELAAR

University of Delaware

Stability of electrolyte films on solid and structured surfaces

We investigate the stability of a thin liquid film on a structured substrate with a periodic array of gas-filled grooves. We derive a nonlinear evolution equation for film thickness by taking into account the effects of structuring into our system of lubrication-type equations. We analyze how the length of the groove, the slip length at the no-shear segments, and the electric charges at each of the interfaces affect the stability of an electrolyte film.

We perform nonlinear simulations for the evolution of the film thickness and compare these results with the solid substrate case.

SHILPA KHATRI

University of California, Merced

Modeling of Pulsating Soft Coral

Coral reefs are of significant interest to conservationists because of their remarkable biological diversity. Soft coral of the family Xeniidae have been shown to compete successfully in regions with depleting coral reefs. Xeniidae have a pulsating motion, a behavior not observed in many other sessile organisms. We are studying how this behavior may give these coral a competitive advantage. These pulsations consume a large amount of energy, and determining the benefits of this behavior is vital to understanding the evolution of such animals. We will present direct numerical simulations of the pulsations of the coral and the resulting fluid flow by solving the Navier-Stokes equations coupled with the immersed boundary method incorporating kinematic data. Comparisons with experimental and field data will also be discussed.

LUDVIG KLINTEBERG

KTH, Royal Institute of Technology

A Fast and Accurate Integral Equation Method for Particles in Viscous Flow Using QBX

The flow around rigid particles sedimenting in a viscous fluid can be described using the Stokes equations. Solving these equations using a double-layer boundary integral formulation gives a well-conditioned problem which can be solved to high accuracy, provided that a suitable quadrature method is used for computing the singular and nearly singular integrals arising in the formulation. We present the development of such a method, specifically adapted for the case where the particles are rigid spheroids. The method is based on the quadrature by expansion (QBX) method (Klöckner et al., J. Comput. Phys., 2013), which uses surrogate local expansions of the layer potential to evaluate it to very high accuracy both on and off the particle surfaces.

We combine our new quadrature method with an existing boundary integral method for periodic particle suspensions, which uses FFT-based fast Ewald summation for computing triply-periodic layer potentials in O(N log N) time (af Klinteberg & Tornberg, Int. J. Numer. Methods. Fluids, 2014). The result is a fast method for computing the flow of periodic particle suspensions to very high accuracy.

ALEXANDER KOSOVICHEV

New Jersey Institute of Technology

Observation and Numerical Simulations of MHD Convection in the Sun

Turbulent convection driven by heat flux from the energy-generating core is a source of strong magnetic fields that emerge on the solar surface and trigger flares and plasma eruptions, causing radiation and electromagnetic storms in the Earth's space environment. The magnetic fields are generated by a non-linear hydromagnetic dynamo process which involves a huge range of turbulent scales. Describing these in mathematical models and numerical simulations is a very challenging task. The current research is focused on developing mathematical models based on separation of turbulent scales by applying various averaging techniques and sub-grid scale turbulence closure models. In particular, 3D MHD simulations based on Large-Eddy Simulation (LES) models have successfully reproduced the local dynamo process in the near-surface turbulent layer responsible for the "magnetic carpet" observed on the solar surface. On the global scale, the LES and mean-field theory approaches have revealed the primary of helical turbulence organized by rotation role in the magnetic field generation, and, in fact, can explain basic features of the solar magnetic cycles. However, the gap in understanding of non-linear coupling between the small- and large-scale MHD turbulence in the highly stratified rotating plasma impedes progress in developing predictive models of solar activity.

GAOJIN LI

University of Notre Dame

Dynamics of Particle Migration in a Channel Flow of Viscoelastic Fluids

Understanding the dynamics of particle transport in flowing fluids is important in problems related with many industrial, environmental and biological applications. Migration of particles across the streamlines due to inertial or/and viscoelastic effects has been studied and is applied in particle manipulation and to enhance fluid mixing. Most of previous studies are limited to low Reynolds number flows and some of the mechanisms still remain unclear. In this work, we numerically studied the migration of a sphere in a pressure-driven channel flow due to viscoelastic effects. The effects of inertia, elasticity, shear-thinning, secondary flows induced by the second normal stress difference, and the block ratio are considered by conducting simulations in a large range of parameters: the Reynolds number Re≈3~300, the Weiseenberg number Wi=0~2, and the Elasticity number El=0~0.2, pure viscoelasticity and shear-thinning effects are both considered. We found that at relative low El and Re, both inertial effects and viscoelastic effects are important, and the final position of the particle varies between the channel centerline and the wall. At higher El and Re, the particle moves to the centerline because the viscoelastic lift dominates the inertial lift. In flows of relative large Reynolds number, a scaling analysis of the two forces balancing predicts the critical elasticity number and Weissenberg number for particle focusing. The shear-thinning effect and the corresponding secondary flow tend to move the particle closer to the wall, and their effects become more pronounced with stronger inertia and elasticity. We also found the particle has a large transient migration velocity at the start-up of channel flow because of the wall induced polymer stress.

XIAOLIN LI

SUNY at Stony Brook

Simulation of Parachute FSI Using the Front Tracking Method

We use the front tracking method on a spring system to model the dynamic evolution of parachute canopy and risers. The canopy surface and the riser string chord of a parachute are represented by a triangulated surface mesh with preset equilibrium length on each side of the simplices. The stretching and wrinkling of the canopy and its supporting string chords (risers) are modeled by the spring system. This mechanical structure is coupled with the incompressible Navier-Stokes solver through the ``Impulse Method''. We analyzed the numerical stability of the spring system and used this computational module to simulate the flow pattern around a static parachute canopy and the dynamic evolution during the parachute inflation process. The numerical solutions have been compared with the available experimental data and there are good agreements.

LONGFEI LI

Rensselaer Polytechnic Institute

Overcoming the Added Mass Instability for Coupling Incompressible Flows and Elastic Beams

A new partitioned algorithm for coupling incompressible flows with elastic beams is described that overcomes the added-mass instability for light solids. The algorithm requires no sub-iterations and is fully second-order accurate. The new scheme is shown to be stable, even for very light beams, through the analysis of a model problem. The approach is then applied to the simulation of FSI problems involving beams undergoing large deformations using deforming composite grids.

DUAN LIAN

New Jersey Institute of Technology

Understanding Big Data through Correlation Analysis

Over the past decades, with the development of automatic identification, data capture, and storage technologies, people generate data much faster and collect data much bigger than ever before in science, engineering, education, and other areas. Big data has emerged as an important area of study for both practitioners and researchers. There are many different types of useful information hidden in big data that require different methods to find them, and correlation analysis is one important method. As nothing can be isolated in nature, correlation exists anywhere, anytime, in any format. Better understanding of correlation helps us in healthcare, education, and other areas. In this talk, we will try to raise your awareness of how important correlation is and how to find it for useful insights.

BIN LIU

University of California, Merced

Swimming with Wobbling Bodies: The Effect of Cell Body on Motility of Flagellated Bacteria

The cell body of a flagellated bacterium is often regarded as a passive cargo when describing the cell motility. To study the role of the cell body in bacterial swimming, we have developed a tracking technique with which we can resolve both the 3-d trajectory and the orientation of individual cells over extended times. We have used this technique to study the motility of the uni-flagellated bacterium Caulobacter cresentus and have found that each cell displays two distinct modes of motility, depending on the rotation direction of the flagellar motor. In the "forward" mode with the flagellum pushes the cell, the cell body is tilted and precesses with respect to the direction of swimming, which traces a helical phase. In the "reverse" mode, the flagellum pulls the cell. In this mode, the precession is much smaller and the cell motility significantly lower. We show that the helical motion of the cell body facilitates the bacteria to swim with lower power consumption, and can explain the direction-dependent changes in swimming motility.

STEFAN LLEWELLYN SMITH

University of California, San Diego

Hollow Vortices

Hollow vortices are vortices whose interior is at rest or alternatively steady vortex sheets. They can be viewed as a desingularization of point vortices. We obtain exact solutions for hollow vortices in linear and nonlinear strain and also examine the properties of propagating hollow vortex dipoles (Pocklington's vortex) and rows and streets of hollow vortices. We discuss extensions to Sadovskii vortices, which have non-zero vorticity in their interior.

ENKELEIDA LUSHI

Brown University

Self-organization of Confined Bacterial Suspensions

Suspensions of swimming microbes are known to display intricate, self-organized spatiotemporal patterns on scales larger than those of the individual motile units. The collective dynamics of swimming microorganisms exhibits a complex interplay with the surrounding fluid: the motile cells stir the fluid, which in turn can reorient and advect them. We show using fast simulations that the dynamics and macroscopic patterns observed in experiments results from a combination of hydrodynamic and steric interactions between the cells and the confining boundaries. The predictions of the simulations are confirmed using new experiments.

SHUANGGE (STEVEN) MA

Yale University

Promoting Similarity of Sparsity Structures in Integrative Analysis

For data with high-dimensional covariates but small to moderate sample sizes, the analysis of single datasets often generates unsatisfactory results. The integrative analysis of multiple independent datasets provides an effective way of pooling information and outperforms single-dataset analysis and some alternative multi-datasets approaches including meta-analysis. Under certain scenarios, multiple datasets are expected to share common important covariates, that is, their models have similarity in sparsity structures. However, the existing methods do not have a mechanism to promote the similarity of sparsity structures in integrative analysis. In this study, we consider penalized variable selection and estimation in integrative analysis. We develop a penalization based approach, which is the first to explicitly promote the similarity of sparsity structures. Computationally it is realized using a coordinate descent algorithm. Theoretically it has the much desired consistency properties. In simulation, it significantly outperforms the competing alternative when the models in multiple datasets share common important covariates. It has better or similar performance as the alternative when there is no shared important covariate. Thus it provides a “safe” choice for data analysis. Applying the proposed method to three lung cancer datasets with gene expression measurements leads to models with significantly more similar sparsity structures and better prediction performance.

KARA MAKI

Rochester Institute of Technology

The Mechanics of a Contact Lens

Abstract "In this work, we aim to better understand how the design of contact lenses can be optimized for patient comfort and ocular fit. To do so, we present a new approach to computing the suction pressure under a soft contact lens. When a contact lens is placed on an eye, it is subjected to forces from both the tear film in which it is immersed and the blinking eyelid. In response, the lens bends and stretches. These forces center the lens, and they produce the suction pressure that keeps the lens on the cornea.

We couple fluid and solid mechanics to determine the most prominent forces acting on the lens. We find that the important mechanical property of the contact lens for producing suction pressure is stretching, i.e., elastic tension. We assume the contact lens must conform to the shape of the eye. This perspective allows us to derive a terse system of ordinary differential equations, through an energy argument, to determine the suction pressure under the contact lens. We first characterize the existence and uniqueness of the system. Next, we solve this system numerically for various eye shapes and contact lens shapes. The system of ordinary differential equations captures the basic physics, the elastic tension, needed to begin to understand a “working” contact lens. Thus, we can begin to create “rules of thumb” for contact lens design. "

KYLE MANDLI

Columbia University

Approaches to Forecasting Storm Surge More Quickly and Accurately

Hurricanes and typhoons can cause significant human and economic costs to coastal communities. The rise of the sea surface in response to wind and pressure forcing from these storms, called storm surge, can have a devastating effect on the coastline. Therefore, the ability to quickly and accurately predict storm surge location and characteristics has been recognized as being critical in these areas.

Computational approaches to this problem must be able to handle its multi-scale nature while remaining computationally tractable and physically relevant. This has commonly been accomplished by solving a depth-averaged set of fluid equations and by employing non-uniform and unstructured grids. These approaches, however, have often had shortcomings due to computational expense, the need for involved model tuning, and missing physics.

In this talk, I will outline some of the approaches we have developed to address several of these shortcomings through the use of advanced computational techniques. These include adaptive mesh refinement, higher levels of parallelism including many-core technologies, and more accurate model equations such as the multi-layer shallow water equations. Combining these new approaches promises to address some of the problems in current state-of-the-art models while continuing to decrease the computational overhead needed to calculate a forecast.

STEPHEN MORRIS

University of Toronto

Ripples on Icicles

Icicles are harmless and picturesque winter phenomena, familiar to anyone who lives in a cold climate. The shape of an icicle emerges from a subtle feedback between ice formation, which is controlled by the release of latent heat, and the flow of water over the evolving shape. The water flow, in turn, determines how the heat flows. The air around the icicle is also flowing, and all forms of heat transfer are active in the air. Many natural icicles exhibit a ripply shape, which is the result of a subtle morphological instability. The wavelength of the ripples is remarkably independent of the growing conditions. Similar ripple phenomena are also observed on stalactites, although certain details of their formation differ. We built a laboratory icicle growing machine and discovered the surprising origin of the ripples.

PETER MUELLER

University of Wisconsin, Madison

Fluid Transport by an Unsteady Microswimmer

We study the drift caused by the microscopic algae \emph{Chlamydomonas reinhardtii}, which swims by rapidly beating two frontal flagella. Previous studies of transport by microswimmers have neglected the ubiquitous time-dependence of their swimming. We model the organism by a time-dependent dumbbell consisting of a solid body and a regularized Stokeslet. We then analyze individual particle paths and their displacements in a region around the swimmer. Of particular interest are particles near the swimmer, which have complex trajectories due to the unsteady model. Particles directly in front of the swimmer contribute large, but rare, displacements. We use this to determine the tails of the distribution of particle displacements. Finally we gauge the importance of time-dependence on overall fluid transport and mixing.

JEAN-CHRISTOPHE NAVE

McGill University

Evolution of Curves, Surfaces, and Arbitrary Sets

In this talk I will present several numerical methods for the evolution of curves and surfaces. First, when the curve is evolved in the normal direction according to a given front velocity, I will propose a generalization of the Fast Marching Method (FMM), allowing for non-monotonous propagation. Second, when a co-dim 1 curve is evolved according to a velocity field in R^n, I will present the Gradient-Augmented Level Set Method (GALSM), and its extensions which enables the evolution of arbitrary sets. I will finish by presenting some applications of the above methods to problems in elasticity and to the 2D incompressible Euler equations.

ANAND OZA

Courant Institute of Mathematical Sciences, New York University

A Dynamical System for Interacting Flapping Swimmers

We present the results of a theoretical investigation into the dynamics of interacting flapping swimmers. Our study is motivated by the recent experiments of Becker et al.*, who studied a one-dimensional array of flapping wings that swim within each other's wakes in a water tank. They discovered that the system adopts certain "schooling modes" characterized by specific spatial phase relationships between swimmers. In addition, they observed multiple stable swimming speeds for identical experimental parameters, and substantial changes in swimming speed for small changes in flapping frequency.

To understand these phenomena, we develop a discrete dynamical system in which the swimmers are modeled as heaving airfoils that shed point vortices during each flapping cycle. The swimming speed is determined by the balance between the vorticity-induced thrust and skin friction drag. Our model reproduces many of the experimental observations, including the observed bistability of swimming speeds and the preference for certain schooling modes. We expect that our model may be used to understand how schooling behavior is influenced by hydrodynamics in more general contexts.

Joint work with Leif Ristroph and Michael J. Shelley.

*Becker, A., Masoud, H., Newbolt, J., Shelley, M. & Ristroph, L. "Hydrodynamic schooling of flapping swimmers" (submitted).

JÉRÉMIE PALACCI

New York University

Emergent Properties in Experiments with Synthetic Micro-swimmers

Self-propelled micro-particles are intrinsically out-of-equilibrium. This renders their physics far richer than passive colloids and give rise to the emergence of complex phenomena e.g. collective behavior, swarming... I will present a variety of non-equilibrium phenomena observed with experimental realization of synthetic micro swimmers: self-assembly, sensing of the environment, or effective interactions, in the absence of any potential.

LIMIN PENG

Emory University, Rollins School of Public Health

Generalizing Quantile Regression for Counting Processes with Applications to Recurrent Events

In survival analysis, quantile regression has become a useful approach to account for covariate effects on the distribution of an event time of interest. In this paper, we discuss how quantile regression can be extended to model counting processes, and thus lead to a broader regression framework for survival data. We specifically investigate the proposed modeling of counting processes for recurrent events data. We show that the new recurrent events model retains the desirable features of quantile regression such as easy interpretation and good model flexibility, while accommodating various observation schemes encountered in observational studies. We develop a general theoretical and inferential framework for the new counting process model, which unifies with an existing method for censored quantile regression. As another useful contribution of this work, we propose a sample-based covariance estimation procedure, which provides a useful complement to the prevailing bootstrapping approach. We demonstrate the utility of our proposals via simulation studies and an application to a dataset from the US Cystic Fibrosis Foundation Patient Registry (CFFPR).

ZHANGLI PENG

University of Notre Dame

Combining Dissipative Particle Dynamics, Finite Element Method and Boundary Element Method to Study Red Blood Cell Diseases

By combining particle-based and continuum-based methods, we investigate the biomechanics of red blood cells (RBCs) and related diseases, such as malaria, anemia and sickle cell disease, for a better understanding of the pathology and development of diagnostic tools. To overcome the computational challenge due to the multiscale feature of RBC mechanics, we apply different numerical methods for different length scales and different conditions. For instance, we applied dissipative particle dynamics (DPD) to simulate the RBC membrane fluctuations and the interaction between RBCs and endothelial cell slits. We applied boundary element method (BEM) to simulate the surrounding shear flow, finite element method (FEM) to simulate the membrane elasticity, Langevin dynamics (LD) to simulate the conformational change of protein complexes, and Monte-Carlo (MC) method to simulate the domain unfolding of individual proteins. By coupling these methods using multiscale modeling approaches, we made important progresses in both applications and fundamental understanding. For example, we discovered that it is easier for mature sexual malaria parasites to transmit than immature ones due to both the unique shape and reduced deformability of their host RBCs. This finding provides a possibility of identifying novel drug targets for malaria eradication. Another example is: we found that the donut-like resting shape of RBCs is due to a unique stress-free initial configuration of the cytoskeleton, which will guide future experiments to measure this stress-free configuration.

ZHEN PENG

University of New Mexico

Boundary Integral Equation Domain Decomposition Methods for Time-harmonic Maxwell Equations

This talk will discuss recent progress in boundary integral equation methods for complex multi-scale electromagnetic applications. The first topic is domain decomposition for boundary integral equations via multi-trace formulation. The entire computational domain is decomposed into a number of non-overlapping sub-regions. Each local sub-region is homogeneous with constant material properties and described by a closed surface. Through this decomposition, we have introduced at least two pairs of trace data as unknowns on interfaces between sub-regions. This multi-trace feature admits two major benefits: the localized boundary integral equation for the homogeneous sub-region problem is amenable to operator preconditioning; the resulting linear systems of equations readily lend themselves to optimized Schwarz methods. A discontinuous Galerkin boundary element method is considered for the finite dimensional discretization of sub-regions. The main objective of this work is to allow the implementation of the combined field integral equation using square-integrable trial and test functions without any considerations of continuity requirements across element boundaries. Due to the local characteristics of L2 vector functions, it is possible to employ non-conformal surface discretizations of the targets. Furthermore, it enables the possibility to mix different types of elements and employ different order of basis functions within the same discretization. Therefore, the proposed method is highly flexible to apply adaptation techniques.

ALEXANDER PETROFF

The Rockefeller University

Fast-Moving Bacteria Self-Organize into Active Two-Dimensional Crystals of Rotating Cells

We investigate a new form of collective dynamics displayed by Thiovulum majus, one of the fastest-swimming bacteria known. Cells spontaneously organize on a surface into a visually striking two-dimensional hexagonal lattice of rotating cells. As each constituent cell rotates its flagella, it creates a tornadolike flow that pulls neighboring cells towards and around it. As cells rotate against their neighbors, they exert forces on one another, causing the crystal to rotate and cells to reorganize. We show how these dynamics arise from hydrodynamic and steric interactions between cells. We derive the equations of motion for a crystal, show that this model explains several aspects of the observed dynamics, and discuss the stability of these active crystals.

THOMAS POWERS

Brown University

Mechanics of Swimming in Complex Fluids

Recent experiments with bacteria in liquid crystalline solutions have revealed that nematic order affects the swimming behavior of bacteria. Motivated by these observations, we study a simple model of low-Reynolds-number swimming in an anisotropic fluid, that of an infinitely long two-dimensional sheet deforming via propagating transverse or longitudinal waves and immersed in a hexatic or a nematic liquid crystal. The liquid crystal is categorized by the dimensionless Ericksen number Er, which compares viscous and elastic effects. Paying special attention to the anchoring strength at the interface of the liquid crystal and the swimmer, we calculate how swimming speed depends on Er for small amplitude waves. We also consider the lubrication limit of long wavelength. We study the sinusoidal steady-state problem as well as the startup problem in which the swimmer starts from rest.

MOHAMED RIAHI

New Jersey Institute of Technology

Parareal in Time Algorithm Face to 3D Simulation of the Time Dependent Neutron Diffusion Model

A parallel in time algorithm for the 3D neutrons calculation of a transient model in a nuclear reactor core is presented. The neutrons calculation consists in numerically solving the time dependent diffusion approximation equation, which is a simplified transport equation. The transient model presents moving control rods during the time of the reaction. We simulate the presented model with a in parallelism across the time by means of the plain-parareal in time algorithm that alternates the use of two appropriates numerical time-marching solver with different and contrasting orders. The high ordered time-marching solver would be a fine solver designed for parallel tasks. Our method is made efficient by means of a coarse solver defined with large time step and fixed position control rods model, while the fine propagator is assumed to be a high order numerical approximation of the full model. A new algorithm inheriting class from plain-parareal is also presented. The new version gives rise to a perfectly balanced parallel tasks, and is appropriate for use in exa-scaled time-parallel complex simulations, where it achieves a respectable efficiency compared to the conventional time-parallel methods. Indeed, we consider a uniformly truncated (means no convergent) time-marching parallel iterative scheme. We avoid the drawback of the truncation through an appropriate initialization for the time-marching iterative scheme. A compression procedure via proper orthogonal decomposition is therefore used which flows into the time-marching scheme through its initialization. We show that this techniques produces a good initialization for the time-marching scheme. Hence we accelerate its solvability that would be coupled with the parareal algorithm iterations in order to achieve accurate parallel solution. Numerical tests, on large light water reactor transient model corresponding to the LangenbuchMaurerWerner benchmark, show the efficiency and the robustness of the method.

Joint work with Yvon Maday(UPMC-FR), Jean-Jacques Lautards (CEA-FR), Anne-Marie Boudron (CEA-FR), and extention with Olga Mula.

USMAN ROSHAN

New Jersey Institute of Technology

A New Iterated Local Search Algorithm for NP-hard Linear Classification

Linear classifiers such as the support vector machine when regularized properly achieve competitive empirical performance for classification. The support vector machine solves an approximate version of the NP-hard problem for linear classification with minimum number of errors. In this talk I will present an iterated local search algorithm for solving the original problem. We study our program empirically on several real datasets from the UCI machine learning repository and compare it to the popular and fast linear support vector machine package called liblinear.

MINGHAO ROSTAMI

Worcester Polytechnic Institute

Efficient Simulation of Fluid-Structure Interactions Using Fast Multipole Method

Regularized Stokes formulation has been shown to be very effective at modeling fluid-structure interactions when the fluid is highly viscous. However, its computational cost grows quadratically with the number of particles immersed in the fluid. We demonstrate how kernel-independent fast multipole method can be applied to significantly improve the efficiency of this method, and present numerical results for simulating the dynamics of a large number of elastic rods immersed in 3D stokes flows.

DANIEL ROTHMAN

Massachusetts Institute of Technology

Climate, Groundwater Flow, and the Geometry of River Networks

Branched stream networks are a ubiquitous feature of Earth's surface, but their relationship to the processes that shape them and the climate in which they grow remains poorly understood. Here we pose and test the following hypothesis: Wherever climate is sufficiently humid such that precipitation enters the subsurface, branching angles tends toward $2\pi/5=72^\circ$, as predicted for channels growing in a diffusive groundwater field. By analyzing nearly one million digitally mapped river junctions throughout the contiguous United States, we find that the branching angle varies systematically with climate. The most humid regions are associated with mean angles near 72°, whereas arid areas exhibit much narrower angles. This relationship, which expresses itself most clearly on shallow slopes, suggests a significant role for groundwater seepage in the growth of roughly one-half the rivers of the conterminous United States.

Joint work with Hansjoerg Seybold.

DAVID SALAC

University at Buffalo

Vesicles in Electric Fields: A Numerical Investigation

Vesicles form a model system for more complicated biological cells such as red blood cells. The behavior of vesicles in the presence of externally driven fluid flow have been of interest for a number of years. More recently, interest in the behavior of vesicles in the presence of both fluids flow and external fields, such as electric fields, has increased. The control of vesicles using external fields has applications in microfluidic and biotechnology fields.

Here a numerical approach will be used to model the behavior of three-dimensional vesicles in the presence of external DC electric fields. The numerical method, including a semi-implicit level set Jet scheme and area/volume-conserving Navier-Stokes projection method will be discussed. The influence of an electric field on the dynamics of a vesicle will be investigated. An investigation of how material property uncertainty influences vesicle dynamics will also be presented.

THEMISTOKLIS SAPSIS

Massachusetts Institute of Technology

Quantification and Prediction of Rare Events in Nonlinear Water Waves

The scope of this work is the development, application, and demonstration of probabilistic methods for the quantification and prediction of extreme events occurring in complex nonlinear systems involving water waves and mechanical vibrations. Although rare these transitions can occur frequently enough so that they can be considered of critical importance. We are interested to address two specific topics related to rare events in complex dynamical systems: i) we want to be able to perform short term prediction given that we are able to measure specific quantities about the current system state (Rare Event Prediction Problem); and ii) we want to be able to quantify the probability of occurrence of a rare event for a given energetic regime of the system (Rare Event Quantification Problem). We first use a new adaptive reduction method to analytically quantify the role of spatial energy localization on the development of nonlinear instabilities and the subsequent formation of rare events in water waves. We then prove that these localized instabilities are triggered through the dispersive 'heat bath' of random waves that propagate in the nonlinear wave field. The interaction of uncertainty induced through the dispersive wave mixing and nonlinear instability defines a critical length-scale for the formation of rare events. To tackle the first problem we rely on this property and show that by merely tracking the energy of the wave field over this critical length-scale allows for the robust, inexpensive prediction of the location of intense waves with a prediction window of 25 wave periods. For the second problem, we also utilize the nonlinear stability analysis to decompose the state space into regions where rare events is unlikely to occur and regions that lead with high probability to the occurrence of a rare event. The two regions are treated differently and the information of the two regimes is merged through a total probability argument, allowing for the efficient quantification of rare events in nonlinear water waves and subjected (to those) mechanical systems.

BENJAMIN SEIBOLD

Temple University

High-Order Methods for Incompressible Flows via Pressure Poisson Equation Reformulations

Pressure Poisson Equation (PPE) reformulations of the Navier-Stokes equations advance incompressible flows forward in time, while decoupling the pressure solve from the velocity solve. In contrast to projection methods (which also achieve such a decoupling) PPE reformulations allow for high-order time-stepping rather naturally. A price to pay for this advantage is that incompressibility is not satisfied exactly. We study a specific PPE reformulation, which prescribes electric boundary conditions for the velocity, and its high-order discretization using mixed finite elements and ImEx time stepping schemes.

MICHAEL SHELLEY

Courant Institute of Mathematical Sciences, New York University

The Dynamics of Microtubule/Motor-protein Assemblies and Structures

I'll talk about recent modeling of systems driven by the interaction of microtubules and motor-proteins. One example is pronuclear migration and positioning in single-cell C elegans embryo, where we have developed a numerical model -- based on start-of-the-art methods for fluid-structure systems of complex geometry -- to investigate different biophysical models of positioning. Another area are experimental and modeling studies to understand the nature of material stresses in active microtubule suspensions, and how these stresses feedback and drive dynamics (sometimes very complex). This work informs other recent modeling work on the formation of the mitotic spindle, which is involved in chromosome segregation and cell division.

KENNETH SHIRLEY

AT&T Labs-Research

Text Mining on Domain Names

In this talk I will describe research on analyzing domain names using text mining. The first part of our work consists of doing supervised learning to detect malicious domain names (as measured by a crowd-sourced reputation score). The second part consists of unsupervised learning, including topic modeling, on the domain names, to learn which words tend to occur together within the same domain names. Underpinning both parts of this research is a word segmentation algorithm that allows us to segment a domain name, which is a single string of alphanumeric characters, into individual words.

MICHAEL SIEGEL

New Jersey Institute of Technology

A Mathematical Model for Retinal Detachment

Retinal detachment is a major contributor to retinal tissue death and permanent vision loss. The two common types of detachments are rhegmatogenous, in which a hole or tear forms in the thin retinal layer, and exudative, in which a blister forms without a retinal hole. We present a mechanical model of exudative retinal detachment. The model determines the conditions that give rise to an irreversible growth of a detached blister or an extended retinal delamination.

SAVERIO SPAGNOLIE

University of Wisconsin, Madison

The Sedimentation of Flexible Filaments in Viscous Fluids

The deformation and transport of elastic filaments in viscous fluids play central roles in many biological and technological processes. Compared with the well-studied case of sedimenting rigid rods, the introduction of filament compliance may cause a significant alteration in the long-time sedimentation orientation and filament geometry. In the weakly flexible regime, a multiple-scale asymptotic expansion is used to obtain expressions for filament translations, rotations and shapes which match excellently with full numerical simulations. In the highly flexible regime we show that a filament sedimenting along its long axis is susceptible to a buckling instability. Incorporating the dynamics of a single filament into a mean-field theory, we show how flexibility affects a well-established concentration instability in a sedimenting suspension.

HANSONG TANG

Civil Engineering Department at the City College of New York/CUNY

Domain Decomposition for Simulation of Small-Scale Coastal Ocean Flows

A domain decomposition method is presented to integrate geophysical fluid dynamics and fully 3D fluid dynamics models for simulation of multiphysics phenomena in coastal flows, especially those within complicated, small-scale, local flows. It integrates different sets of partial differential equations, numerical algorithms, and computational grids, and it is able to capture flow phenomena at spatial scales O (1) m -- O (10,000) km. The domain decomposition method will be outlined, and its unprecedented capabilities will be demonstrated by its applications to emerging problems that are beyond the reach of conventional methods.

SHASHI THUTUPALLI

Princeton University

The Non-equilibrium Dynamics of Active Droplets and Their Collectives

Active droplets i.e. emulsion droplets which exhibit self-propelled motion are of tremendous interest in understanding collective dynamics of systems far from thermal equilibrium. A particularly appealing feature of these active droplet systems is that the coupling between the individuals are mediated by physical effects such as steric interactions and hydrodynamics, leading to a range of collective behaviour. We create such active droplet systems using emulsions (water-in-oil or oil-in-water, respectively) stabilized by surfactants. A common theme in the propulsion of these individual droplets is a spontaneously broken symmetry (unlike colloidal swimmers which are often asymmetric by design) which is sustained via dissipation of chemical energy. I will talk about the molecular mechanisms involved in the self-propulsion, the resultant hydrodynamic flow fields of individual swimmers and the emergent collective dynamics of populations of many swimmers. In particular, we show that hydrodynamics and geometry play a crucial role in the emergent self-organization of the active droplets, which might be exploited for computation mediated by activity, physical coupling and confinement.

CHAD TOPAZ

Macalester College

Topological Data Analysis of Biological Aggregation Models

Biological aggregations are groups such as bird flocks, fish schools, and insect swarms in which organisms may interact socially. They are striking examples of emergent self-organization, and simultaneously, they have served as the inspiration for the development of algorithms in robotics, computer science, applied mathematics, and other fields. This talk will demonstrate a method for assessing the emergent dynamics of aggregations. We apply techniques of topological data analysis to influential models of Vicsek et al. (1995) and D'Orsogna et al. (2006). We construe position and velocity data from numerical simulations as point clouds varying over time. We measure topological features that persist over multiple spatial scales, and see that the topological analysis detects dynamical events that are undetected by more commonly used methods. This talk assumes no prior knowledge of topology.

ANNA-KARIN TORNBERG

KTH, Royal Institute of Technology

Accelerated Boundary Integral Methods for Interactions of Drops and Solids in Micro-fluidics.

In micro-fluidic applications where the scales are small and viscous effects dominate, the Stokes equations are often applicable. Simulation methods can be developed based on integral equations, which leads to discretizations of the boundaries of the domain only, and hence fewer unknowns compared to a discretization of the PDE.

Two main difficulties associated with boundary integral discretizations are to construct accurate quadrature methods for singular and nearly singular integrands, as well as to accelerate the solution of the linear systems, that will have dense system matrices. If these issues are properly addressed, boundary integral based simulations can be both highly accurate and very efficient. For drops and solids in 2D, we will discuss how to apply a general special quadrature approach to achieve highly accurate simulations also for very complicated settings. Depending on the boundary conditions, the simulations are accelerated with either the Fast Multipole method or a spectrally accurate FFT based Ewald method (for periodic problems). Simulation results for very challenging problems are presented.

ALESSANDRO VENEZIANI

Emory University

Cardiovascular Mathematics - from the Computer Lab to the Bedside: Perspectives and Challenges

Mathematical and numerical modelling of cardiovascular problems has experienced a terrific progress in the last years, evolving into a unique tool for patient-specific analysis. However, the extensive introduction of numerical procedures as a part of an established clinical routine and more in general of a consolidated support to the decision making process of physicians still requires some steps both in terms of methods and infrastructures (to bring computational tools to the operating room or to the bedside).

The quality of the numerical results needs to be carefully assessed and certified. An important research line - quite established in other fields - is the integration of numerical simulations and measurements in what is usually called Data Assimilation. A rigorous merging of available data (images, measures) and mathematical models is expected to reduce the uncertainty intrinsic in mathematical models featuring parameters that would require a patient-specific quantification; and to improve the overall quality of information provided by measures. However, computational costs of assimilation procedures - and in particular variational approaches - may be quite high, as typically we need to solve inverse problems, dual and possibly backward-in-time equations. For this reason, appropriate model reduction techniques are required, to fit assimilation procedures within the timelines and the size of patient cohorts usually needed by medical doctors. In this talk, we will consider some applications of variational data assimilation in vascular and cardiac problems and associated model reduction techniques currently investigated to bring numerical simulations into the clinical routine.

For solving incompressible flows in network of pipes we will address hierarchical modeling (HiMod) of the solution of partial differential equations in domains featuring a prevalent mainstream, like arteries. The HiMod approach consists of approximating the main direction of each vessel with finite elements, coupled with spectral approximation of the transverse dynamics. The rationale is that a few modes are enough to a reliable approximation of secondary motion. In addition, modal adaptivity allows to tune the local accuracy of the model. This results in a ""psychologically"" 1D modeling to be compared with classical approaches based on the Euler equations.

Finally, we will address some more advanced applications of geometrical processing for (a) investigating patient-specific bioresorbable stents; (b) supporting decision making of neurosurgeons in deploying flow diverters for cerebral aneurysms.

ANTAI WANG

New Jersey Institute of Technology

The Analysis of Left Censored Bivariate Data Using Frailty Models

In this research, we study the properties of frailty models for bivariate data under fixed left censoring. It turns out that the distribution of observable pairs forms a new class of bivariate frailty models. Both the original model for complete data and the new class of model for observable pairs are members of Archimedean copula family. We develop a novel estimation strategy to analyze left censored data using corresponding Archimedean copula models. A general goodness-of-fit test procedure are then established for original models based on left censored data. Our strategy is a generalization of the methodologies proposed in Wang (2007) and Romdhani and Lakhal-Chaieb (2012). We demonstrate our new methodology using simulations and an illustrative example.

SHIYAN WANG

Purdue University; University of Notre Dame

Biogenic Mixing in a Stratified Fluid

The goal of this work is to answer the intriguing question vigorously argued in the literature during the past few years that whether the combined motion of marine organisms contributes to the global ocean mixing. Specifically, we are interested in centimeter-scale organisms such as Ctenophora and Euphausiids, where their swimming Reynolds number is on the order of O(100). We utilize the squirmer model to resolve the hydrodynamic interactions of a suspension of swimmers in a density-stratified fluid. Our study shows that the eddy diffusivity generated by a suspension of squirmers is comparable to the value reported for the ocean turbulent mixing, even though the corresponding mixing efficiency is smaller than the typical value of 0.2 reported for the turbulent mixing. We have also considered a suspension of squirmers in a decaying isotropic turbulence. We find that the eddy diffusivity in the presence of a suspension of squirmers enhances due to the strong viscous dissipation generated by squirmers as well as the interaction of squirmers with the background turbulence.

ZHI WEI

New Jersey Institute of Technology

An Empirical Bayes Change-point Model for Identifying 3' and 5' Alternative Splicing by Next-generation RNA Sequencing

Next-generation RNA sequencing (RNA-seq) has been widely used to investigate alternative isoform regulations. Among them, alternative 3' splice site (SS) and 5' SS account for more than 30% of all alternative splicing events in higher eukaryotes. Recent studies have revealed that they play important roles in building complex organisms and have critical impact on biological functions which could cause diseases. Quite a few analytical methods have been developed to facilitate alternative 3' SS and 5' SS study using RNA-seq data. However, these methods have various limitations and their performances may be further improved. We propose an empirical Bayes change-point model to identify alternative 3' SS and 5' SS. Compared with previous methods, our approach has several unique merits. First of all, our model does not rely on annotation information; instead, it provides for the first time a systematical framework to integrate various information when available, in particular the useful junction reads information, in order to obtain better performance. Secondly, we utilize an empirical Bayes model to efficiently pool information across genes to improve detection efficiency. Thirdly, we provide a flexible testing framework in which the user can choose to address different levels of questions, namely, whether alternative 3' SS or 5'SS happens, and/or where it happens. Simulation studies and real data application have demonstrated that our method is powerful and accurate.

PETER WILLS

University of Colorado, Boulder

Stochastic Perturbation of the Magnetic Droplet Soliton

The magnetic droplet soliton is a strongly nonlinear wave structure in the magnetization field of a ferromagnet that can be stabilized against magnetic damping by a spin torque nanocontact device. Recent experimental results motivate an examination of the effect of thermal noise on these structures. Using a previously developed perturbation theory framework, a set of coupled stochastic differential equations which describe the time-evolution of the droplet parameters under a stochastic perturbation is derived. The zero noise, stable droplet corresponds to a stable node originating from a saddle-node bifurcation of the modulation system. The low temperature, linearized dynamics correspond to an Ornstein-Uhlenbeck relaxation process for the droplet's frequency and position. Numerical solution of the fully non-linear stochastic differential equations reveal the impact of large temperature fluctuations. In particular, the droplet's frequency linewidth is determined.

LAN XUE

Oregon State University

Estimation and Model Selection in Generalized Additive Partial Linear Models For Correlated Data With Diverging Number of Covariates

We propose generalized additive partial linear models for complex data which allow one to capture nonlinear patterns of some covariates, in the presence of linear components. The proposed method improves estimation efficiency and increases statistical power for correlated data through incorporating the correlation information. A unique feature of the proposed method is its capability of handling model selection in cases where it is difficult to specify the likelihood function. We derive the quadratic inference function-based estimators for the linear coefficients and the nonparametric functions when the dimension of covariates diverges, and establish asymptotic normality for the linear coefficient estimators and the rates of convergence for the nonparametric functions estimators for both finite and high-dimensional cases. The proposed method and theoretical development are quite challenging since the numbers of linear covariates and nonlinear components both increase as the sample size increases. We also propose a doubly penalized procedure for variable selection which can simultaneously identify non-zero linear and nonparametric components, and which has an asymptotic oracle property. Extensive Monte Carlo studies have been conducted and show that the proposed procedure works effectively even with moderate sample sizes. A pharmacokinetics study on renal cancer data is illustrated using the proposed method.

JUN YAN

University of Connecticut

A Bivariate Two-Part Model

In a study of young adults in the greater Boston metropolitan area, participants were screened for major depression and relational stressor. A large portion of the subjects did not experience either one or both events, resulting in a probability mass at zero marginally and jointly. For those who did experience major depression or relational stressor, the durations were right skewed and right censored. Researchers were interested in how coping strategies affect the durations of the major depression and relational stressor.

We propose a two-part marginal model for the censored duration data. In the first part, the probability of experiencing an event modeled with a logistic regression with generalized estimating equations (GEE). In the second part, the positive durations are modeled by marginal semiparametric accelerated failure time models with GEE, where the marginal error distributions and regression coefficients are margin specific, and a working correlation structure helps to improve the efficiency. In a large scale simulation study, our estimator is more efficient than the estimator that ignores the within-cluster dependence, especially when the within-cluster dependence is strong. Application to the Boston study reveals that the coping strategies have different, interesting effects on the duration of major depression and relational stressor.

ZEYNEP AKCAY

Queensborough Community College, CUNY

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 phase response curves (PRC) of individual neurons to define a map for the activity of a network of two neurons. Using this PRC based map we show that short-term synaptic depression may cause two stable phase locked solutions.

EDISON AMAH

New Jersey Institute of Technology

Electrohydrodynamic Manipulation of Particles Adsorbed on the Surface of a Drop

In our previous studies we have shown that particles adsorbed on the surface of a drop can be concentrated at its poles or equator by applying a uniform electric field. This happens because the electric field on the surface of the drop is nonuniform, and so particles adsorbed on its surface are subjected to dielectrophoretic forces. In this paper, we study the behavior of absorbed particles at low electric field frequencies when the drop and ambient liquids are weakly conducting dielectric liquids, and model their behavior using a leaky dielectric model. At low frequencies there is an electrohydrodynamic (EHD) flow on the surface of the drop which arises because of the accumulation of charge on the surface of the drop. The direction of the EHD flow can be pole-to-equator or equator-to-pole depending on the properties of the drop and ambient liquids. This causes particles adsorbed on the surface of the drop to move in the direction of the flow. The flow however diminishes with increasing frequency, and there is a critical frequency at which the drag force on a particle due to the EHD flow becomes equal to the dielectrophoretic (DEP) force. For a frequency above the critical value, the DEP force dominates. When the fluid and particles properties are such that the EHD and DEP forces are in the opposite directions, particles can be can be collected at the poles or the equator, and also can be moved from the poles and the equator, or vice versa, by varying the frequency of electric field. It is also shown that it is possible to separate the particles of a binary mixture when the critical frequencies for the two types of particles are different.

VALERIA BARRA

New Jersey Institute of Technology

Numerical Study of Thin Viscoelastic Films on Substrates

We numerically study the interfacial dynamics and instability of a thin viscoelastic film on a substrate. We use the long wave approximation to describe the non-linear evolution of the interface. We consider different regimes of slippage, and in each regime, we investigate the role of the liquid viscoelasticity and of the contact angle on the thin film break-up. Numerical solutions of the full non-linear equations are compared with the results of the linear stability analysis.

NICHOLAS BRUBAKER

The University of Arizona

Elasto-capillary Deformations

Elasto-capillary interactions dominate the behavior of many natural systems and cause a wide range phenomena such as the ejection of fungal spores and the clustering of insect bristles. They also play an important role in understanding the morphology of many engineered systems and have led to a number of applications at the micrometer or nanometer scale. One application of particular interest is in the field of micro-scale fabrication, where it has been shown that the folding of a two-dimensional elastic sheet by action of surface tension, known as capillary origami, can produce three-dimensional structures. In this talk, we discuss recent work on modeling capillary origami and the predictions that can be made.

RUI CAO

New Jersey Institute of Technology

A Hybrid Numerical Method for Electro-Osmotic Flow with Deformable Interfaces

When a drop or vesicle is suspended in a viscous electrolyte fluid and a direct current (D.C.) electric field is applied, the drop interface or vesicle membrane and the suspending fluid are driven into motion. This occurs due to the attraction and repulsion of ions, which causes a thin diffuse charge double layer to form adjacent to an interface that is called a 'Debye layer'. The electric field exerts a force on the charge inside the Debye layer. This force together with interfacial surface tension or the elastic properties of the membrane govern the deformation and fluid motion.

By taking into account the ion concentration and related governing equations, we construct a model that describes the evolution of the drop interface or vesicle membrane. This combines an asymptotic analysis of the Debye layers with the boundary integral method for determining the fluid velocity and electrostatic potential, and leads to an accurate and efficient numerical method for solving this nonlinear moving boundary problem.

PAVEL DUBOVSKI

Stevens Institute of Technology

Wave-like Behavior in Coagulation Processes

We discuss the Safronov coagulation model. Unlike the Smoluchowski equation, it possesses strong hyperbolic properties that allow us to consider running coagulation front and estimate analytically the phase transition (gelation) phenomenon. Also, we prove the global existence for essentially broader classes of collision kernels. Relying on the hyperbolic properties, we also prove the local existence theorem for arbitrary fast coagulation intensities. The analytical results are supported by computations for which a special implicit numerical method was developed.

KARL OSCAR FLODIN

New Jersey Institute of Technology

Mechanism of Generation of Resonant Spiking Patterns in a Neuronal Model in Response to Periodic Inputs

Various neuron types exhibit preferred frequency responses to subthreshold sinusoidal current inputs. A neuron exhibits subthreshold (or membrane potential) resonance if the steady state oscillation amplitude peaks at a non-zero (resonant) input frequency and it exhibits phasonance if the input and output (steady state) peak at the same time for a non-zero (phasonant) input frequency. Whether and how the characteristic time scales underlying these preferred frequency responses are communicated to the spiking regime is not well understood. In this work we explore these ideas using a neuronal model that includes a hyperpolarization-activated (h-) mixed-cation (sodium and potassium) inward current and a persistent sodium current. This model has been shown to exhibit subthreshold resonance and phasonance in the theta frequency band (8 - 12 Hz). Here we show that spiking resonance occurs at these frequencies by a mixed-mode oscillations (MMOs) mechanism. Specifically, for suprathreshold input frequencies at the theta frequency band spiking occurs at these frequencies. As the input frequencies increase above the theta range, the number of spikes per second remains in the theta frequency band, but subthreshold oscillations (STOs) emerge in between spikes, thus generating MMO patterns. The number of STOs per spike increases as the input frequency increases within the range for which spiking responses are present. We show that the mechanism of generation of these patterns involve a complex interaction between the model nonlinearities and the effective time scales.

ROGER GARCIA

Kean University

A Consistent Orbital Stability Analysis for Modeling Planetary Systems

In this study, we present an analysis of the detection and characterization of planets around other stars. Using publicly available radial velocity data obtained from the HARPS spectrograph at La Silla Observatory, we apply a combination of N-body modeling techniques and automated data fitting with Monte Carlo Markov Chain uncertainty analysis of Keplerian orbital models to determine long term stability of a planetary system. In particular, we explore the discrepancies in the number of planets orbiting the solar-type star HD 10180 that exist among scholars studying these unique multi-planet systems. Tidal damping and general relativistic (GR) effects both have the effect of causing a slight precession of the orbits of planets affected. This typically only happens for planets very close to the center star, such as Mercury in our own solar system. We compare the solution of a modified Laplace-Lagrange secular solution (as detailed in Laskar et al 2011) with a standard N-Body model solved using a symplectic integrator, incorporating tidal and GR forces either explicitly or approximating with an effective quadrupole moment.

SAMIRAN GHOSH

Wayne State University

Feature Import Vector Machine: A General Classifier

The support vector machine (SVM) and other reproducing kernel Hilbert space (RKHS) based classifier systems are drawing much attention recently due to its robustness and generalization capability. General theme here is to construct classifiers based on the training data in a high dimensional space by using all available dimensions. The SVM achieves huge data compression by selecting only few observations which lie close to the boundary of the classifier function. However when the number of observations are not very large (small n) but the number of dimensions/features are large (large p), then it is not necessary that all available features are of equal importance in the classification context. Possible selection of a useful fraction of the available features may result in huge data compression. In this paper we propose an algorithmic approach by means of which such an {\it optimal} set of features could be selected. In short, we reverse the traditional sequential observation selection strategy of SVM to that of sequential feature selection. To achieve this we have modified the solution proposed by Zhu and Hastie (2005) in the context of import vector machine (IVM), to select an {\it optimal} sub-dimensional model to build the final classifier with sufficient accuracy.

DAVID HORNTROP

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.

YU JIANG

Yale University

Integrated Analysis of Multidimensional (Epi)Genetic Data on Cutaneous Melanoma Prognosis

Cutaneous melanoma poses a serious public health concern. Its prognosis is a complex progress, with multiple types of (epi)genetic changes possibly involved. Many existing studies, especially the early ones, are limited in analyzing a single type of (epi)genetic measurement and cannot comprehensively describe the biological processes underlying prognosis. As a result, the obtained prognostic models can be less satisfactory. The recently collected TCGA (The Cancer Genome Atlas) cutaneous melanoma data have high quality comprehensive (epi)genetic measurements, making it possible to more comprehensively and more accurately modeling prognosis. In this study, we conduct the integrated analysis of multiple types of (epi)genetic measurements with the assistance of variable selection and dimension reduction techniques. It is found that integrating multiple types of measurements can lead to prognostic models with improved prediction performance. In addition, the analysis also identifies informative individual markers and pathways, which may provide valuable insights into melanoma prognosis.

HUANG JIANJUN

Worcester Polytechnic Institute

Interactions of Micro-organisms Near a Wall in Stokes Flow Using a Regularized Image System

We present an extension of the regularized image system for Stokeslets, where regularization functions and parameters are chosen to satisfy zero flow at the wall for several different fundamental solutions. Interactions of different representative microorganisms near a wall are studied. Sperm and bacteria flagella are described by a version of the Kirchhoff rod model, where intrinsic curvature and twist are prescribed. Results are presented for swimming speeds and attraction to a wall.

NICKOLAS KINTOS

Saint Peter's University

Using a Mathematical Model to Compare How Distinct Pathways for Activating the Same Modulatory Input can Influence a Central Pattern Generator Network

Although distinct neuromodulators often target distinct components within a neural network, their actions can produce a convergent influence upon the network by targeting the same cellular or synaptic mechanisms, albeit in different neuron types. Such convergence of modulatory actions can provide a neural network with greater flexibility for producing a given mode of output. However, it may appear redundant or inefficient when distinct neuromodulators activate the same mechanism in the same neuron type. The purpose of such redundant actions is not well understood. We investigate what advantage such redundancy could provide using a reduced mathematical model of the gastric mill (chewing) central pattern generator network of the crab, Cancer borealis.

The biphasic gastric mill rhythm (GMR) is represented by the burst and interburst phases of the lateral gastric (LG) neuron. Together with interneuron 1 (Int1), the LG-Int1 neuron pair forms the core reciprocally inhibitory half-center oscillator that underlies the GMR activity pattern. In vitro, stimulation of the projection neuron, modulatory commissural neuron 1 (MCN1), elicits a GMR. Moreover, synaptic interactions between MCN1 axon terminals and the LG neuron are necessary for the MCN1-elicited GMR.

We compared the convergent actions of two distinct neuromodulators: Cancer borealis tachykinin-related peptide Ia (CabTRP Ia) and crustacean cardioactive peptide (CCAP). Both produce the same excitatory modulator-activated, voltage-gated, inward current (IMI) in the same (LG) neuron (DeLong et al, 2009 J Neurosci). However, because CabTRP Ia is synaptically released by MCN1 onto the LG neuron, the resulting current (IMI-MCN1) is constrained by LG presynaptic inhibition of MCN1 axon terminals. In contrast, CCAP is hormonally released onto the LG neuron, and the resulting current (IMI-CCAP) is not constrained by any synaptic interactions.

We focused on how IMI-MCN1 and IMI-CCAP can influence the MCN1-elicited GMR at the network level. We exploited the separation of time scales in the biological system to obtain a reduced, 2D model of the MCN1-elicited GMR. Using this model, we reproduced the biological finding that IMI-MCN1 primarily influences the LG interburst phase of the MCN1-elicited GMR, whereas IMI-CCAP influences both phases. Using phase plane analysis, we found that IMI-MCN1 influenced the GMR in a manner similar to that of the Int1-to-LG synapse, whereas IMI-CCAP had an effect similar to the LG-to-Int1 synapse. The similarity of these influences allowed for IMI-MCN1 or IMI-CCAP to produce oscillations even in the absence of the respective synapse. We conclude that although these two neuromodulators have a convergent influence at the cellular level by activating the same voltage-gated ion channel, they produce a surprisingly divergent influence at the network level, thus increasing the flexibility of neuromodulator actions on the network activity.

YEO KYONGMIN

IBM T.J. Watson Research Center

Collective Dynamics of Bi-disperse Suspensions of Active Rotors

The dynamics of suspensions of active spherical rotors is investigated by using the force coupling method. The suspension consists of 50:50 mixture of counter-rotating rotors. The motions of the suspended rotors are confined to the horizontal plane perpendicular to the axis of rotation. Unlike the previous results in non-hydrodynamic limit, it is shown that the conversion rate of the rotational kinetic energy to the translational kinetic energy increases slowly with the increase in volume fraction and eventually exhibits a sharp drop around a critical volume fraction of ~ 0.54. A closer investigation of suspension microstructure reveals that demixing of active rotors occurs around the volume fraction of 0.30, which changes to the large counter-rotating vortices at the volume fraction of 0.50. Around the critical volume fraction of 0.54, hexagonal structures emerge, which prevents the suspensions from de-mixing.

MICHAEL LAM

New Jersey Institute of Technology

Saffman-Taylor Instability of Complex Fluids in a Hele-Shaw Cell

We present analytical, experimental, and numerical results for the Saffman–Taylor instability for a two-phase flow in a Hele-Shaw Cell. Experimentally, we have considered several different fluid combinations: water-glycerol, water-PEO (polyethylene oxide), and water-5CB (4-Cyano-4'-pentylbiphenyl). PEO and 5CB are non-Newtonian fluids that exhibit more complex behavior such as shear thinning and elastic response. Theoretically, we have analyzed the stability of the simple (Newtonian) fluid interface and compared the predictions with the experimental results. Computationally, we have carried out Monte-Carlo type simulations based on the so-called diffusion limited aggregation (DLA) approach. We have computed various measures of the emerging patterns, including fractal dimension for both experimental and computational results.

RANDOLPH LEISER

New Jersey Institute of Technology

Effects of Coupling on Beta Cells and Relaxation Oscillators

It is generally accepted that electrical coupling via gap junctions leads to in phase synchronization. This type of coupling is present in many systems within the body, including the heart, neurons, and pancreatic beta cells. Synchronization is important to efficient function in all of these systems. However, if cells with different periods are coupled, in-phase synchronization is not always the result. Depending on the timing and strength of the coupling, anti-phase synchronization and even oscillator death are possible outcomes. The robustness of these behaviors is tested when the coupling is "turned off" to see which state the uncoupled cells will revert to. We explore which other patterns of behavior outside of in-phase synchronization. We explore which regimes of parameter values lead to these alternate patterns. We investigate nullclines and use phase-plane analysis to determine the underlying mechanisms that lead to the different behaviors. Finally, we explore what changes we can make to a system that has not synchronized in-phase in order to make it do so.

JEFF MASSENA

Queensborough Community College

Phase Response Curves in Determining the Activity of Neuronal Networks

The behavior generated by a small neuronal network depends on the firing phase relations of its neurons. A tool that is used to determine the phase relation in a neuronal network is the Phase Response Curve (PRC). The PRC measures the response of a firing neuron to a given stimulus. First, we use analytical and numerical methods to obtain PRCs for the Quadratic Integrate and Fire (QIF) neuron model. Next, we study how PRCs have been used to determine the activity of networks of neurons. Finally, we do simulations of a network of two QIF neurons and compare the resulting phase relation obtained from simulation with the one obtained from a map that makes use of PRCs.

DANIEL MELDRIM

New Jersey Institute of Technology

Efficient Mode Calculation of Optical Waveguides

We propose a comprehensive research program in the design of numerical methods for, and the development of efficient parallel algorithms aimed at the large-scale simulation needs of the photonic components industry. The overall objective of the project is to achieve accurate, robust and efficient simulation of complex photonic systems such as arrayed waveguide gratings. An important component of the project is the development of parallel algorithms that are free of scalability bottlenecks, make good use of available hardware, and enable engineering-scale simulation.

NAGA ADITYA MUSUNURI

New Jersey Institute of Technology

Fluid Dynamics of Hydrophilous Pollination

The aim of this work is to understand the physics underlying the mechanisms of two-dimensional aquatic pollen dispersal, known as hydrophily, that have evolved in several genera of aquatic plants, including Halodule, Halophila, Lepilaena, and Ruppia. We selected Ruppia, which grows in the wetlands of the New Jersey/New York metropolitan area, for this study. Our experiments show that the pollen grains from an anther suddenly disperse and form a monolayer when they come in contact with a water surface. This is a crucial first step in the formation of floating porous pollen structures called "pollen rafts," which often contain pollen grains from several anthers. The formation of porous pollen rafts increases the probability of pollination by increasing the two-dimensional reach of the pollen from each individual anther.

HAIYANG QI

New Jersey Institute of Technology

Numerical Methods for Two-dimensional Helmholtz Transmission Problems

We develop numerical methods for the solution of integral equations for the solution of two-dimensional scattering problems of multi-domain.

AMINUR RAHMAN

New Jersey Institute of Technology

A Scheme for Modeling and 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 a discrete dynamical system is relatively inexpensive. A model for the RS flip-flop circuit, made with chaotic NOR gates, is found in an ad-hoc manner. This is shown to replicate the qualitative features of the physical realization. Next, a systematic - algorithmic - first principles based approach is developed in order for such dynamical models to more accurately 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.

BALJEET SINGH

Post Graduate Government College

Rayleigh Wave in Thermoelasticity with Impedance Boundary Conditions

The governing equations of linear, homogeneous and isotropic generalized thermoelasticity are solved for surface wave solutions. With the use of appropriate radiation conditions, the particular solutions in a half-space are obtained. These solutions are applied to impedance boundary conditions at free surface to obtain the secular equation of Rayleigh wave. The non-dimensional speed of Rayleigh wave is plotted against non-dimensional material parameters for different values of impedance parameters.

MIMI SZETO

University of New Hampshire

Periodic Orbits and the Dynamics of Turbulence

Modern dynamical systems theory offers a means to investigate the complex spatio-temporal dynamics of turbulent flows. In this approach, high-dimensional numerical simulations of flows are viewed as orbits through a state space. Governed by a system of Navier-Stokes equations, a flow is thought to transition through a sequence of the system's prominent dynamic behaviors. In other words, the orbit representing a particular flow in the state space makes a sequence of close passes to unstable periodic orbits. For plane Couette flow with periodic boundary conditions, we map the state space onto a Poincare section, identify unstable periodic orbits of the system, and produce second-order approximations of the unstable eigenspaces surrounding the periodic orbits. Given that the eigenspaces are unstable in only a few dimensions, we aim to develop a precise spatio-temporal model for the high-dimensional dynamics of a turbulent flow as a sequence of low-dimensional transitions between the flow's periodic orbits. This research suggests that complex turbulent flows self-organize into coherent dynamic structures as they evolve.

OLEKSIY VARFOLOMIYEV

New Jersey Institute of Technology

An Efficient Boundary Integral Method for Stiff Fluid Interface Problems

The purpose of this thesis is to formulate and investigate a boundary integral method for the solution of the internal waves/Rayleigh-Taylor problem. This problem describes the evolution of the interface between two immiscible, inviscid, incompressible, irrotational fluids of different density in three dimensions. A mathematical model of this interfacial flow problem in 3D is derived. The motion of the interface and fluids is driven by the action of a gravity force, surface tension at the interface, elastic bending and/or a prescribed far-field pressure gradient. The presented models include derived equations for the evolution of the interface and dipole density on the interface. The interface is a generalized vortex sheet, and dipole density is interpreted as the (unnormalized) vortex sheet strength. Presence of the surface tension or elastic bending effects introduces high order derivatives into the evolution equations. This makes the considered problem stiff and the application of the standard explicit time-integration methods suffers strong time-step stability constraints. The derived initial value problem for the Rayleigh-Taylor and hydroelastic waves in three dimensions is solved using the proposed efficient numerical method.

The proposed numerical method employs a special interface parameterization that enables the use of an efficient implicit time-integration method via a small-scale decomposition. This approach allows one to capture the nonlinear growth of normal modes for the case of Rayleigh-Taylor instability with the heavier fluid on top. Linear stability analysis is performed and the numerical results for the nonlinear problem are validated by comparison to the obtained analytic solution of the linearized problem for a short time. Further validation is done by checking the energy and the interface mean height preservation. The developed model and numerical method can be efficiently applied to study the motion of internal waves for doubly periodic interfacial flows with surface tension and elastic bending stress at the interface.

The thesis has three parts. The nondimensionalized governing equations for the interfacial fluid flow with surface tension and elasticity are presented in Chapter 1. This chapter also includes the equations for the elastic interface position, interface density and the equations for the fluids' normal and tangential velocities. In Chapter 2 the small-scale decomposition for the normal velocity integral is performed. A leading order approximation of the singular velocity integral, known as a Birkhoff-Rott integral, is derived. The leading order part consists of the terms in the governing equations that are dominant at high wavenumber and cause the numerical stiffness (equivalently these are the high derivative terms). These terms are contained in a nonlocal operator. The leading order approximation is expressed in terms of the Riesz transform, and it is computed with spectral accuracy using the FFT method. Then the expressions for the mean height of the interface and the total energy of the system are derived. These quantities are the invariants of the interface motion. The symmetry property of the solution is studied. It is utilized later for improving the efficiency of the numerical method. A linear stability analysis of the proposed problem is also performed. Finally, in Chapter 3 an efficient semi-implicit numerical method is presented. It includes the discussion of the integration method for the interface velocity, using the fast Ewald summation algorithm for the velocity integral, and contains the results of numerical simulations for the interface evolution subject to gravity, surface tension and elastic bending stress.

CEN WU

Yale School of Public Health, Yale University

A Robust Network-Constrained Penalization Approach for Integrative Analysis with Applications in TCGA Data

Integrative analysis of multiple genomic features has become increasingly important, partly due to the unique perspective that it offers to elucidate the complicated regulation mechanism among the features. Although heavy-tailed errors and outliers in response variables of the integrative analysis have been commonly observed, the issue has not been taken care of in existing studies. We develop a robust network-constrained penalization approach for the integrative analysis of two genomic features with high dimensional multivariate measurements. Consider copy number alterations (CNAs) and gene expressions (GEs). Both of them play pivotal roles in the development of complex diseases. A semi-parametric modelling strategy is taken to flexibly model the effects of multiple CNAs on multiple GEs. We choose the least absolute deviation (LAD) loss function to tackle data contamination and heavy-tailed errors in GEs. A network-constrained penalty is adopted to accommodate the network adjacency accounting for the correlations. Sparse and biologically meaningful associations are identified by the penalization procedure which can be effectively implemented within the coordinate descent framework. The proposed approach outperforms the alternatives in simulation study. We carry out the integrative analysis with The Cancer Genome Atlas (TCGA) data on melanoma, and demonstrate the advantage of the proposed approach.

ARJUN SINGH YADAW

Mount Sinai School of Medicine

Grid Generation and Uniform Convergence for Singularly Perturbed One-dimensional Parabolic Reaction-diffusion Problems with Two Small Parameters

Singularly perturbed two-point boundary value problems require highly non-uniform grids for their efficient numerical treatment. In this presentation, we have developed a simple technique for distributing the grid points, based on a density function which accounts for the structure of the problem. The grid is obtained by analytical-numerical techniques and can be used to get a parameter-uniform numerical methods for a class of singularly perturbed one-dimensional parabolic reaction-diffusion problems with two small parameters on a rectangular domain. The method comprises a standard implicit finite difference scheme to discretize in temporal direction on a uniform mesh by means of Rothe's method and finite element method in spatial direction on a piecewise uniform mesh of Shishkin type and W-grid. The computational examples show that the convergence of the methods has a uniform behavior with respect to parameters. The technique is compared to using a Shishkin mesh and shown to be more efficient in numerical tests.

QUANJIAN YAN

Queensborough Community College, CUNY

Early Signature Phase Change in Epilepsy EEG

EEG now start to narrow down its key role in the diagnosis and management of patients with seizures, epilepsy, and altered mental status. Focal EEG abnormalities may consist of epileptiform, nonepileptiform and background wave form. We find the potential useful diagnostic information hide in background wave form with numeric analyses their phase response curve and find the signature change.

YUAN-NAN YOUNG

New Jersey Institute of Technology

Gating of a Mechanosensitive Channel Due to Cellular Flows

In this work we construct a multiscale continuum model for a mechanosensitive (MS) channel gated by tension in a lipid bilayer membrane under fluid stress. We illustrate that for typical physiological conditions vesicle hydrodynamics driven by a fluid flow may render a membrane tension sufficiently large to gate a MS channel open. We focus on the dynamic opening/closing of a MS channel in a vesicle membrane under a planar shear flow and a pressure-driven flow across a constriction channel. Our modeling and numerical simulation results quantify the critical flow strength or flow channel geometry for intracellular transport through a MS channel. Furthermore our results suggest that lipid bilayer membrane reconstituted with MS channels can be mechanically gated for permeability under fluid flows that are physiologically relevant and realizable in microfluidic configurations for medical applications. These modeling and simulation results imply that stress-induced intracellular transport across the lipid membrane can be achieved by the gating of reconstituted MS channels, which can be useful for designing drug delivery in medical therapy and understanding complicated mechanotransduction.

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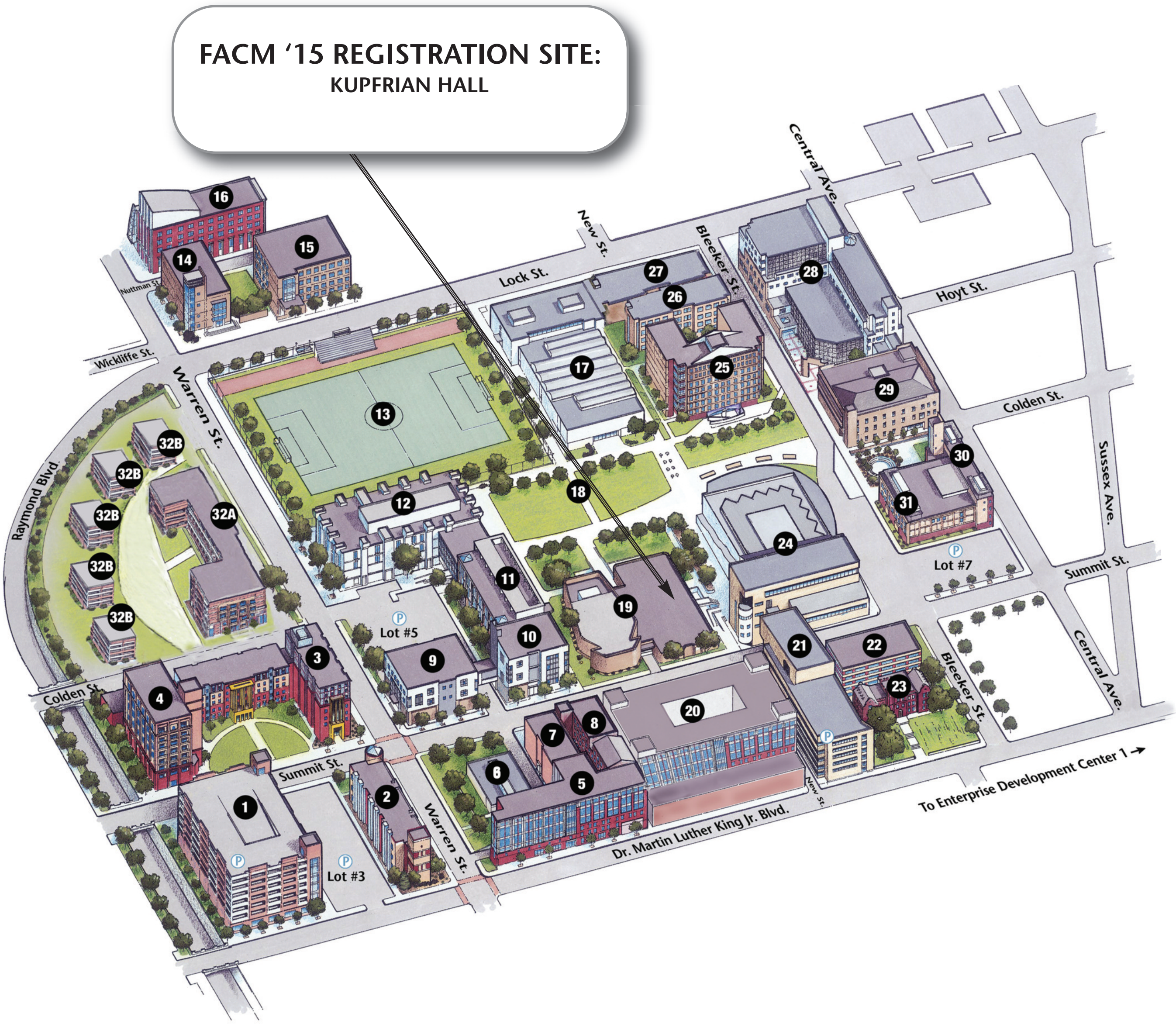
NOTES

NJIT CAMPUS MAP



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

New Jersey Institute of Technology