CAMS

Center for Applied Mathematics and Statistics

ANNUAL REPORT

2019 – 2020

July 1, 2019 – June 30, 2020

NJIT New Jersey Institute of Technology

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I. FROM THE DIRECTOR

The Center for Applied Mathematics and Statistics (CAMS) is entering its 34th year as a vehicle for research in applied mathematics and statistics at NJIT. CAMS supports faculty research by organizing colloquia, seminars and conferences and by facilitating group and interdisciplinary research proposals. We take particular pride in the undergraduate research that is supported by CAMS, which includes the activities of the NSF EXTREEMS Grant as well as undergraduate research publications.

This has been a challenging year due to Covid-19 and unfortunately some of the normal CAMS activities, in particular the annual Frontiers in Applied and Computational Mathematics meeting, were forced to be put on hold. However, there were still a number of highlights and significant achievements in this past year, including:

- Ten new funded projects, including several major grants awarded by the National Science Foundation.

- The oversight of an additional twenty nine continuing grants from various agencies. CAMS receives substantial funding for graduate student and faculty research from sources such as the National Science Foundation, National Institutes of Health, Office of Naval Research, Air Force Office of Scientific Research, NASA, DARPA, American Chemical Society, and other state and local agencies along with private industry.

- The formation of two new degree programs in data science, one each at the masters and bachelors level. Recently there has been a significant expansion in the number of faculty whose primary research area is in data science, and this is expected to continue in the next year.

As always, the accomplishments of CAMS have been built with the support and dedication of many individuals. We are grateful to Fadi Deek, Provost and Senior Vice President of Academic Affairs, Jonathan Luke, Department of Mathematical Sciences Chair, and Atam Dhawan, Senior Vice President for Research, for encouraging CAMS through their strong support of scientific research. Finally, we thank President Joel Bloom, who has been a constant source of support for CAMS and its mission. We look forward to continued fruitful interactions with these individuals in the upcoming year, as well as to significant contribution of CAMS to the universities strategic priorities.

Michael Siegel, Director • Cyrill Muratov, Associate Director

II. MISSION STATEMENT

The Center for Applied Mathematics and Statistics (CAMS) is an interdisciplinary research center dedicated to supporting applied research in the mathematical sciences at NJIT. CAMS was established in 1986 to promote research in the mathematical sciences at the New Jersey Institute of Technology. Members of the Department of Mathematical Sciences naturally form the core of CAMS membership, but the importance of mathematics for science and technology has made CAMS an interdisciplinary organization.

CAMS brings researchers from academia, industry, and government to NJIT by organizing interdisciplinary workshops and by bringing together researchers with common goals whose strengths are complementary. CAMS activities also include support for the submission of research proposals, which is done through dissemination of information, organization of group projects, collegial advice and assistance with application documents. Graduate student research is encouraged through the CAMS Summer Research Program and support for students to attend conferences. CAMS sponsors an annual conference, “Frontiers in Applied and Computational Mathematics,” which has become a leading forum for the presentation of new research in applied mathematics and the sciences.

In the future, CAMS hopes and expects to maintain its high standards of professionalism and scholarship and plans to extend its activities to include fostering more research by undergraduate students and developing long-term relationships with industry.

III. MEMBERS AND VISITORS

Department of Mathematical Sciences

Afkhami, Shahriar
Ahluwalia, Daljit S.
Askham, Travis
Bechtold, John
Blackmore, Denis
Booty, Michael
Bose, Amitabha
Boubendir, Yassine
Bukiet, Bruce
Bunker, Daniel
Chiu, Shang-Huan
Choi, Wooyoung
Cummings, Linda
Deek, Fadi
Dhar, Sunil
Diekman, Casey
Frederick, Christina
Golowasch, Jorge
Goodman, Roy
Guo, Wenge
Hamfeldt, Brittany
Horntrop, David
Horwitz, Kenneth
Jiang, Shidong
Johnson, Kenneth
Kappraff, Jay
Kondic, Lou
Loh, Ji Meng
Luke, Jonathan
Lushi, Enkeleida
Matveev, Victor
MacLaurin, James
Michalopoulou, Zoi-Heleni
Milojevic, Petronije
Muratov, Cyrill
Nadim, Farzan
Oza, Anand
Petropoulos, Peter
Russell, Gareth
Shang, Zuofeng
Shirokoff, David
Siegel, Michael
Subramanian, Sundarraman
Turc, Catalin
Vilanova, Pedro
Wang, Antai
Young, Yuan-Nan

Department of Civil and Environmental Engineering: Meegoda, Jay

Department of Mechanical & Industrial Engineering: Marras, Simone

Rosato, Anthony

Federated Department of Biological Sciences: Holzapfel, Claus (Rutgers University)

Rotstein, Horacio

CAMS External Faculty Members

Booth, Victoria	University of Michigan, Ann Arbor
Diez, Javier	University Nacional del Centro, Tandil, Argentina
Erneux, Thomas	Université Libre de Bruxelles, Belgium
Huang, Huaxiong	York University, Toronto, Canada
Moore, Richard	SIAM, Philadelphia
Papageorgiou, Demetrios	Imperial College, London
Pugnaloni, Luis	University of La Pampa, Argentina
Tao, Louis	Peking University, China
Vanden-Broeck, Jean-Marc	University College London
Wylie, Jonathan	City University of Hong Kong

IV. COLLOQUIA AND SEMINARS

Applied Mathematics Colloquium/ Department of Mathematical Sciences Colloquium

September 6, **Yuan-nan Young**, New Jersey Institute of Technology
From Self-Assembly of Nanoscale Lipid Molecules to Micronscale Vesicle Hydrodynamics Under Adhesion

September 13, **Marsha J. Berger**, Courant Institute, NYU
Progress in Modeling of Asteroid-Generated Tsunamis

September 20, **Sean Lawley**, University of Utah
New Questions in Diffusion Theory Prompted by Biology

September 27, **Andrej Košmrlj**, Princeton University
Phase Separation in Multicomponent Liquid Mixtures

October 4, **Tamer Zaki**, Johns Hopkins University
Vorticity Dynamics in Viscoelastic Turbulence

October 11, **Nathan Glatt-Holtz**, Tulane University
A Bayesian Approach to Quantifying Uncertainty in Divergence Free Flows

October 18, **Ian Tice**, Carnegie Mellon University
Analysis of Free Boundary Problems in Fluid Mechanics

October 25, **Pak-Wing Fok**, University of Delaware
Simulating the Vulnerable Atherosclerotic Plaque through Morphoelasticity

November 1, **Darlayne Addabbo**, University of Notre Dame
Discrete and Ultra-discrete Integrable Systems and Representation Theory

November 8, **Rachel Ward**, ICES, University of Texas (Austin)
Stochastic Gradient Descent, from Linear Systems to Neural Networks

November 15, **Antoine Cerfon**, Courant Institute, NYU
Efficient Integral Equation Based Solvers for Optimized Magnetic Fusion Devices

November 22, **Catalin Turc**, New Jersey Institute of Technology
Planewave Density Interpolation Methods for 3D Helmholtz and Maxwell Boundary Integral Equations

December 6, **David Bader**, New Jersey Institute of Technology
Solving Global Grand Challenges with High Performance Data Analytics

January 31, **Carlos Pérez**, Pontificia Universidad Católica de Chile
Integral Equation Methods for Inverse Design of Metasurfaces

February 7, **Bryan Quaife**, Florida State University
Coupling Between Flow and Porous Structures

February 14, **Roy Goodman**, New Jersey Institute of Technology
Transfer Entropy for Network Reconstruction in a Simple Model

February 21, **Alejandro Rodriguez**, Princeton University
Bringing to Light the Fundamental Limits of Optical Control at the Nanoscale

February 28, **Rongjie Lai**, RPI
Understanding Manifold-Structure Data via Geometric Modeling and Learning

March 6, **Misha Tsodyks**, Institute for Advanced Study
Mathematical Models of Human Memory

April 24, **Shang-Huan Chiu**, New Jersey Institute of Technology
Erosion and Binary Encounters of bodies in Stokes Flows

May 1, **Mohammad Farazmand**, North Carolina State University
Extreme Events: Dynamics, Prediction and Mitigation

Applied Statistics Seminar

October 24, **Zuofeng Shang**, New Jersey Institute of Technology
Statistical Optimality of Deep Neural Networks in Regression and Classification

October 31, **Jiahui Yu**, Boston University
Smoothing Spline Semiparametric Density Models

November 11, **Han Xiao**, Rutgers University
Autoregressive Models for Matrix-Valued Time Series

February 27, **Qiang Tang**, New Jersey Institute of Technology
Rebuilding Trust in the Digital Age

Mathematical Biology Seminar

September 10, **Christopher Miles**, New York University
Diffussive Search for Diffusing Receptors

September 24, **Tapomoy Bhattacharjee**, Princeton University
Bacteria Motility in Three-dimensional Disordered Media

October 1, **Nikolai Chapochnikov**, Flatiron Institute
Does the Fly Know PCA? Evidence for Signal Decorrelation from Connectomics and Neural Activity in Olfaction

October 8, **Emma Greenspon**, Monmouth University
Sensorimotor Mapping of Pitch

October 15, **Sophie Marback**, New York University
Active Mixing and Sieving at the Nanoscale

October 22, **Phillip Barden**, Department of Biological Sciences, New Jersey Institute of Technology
One Hundred Million Years on Forty Sextillion Legs: How Ants and Fossil Amber help us to Understand Evolution

November 12, **Calina Copos**, New York University
A Model for How Cells form a Front and a Rear

November 19, **Matthew Mizuhara**, The College of New Jersey
Synchronization and Pattern Formation in the Kuramoto Model on Random Graphs

February 12, **Shane Kepley**, Rutgers University
Computing Global Dynamics for Biological Networks

February 18, **Saskia Haegens**, Columbia University & Donders Institute
Oscillatory Building Blocks Underlying Perception & Cognition

February 25, **Ulises Obilinovic**, New York University
Attractors, Chaos, Sequences and Meta-Stable Attractors in Recurrent Networks Endowed with Hebbian Plasticity

Fluid Mechanics and Waves Seminars

September 23, **Amir Sagiv**, Department of Applied Physics and Applied Mathematics, Columbia University
Prediction of Random and Chaotic Dynamics in Nonlinear Optics

October 7, **Eduardo Corona,** Department of Mathematics, New York Institute of Technology
A Fast Algorithmic Framework for Dense Rigid Body Suspensions in Stokes Flow

October 21, **Scott Wunsch**, Johns Hopkins University
Internal Waves in Variable Stratification

November 18, **David Stein**, Center for Computational Biology, Flatiron Institute
High-Accuracy Simulations of Thousands of Deformable, Interacting, Active Droplets

February 10, **Pavel Lushnikov**, Department of Mathematics and Statistics, University of New Mexico
Motion of Complex Singularities and Hamiltonian Integrability of Surface Dynamics

February 24, **Stephane Perrard**, Ecole Normale Supérieure, Département de Physique
Surface Wave Generation by Turbulent Flows

V. PUBLICATIONS, PRESENTATIONS, AND REPORTS

A. PUBLICATIONS

Journal Publications

Travis L. Askham

A fast integral equation method for the two-dimensional navier-stokes equations (with L. af Klinteberg and M. C. Kropinski), *Journal of Computational Physics*, Vol 409, Issue 109353, pp. 33, May 2020.

A boundary integral equation approach to computing eigenvalues of the Stokes operator (with M. Rachh), *Advances in Computational Mathematics*, Vol 46, pp. 42, March 2020.

Denis L. Blackmore

Theory of multidimensional Delsarte--Lions transmutation operators. I (with A. Samoilenko, Y. Prykarpatsky, and A. Prykarpatski), *Ukrainian Mathematical Journal*, Vol 70, pp. 1913-1952, July 2019.

Non-associative structure of commutative algebras related with quadratic Poisson brackets (with O. Artemovych and A. Prykarpatski), European Journal of Mathematics, 21 pages, February 2020.

Theory of multidimensional Delsarte--Lions transmutation operators. II (with A. Samoilenko, Y. Prykarpatsky, and A. Prkarpatski), *Ukranian Mathematics Journal,* Vol 71, pp. 921-955, November 2019.

Dispersionless multi-dimensional integrable systems and related conformal structure generating equations of mathematical physics (with O. Hentosh, Y. Prykarpatsky, and A. Prykarpatski), *SIGMA*, Vol 15, pp. 20, October 2019.

A dynamical systems-based hierarchy for Shannon, metric and topological entropy (with R. Addabbo), *Entropy*, Vol 21,14 pages, September 2019.

Bruce G. Bukiet

Nonlinear behavior of high-intensity ultrasound propagation in an ideal fluid (with J. A. Kewalramani, Z. Zhenting, R. W. Marsh, and J. N. Meegoda), *Acoustics*, Vol 2, Issue 1, pp. 147-163, March 2020.

Daniel E. Bunker

TRY plant trait database – enhanced coverage and open access (with J. Kattge, S. Diaz, et al.), *Global Change Biology*, Vol 26, Issue 1, pp. 119-188, December 2019.

Wooyoung Choi

High-order unidirectional model with adjusted coefficients for large-amplitude long internal waves (with C. Zhiand and R.Barros), *Ocean Modeling*, Vol 151, pp. 101643, June 2020.

Group resonant interactions between surface and internal gravity waves in a two-layer system (with T. M. Takloand), *Journal of Fluid Mechanics*, Vol 892, A14, pp. 1-39, April 2020.

Strongly nonlinear effects on internal solitary waves in three-layer flows (with R. Barros and P. Milewski), *Journal of Fluid Mechanics*, Vol 883, A16, pp. 1-36, January 2020.

Stability analysis of deep water waves on a linear shear current using unsteady conformal mapping (with S. Murashige), *Journal of Fluid Mechanics*, Vol 885, A41, pp. 1-27, January 2020.

On Rayleigh expansion for nonlinear long water waves, *Journal of Hydrodynamics*, Vol 31, pp.1115-1126, December 2019.

Shang-Huan Chiu

Viscous Transport in Eroding Porous Media (with M. N. J. Moore and B. D. Quaife), *Journal of Fluid Mechanics*, Vol. 893, June 2020

Linda J. Cummings

Modeling and design optimization for pleated membrane filters (with Y. Sun, P. Sanaei, and L. Kondic), *Physical Review Fluids*, Vol 5, Issue 4, pp.44306, April 2020.

Membrane filtration with multiple fouling mechanisms (with P. Sanaei), *Physical Review Fluids*, Vol 4, Issue 12, pp.124301, December 2019.

Oscillatory instability of liquid films nonlocally heated from below (with W. Batson, D. G. Shirokoff, and L. Kondic*), Journal of Fluid Mechanics*, Vol 872, pp.928-962, August 2019.

Casey O. Diekman

CikA, an input pathway component, senses the oxidized quinone signal to generate phase delays in the cyanobacterial circadian clock (with P. Kim, B. Porr, T. Mori, Y.-S. Kim, C. Johnson, and Y. I. Kim), *Journal of Biological Rhythms*, January 2020.

Magnesium regulates the circadian oscillator in cyanobacteria (with Y. Jeong, C. L. Dias, H. P. Kim, M. Kaur, Y.-S. Kim, H.-I. Jang, and Y. I. Kim), *Journal of Biological Rhythms*, Vol 34, Issue 4, pp. 380-390, August 2019.

Roy H. Goodman

Loss of physical reversibility in reversible systems (with A. Sagiv, A. Ditkowski, and G. Fibich), *Physica D*, Vol 404, pp. 132515, April 2020.

Stability of leapfrogging vortex pairs: a semi-analytic approach (with B. M. Behring), *Physical Review Fluids*, Vol 4, pp. 124703, December 2019.

Topological features determining the error in the inference of networks using transfer entropy (with M. Porfiri), *Mathematics in Engineering*, Vol 2, Issue 1, pp. 34-54, October 2019.

Drift of spectrally stable shifted states on star graphs (with A. Kairzhan and D. E. Pelinovsky), *SIAM Journal of Applied Dynamical Systems*, Vol 18, Issue 4, pp. 1723-1755, October 2019.

Wenge Guo

Familywise error rate controlling procedures for discrete data (withY. Zhu), *Statistics in Biopharmaceutical Research*, Vol 12, pp. 117-128, January 2020.

Shidong Jiang

An integral equation method and variational approach for amphiphilic lipid dynamics (with S.-P. Fu, R. Ryham, A. Klockner, M. Wals, and Y.-N.Young), *SIAM Journal of Multiscale Modeling and Simulation*, Vol 18, Issue 1, pp. 79-103, February 2020.

Lou Kondic

Interaction network analysis in shear thickening suspensions (with A. Signh, M. Gameiro, K. Mischaikow, and J. Morris), *Physical Review Fluids*, Vol 5, pp. 34307, February 2020.

Modeling and design optimization for pleated membrane filters (with Y. Sun, P. Sanaei, and L. J. Cummings), *Physical Review Fluids*, Vol 5, Issue 4, pp. 44306, April 2020.

Intruder in a two-dimensional granular system: Effects of dynamic and static basal friction on stick-slip and clogging dynamics (with M. Carlevaro, R. Kozlowski, L. Pugnaloni, H. Zheng, and J. Socolar), *Physical Review E*, Vol 101, pp. 12909, February 2020.

Liquid-state dewetting of pulsed-laser-heated nanoscale metal films and other geometries (with A. Gonzalez, J. Diez, J. Fowlkes, and P. Rack), *Annual Review of Fluid Mechanics*, Vol 52, pp. 235-262, September 2019.

Oscillatory instability of liquid films nonlocally heated from below (with W. Batson, L. J. Cummings, and D. G. Shirokoff), *Journal of Fluid Mechanics*, Vol 872, pp. 928-962, August 2019.

Energy Propagation through dense granular systems, *Granular Matter*, Vol 21, pp. 85, July 2019.

Enkeleida Lushi

Relating rheotaxis and hydrodynamic actuation using asymmetric gold-platinum phoretic rods (with Q. Brosseau, F. B. Usabiaga, Y. Wu, L. Ristroph, J. Zhang, M. Ward, and M. J. Shelley), *Physical Review Letters*, Vol 123, Issue 17, October 2019.

James N. MacLaurin

Determination of effective brain connectivity from activity correlations (with P. Robinson), *Phys Rev E*, March 2019.

Wandering bumps in a stochastic neural fields: a variational approach (with P. Bressloff), *Physica D*, February 2020.

Phase reduction of stochastic biochemical oscillators (with P. Bressloff), *SIAM Journal of Applied Dynamical Systems*, Vol 19, Issue 1, pp. 151-180, January 2020.

Zoi-Heleni Michalopoulou

Multipath broadband localization, bathymetry, and sediment inversion (with P .Gerstoft), *IEEE Journal of Oceanic Engineering*, Vol 45, pp. 92-102, January 2020.

Introduction to the special issue on acoustic source localization (with B. Ferguson, P. Gendron, and K. T. Wong), *Journal of the Acoustical Society of America*, Vol 146, pp. 4647-4649, December 2019.

Bayesian coherent and incoherent matched-field localization and detection in the ocean (with A.Pole and A. Abdi), *Journal of the Acoustical Society of America*, Vol 146, pp. 4812-4820, December 2019.

Cyrill B. Muratov

Variational principles of micromagnetics revisited (with G. Di Fratta, F. Rybakov, V. Slastikov), *SIAM J. Math. Anal.*, Vol52, pp. 3580–3599, July 2019.

The voltage-dependent manipulation of few-layer graphene with a scanning tunneling microscopy tip (with M. M. Alyobi, C. J. Barnett, V. Moroz, and R. J. Cobley), *Carbon*, Vol 163, pp. 379-384, March 2020.

Unraveling the role of dipolar vs. Dzyaloshinskii-Moriya interaction in stabilizing compact magnetic skyrmions (with A. Bernand-Mantel, and T. Simon), *Phys. Rev. B*, Vol 101, pp. 45416, January 2020.

Edge domain walls in ultrathin exchange-biased films (with R. Lund and V.Slastikov), *J. Nonlin. Sci.*, Vol 30, pp.1165-1205, January 2020.

Emergence of non-trivial minimizers for the three-dimensional Ohta-Kawasaki energy (with H. Knuepfer and M. Novaga), *Pure Appl. Analysis*, Vol2, pp. 43851, November 2019.

Farzan Nadim

Membrane potential resonance arising from responses of neuronal models to oscillatory inputs in current versus voltage clamp (with H. G. Rotstein), *Biological Cybernetics*, Vol 113, pp. 373–395, July 2019.

Anand U. Oza

Lattices of hydrodynamically interacting flapping swimmers (with L. Ristroph and M. J. Shelley), *Physical Review X*, Vol 9, Issue 41024, November 2019.

Luis Pugnaloni

Differential equation for the flow rate of discharging silos based on energy balance (with J. R. Darias, and M. A. Madrid), *Physical Review E*, Vol 101, pp. 052905, May 2020.

Intruder in a two-dimensional granular system: Effects of dynamic and static basal friction on stick-slip and clogging dynamics (C. M. Carlevaro, R. Kozlowski, H. Zheng, J. E. S. Socolar, and L. Kondic), *Physical Review E*, Vol 101, pp. 012909, January 2020.

Dynamics of a grain-scale intruder in a two-dimensional granular medium with and without basal friction (with R. Kozlowski, C. M. Carlevaro, K. E. Daniels, L. Kondic, J.E.S. Socolar, H. Zheng and R.P. Behringer), *Physical Review E*, Vol 100, pp. 032905, September 2019.

Velocity profiles in forced silo discharges (with M. A. Madrid), *Granular Matter*, Vol 21, pp. 76, July 2019.

Horacio G. Rotstein

Analysis of spike-driven processes through attributable components (with E. Tabak), *Comm Math Sci*, Vol 17, pp. 1177-1192, December 2019.

Membrane potential resonance arising from responses of neuronal models to oscillatory inputs in current versus voltage clamp (with F. Nadim), *Biological Cybernetics*, Vol 113, pp. 373–395, July 2019.

Resonance-based mechanisms of generation of relaxation oscillations in networks of non-oscillatory neurons (with A. Bel), *Trends in Mathematics: Research Perspectives (CRM Barcelona, Summer 2018)*, Vol 2018, July 2019.

Zuofeng Shang

Nonparametric distributed learning under random design(with M. Liu and G.Cheng), *Electronic Journal of Statistics*, January 2020.

Identification and estimation in panel models with overspecified number of groups (with R. Liu, Y. Zhang, and Q.Zhou), *Journal of Econometrics*, January 2020.

Distributed generalized cross-validation for divide-and-conquer kernel ridge regression and its asymptotic optimality (with G. Xu and G. Cheng), *Journal of Computational and Graphical Statistics*, January 2019.

Nonparametric bayesian aggregation for massive data (with B. Hao and G. Cheng), *Journal of Machine Learning Research*, January 2019.

Statistical inference on panel data models: a kernel ridge regression method (with S. Zhao and R. Liu), *Journal of Business & Economic Statistics*, January 2019.

David Shirokoff

Oscillatory instability of liquid films nonlocally heated from below (with W. Batson, L. J. Cummings, and L. Kondic), *Journal of Fluid Mechanics*, Vol 872, pp. 928-962, August 2019.

Michael Sigel

Rotation of a superhydrophobic cylinder in a viscous liquid (with E. Yariv), *Journal of Fluid Mechanics,* Vol 880, pp. R4 1-13 (13 pages), December 2019.

Sundarraman G. Subramanian

Function-based hypothesis testing in censored location-scale models, *Lifetime Data Analysis*, Vol 27, Issue 1, 31 pages, January 2020.

Pedro Vilanova

Data-driven, variational model reduction of high-dimensional reaction networks (with M. Katsoulakis), *Journal of Computational Physics*, Volume 401, Jan 2020.

Synchronization in stochastic biochemical oscillators subject to common multiplicative extrinsic noise (with J. Maclaurin), *SIAM Journal on Applied Dynamical Systems*, 2020.

Yuan-Nan Young

An integral equation method and variational approach for amphiphilic lipid dynamics (with S.-P. Fu, R. Ryham, A. Klockner, M. Wals, and S.Jiang), *SIAM Journal of Multiscale Modeling and Simulation*, Vol 18, Issue 1, pp. 79-103, February 2020.

Hydrodynamics and rheology of a vesicle doublet suspension (with B. Quaife and S. Veerapaneni), *Physical Review Fluids*, Vol 4, pp. 103601, October 2019.

Primary cilia have a length-dependent persistence length (with J. Flaherty, Z. Feng, Z. Peng, and A. Resnick), *Biomechanics and Modeling in Mechanobiology*, Vol 19, pp. 445-460, September 2019.

Conferences

Bruce Bukiet

Integrating online student reflection in a constructively aligned college math course: a faculty case study (with J. M. Lipuma), Global Learn, JAssociation for the Advancement of Computing in Education (AACE), pp. 47-56, July 2019.

Kenneth Horwitz

Utilizing analytics to show representations in comparing and ordering fractions, WTM, Verlag für wissenschaftliche Texte und Medien, August 2019.

Ji Meng Loh

Quantitative metrics for mutation testing (withA. Ayad and A. Mili), International Conference on Software Technologies (ICSOFT), July 2019.

Enkeleida Lushi

Accumulation of motile microorganisms in turbulence (with C. Zhan, G. Sardina, and L. Brandt), January 2020.

Zuofeng Shang

Non-asymptotic theory for nonparametric testing (with Y. Yang and G. Cheng), 33rd Annual Conference on Learning Theory, January 2020.

Sharp theoretical analysis for nonparametric testing under random projection (with M. Liu and G. Cheng), 32nd Annual Conference on Learning Theory, January 2019.

David Shirokoff

DIRK schemes with high weak stage order (with D. Ketcheson, B. Seibold, and D. Zhou), pp. 453-463, August 2020.

Software

Victor Matveev

Calcium Calculator (CalC) modeling software, release 7.9.6, Software, August 2019.

Books

Anthony Rosato

Segregation in Vibrated Granular Systems (with C. Windows-Yule), *Academic Press,* June 2020.

B. PRESENTATIONS

Shahriar Afkhami

August 25, 2019: Max Planck Institute for the Physics of Complex Systems Workshop: Challenges in Nanoscale Physics of Wetting Phenomena, Dresden, Germany
"Pore-scale Direct Numerical Simulation of Haines Jumps in a Porous Media Model"

Travis L. Askham

July 2019: International Congress on Industrial and Applied Mathematics, International Council for Industrial and Applied Mathematics, Valencia, Spain
"Fredholm Determinants: a Robust Approach to Computing Stokes Eigenvalues"

Denis L. Blackmore

November 8, 2019: Nonlinear Analysis and Dynamics Seminar, University of Texas at Dallas, Dallas, TX
"Unusual Chaotic Bifurcations"

October 22, 2019: Lunch @ ITE, ITE, NJIT, Newark, NJ
"A Fractal Primer"

Michael R. Booty

November 23, 2019: 72nd Annual Meeting of the American Physical Society Division of Fluid Dynamics, American Physical Society, Seattle, WA
"A Model for Electrokinetic Flow With Deformable Interfaces"

Yassine Boubendir

Air Force Office of Scientific Research Meeting, San-Antonio

Shang-Huan Chiu

June 19, 2020: The Northeast Complex Fluids and Soft Matter Workshop, City College of New York, New York, NY **Virtual**
“The Wave Instability in Two-Phase Flows of Non-Newtonian Fluids”

April 24, 2020: Applied Mathematics Colloquium. New Jersey Institute of Technology, Newark, NJ **Virtual**
“Erosion and Binary Encounters of Bodies in Stokes Flows”

January 17, 2020: The Northeast Complex Fluids and Soft Matter Workshop, Manhattan College, Riverdale, NY
“Viscous Transport in Eroding Porous Media”

November 26, 2019: Annual Meeting of the APS Division of Fluid Dynamics, Seattle, WA
“Viscous Transport in Eroding Porous Media”

November 15, 2019: Mid-Atlantic Numerical Analysis Day. Temple University, Philadelphia, PA
“Viscous Transport in Eroding Porous Media”

September 21, 2019: Annual Meeting of SIAM Southeastern Atlantic Section, University of Tennessee, Knoxville, TN
“Viscous Transport in Eroding Porous Media”

Casey O. Diekman

June 10, 2020: Centre for Biological Timing Seminar, University of Manchester, Manchester, UK **Virtual**
"Data Assimilation Methods and Modeling of Circadian Clock Neurons"

May 18, 2020: Quantitative Biology and Medicine Seminar, University of Exeter, Exeter, UK
"Data Assimilation and Modeling of Circadian Clock Neurons"

May 5, 2020: MBI Workshop on Mathematical and Computational Methods in Biology, Mathematical Biosciences Institute, The Ohio State University,Columbus, OH **Virtual**
"Data Assimilation Methods for Conductance-based Neuronal Modeling"

February 3, 2020: Physiology, Pharmacology, and Neuroscience Seminar, University of Bristol, Bristol, UK "Data Assimilation Methods for Neuronal State and Parameter Estimation"

January 7, 2020: Fulbright Forum, US-UK Fulbright Commission, Cardiff, Wales, UK
"Multiscale Modeling of Circadian Rhythms"

October 1, 2019: Dynamics Seminar, University of Exeter, Exeter, UK
"Mathematical Modeling of Circadian Rhythms: Gene Expression, Membrane Excitability, and Jet Lag"

August 29, 2019: EBRS 2019, European Biological Rhythms Society, Lyon, France
"Circadian Rhythmicity of Cardiac Arrhythmias in a Computational Model of Ventricular Myocytes"

Christina A. Frederick

April 24, 2020: CUNY Harmonic Analysis and PDE, CUNY Graduate Center, New York, NY
"Finding Orthogonal Systems of Exponentials on Multi-tiles"

July 31, 2019: Computational Multiscale Methods, Oberwolfach Institute, Overwalfach, Germany

July 13, 2019: ICIAM 2019, NJIT, Valencia, Spain

July 1, 2019: 5th International Conference on Underwater, Acoustics, Crete, Greece
“Machine Learning, Compressive Sensing and Signal Processing”

Roy H. Goodman

February 14, 2020: Applied Mathematics Colloquium, Department of Mathematical Sciences, NJIT, Newark, NJ
"Transfer Entropy for Network Reconstruction in a Simple Dynamical Model"

December 5, 2019: Canadian Mathematical Society Winter Meeting,Canadian Mathematical Society, Toronto, ON
"Leapfrogging Vortex Pairs: Linear Stability, Nonlinear Dynamics, and Escape"

Wenge Guo

July 30, 2019: 2019 Joint Statistical Meetings,American Statistical Association, Denver, CO
"A New Approach for Large-scale Multiple Testing With Application to FDR Control for Graphically Structured Hypotheses"

Brittany D. Hamdelfdt

June 30, 2020: NJIT DMS Summer Talks, NJIT, Newark, NJ **Virtual**
"Convergent Numerical Methods for Optimal Transport"

April 20, 2020: Applied and Computational Math Colloquium, University of Minnesota, Minneapolis, MN **Virtual**
"Numerical Methods for Optimal Transport"

September 20, 2019: Applied and Computational Math Seminar, Rutgers University, Piscataway, NJ
"Generalised Finite Difference Methods for Fully Nonlinear Elliptic Equations"

Kenneth A. Horwitz

January 2020: Joint Mathematics Meetings, MAA, Denver CO
"Utilizing Inquiry Based Learning to Prepare Urban High School Students for Success in College Mathematics"

October 2019: Mid-Atlantic RUME Regional, RUME, James Madison University, VA
"Utilizing Open Educational Resources to Promote Inquiry Based Learning in Calculus"

August 2019: International Conference on Mathematics Education for the Future Project, Kildare, Ireland
"Utilizing Analytics to Show Representations in Comparing and Ordering Fractions"

Lou Kondic

April 1, 2020: Granular Matter Course Series, University Twente, Enschede, Netherlands
"Topology Methods for Granular Matter"

February 5, 2020 :Advanced School: “Introduction to wetting dynamics”, Muenster University, Muenster, Germany
"Modeling Dynamics of Thin Films Including Thermal Effects"

February 1, 2020: WE-Heraeus Seminar on Wetting and Capillarity, Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany
"Instabilities of Liquid Crystal Films on Nanoscale"

November 1, 2019: WE-Heraeus Seminar on Wetting and Capillarity, DFG, Bad Honnef, Germany
"Instabilities of Liquid Crystal Films on Nanoscale"

October 10, 2019: Seminar at Department of Physics, Muenster University, Muenster, Germany
"Modeling and Computing Evolution of Thin Films on Thermally Conductive Substrates,"

October 5, 2019: Seminar Max Planck Institute for Dynamics and Self-Organization, Max Planck Institute, Göttingen, Germany
"Modeling and Computing Evolution of Thin Films on Thermally Conductive Substrates"

October 1, 2019: Seminar at Max Planck Institute for Dynamics and Self-Organization, Max Planck Institute, Göttingen, Germany
"Modeling and Computing Evolution of Thin Films on Thermally Conductive Substrates"

September 10, 2019:13th European Coating Symposium, European Coating Society, Heidelberg, Germany
"Metal Films of Nanoscale Thickness: from Targeted Experiments to Predictive Modeling and Accurate Simulations"

September 10, 2019: Seminar at Max Planck Institute for Polymer Research, Max Planck Institute, Mainz, Germany
"Modeling Metal Films on Nanoscale Including Thermal Effects"

September 5, 2019: Seminar at the Department of Physics, University of Twente, Enschede, Netherlands
"Understanding Dense Granular Matter Using Persistent Homology"

August 25, 2019: Workshop on Challenges in Nanoscale Physics of Wetting Phenomena, Max Planck Institute for Complex Systems, Dresden, Germany
"Computing Evolution of Thin Films on Nanoscale"

July 10, 2019: 27th Congress on Statistical Physics, University of Buenos Aires, Buenos Aires, Argentina
1. "Loss of Memory in Dense Sheared Particulate Systems"
2. "Stochastic Modeling of Flow Through Complex Geometries"

Enkeleida Lushi

June 2020: Seminar, Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany
"Micro-swimmers Moving in Complex Confinement"

April 2020: Invited talk, Conference “Active Matter at the Frontier”, Kavli Institute of Theoretical Physics, CA
"Controlling and Directing Microswimmers by Confinement"

February 2020: Seminar, Widely Applied Mathematics, Harvard University, Cambridge, MA
"Micro-swimmers Moving in Complex Confinement"

November 2019: APS-DFD Annual Meeting, Seattle, WA
1. "Relating Microswimmer Synthesis to Hydrodynamic Actuation and Rheotactic Tunability"
2. "Microswimmer and Obstacle Interactions Mediated by Pressure Fields"
3. "Interaction of spermatozoa with micro-structured surfaces"
4. "Auto-phoretic nanorods driven up the wall by gravity"

November 2019: Applied Math Seminar at University of Delaware, Department of Math, University of Delaware, Newark, DE
"Nonlinear concentration patterns and bands in chemotactic active suspensions"

October 2019: SES Annual Meeting,Society of Engineering Science
"Improved Models and Scale Simulations of Micro-swimmer Collective Motion"

August 2019: Gordon Research Conference on Soft Matter
"Relating Rheotaxis and Hydrodynamic Actuation Using Asymmetric Gold-platinum Phoretic Rods"

July 2019: Keynote Talk, Workshop Fluid-Structure Interactions at Micro-Scale, Lawrence Berkeley National Lab, CA
"Micro-swimmers in Complex Confinement"

July 2019: International Council for Applied and Industrial Mathematics, Valencia, Spain
1. "Bacterial Spread in Porous Media"
2. "Minimal Models of Micro-swimmers in Confinement"

June 2019: Seminar, Soft Materials Coffee Hour, Princeton University
"Micro-swimmers in Complex Confinement"

James N. MacLaurin

October 25, 2019: Drexel University Departmental Seminar, Drexel University, Philadelphia, PA
"Spin Glass Dynamics"

October 19, 2019: SIAM Texas Louisiana Second Annual Meeting, SIAM, Southern Methodist University, Dallas, Texas
"Synchronization Through Common Noise in Pdmp Oscillators"

July 30, 2019: Society for Mathematical Biology 2019, SMB, Montreal, Canada
"Synchronization in Biological Oscillators"

July 3, 2019: Chemical Reactions Workshop, University of Torino, Turin, Italy
"Stochastic Oscillations in Biology"

Cyrill B. Muratov

May 2020: Applied Mathematics Seminar, University of Pisa, Pisa, Italy
"Mathematics of Charged Liquid Drops"

February 2020: Mathematical Physics Seminar, Rutgers University, New Brunswick, NJ
"Mathematics of Charged Liquid Drops"

November 2019: Workshop on Modeling of Crystalline Interfaces and Thin Film Structures, The Erwin Schroedinger International Institute for Mathematics and Physics, Vienna, Austria
"Chiral Domain Walls and Domain Wall Tilt in Ferromagnetic Nanostrips"

October 2019: Workshop on PDEs and Applications to Life Sciences, Penn State University, State College, PA
"The Mathematics of Charged Liquid Drops"

July 2019: LPCNO Seminar, CNRS, INSA, Toulouse, France
"The Mathematics of Charged Liquid Drops"

July 2019: The 9th International Congress on Industrial and Applied Mathematics, NSF, Valencia, Spain
1. "A Nonlocal Variational Problem With Dipolar Repulsion"
2. "An Isoperimetric Problem for Charged Liquid Droplets"
3. "Nonlocality in Variational Problems of Micromagnetics"

Padma Natarajan

March 20, 2020: NJIT Department of Mathematical Sciences Meeting, NJIT, Newark, **Virtual**
"Lockdown Browser and Respondus Monitor"

September 24, 2019: Lunch at ITE Session, ITE, NJIT, Newark, NJ
"Tools to Engage and Assess Students in the Classroom"

Anand U. Oza

March 3, 2020: APS March Meeting, American Physical Society, **Virtual**
"Active Surfers on a Vibrating Bath: Self-propulsion and Interactions"

September 15, 2019:Applied Math Seminar, University of Delaware, Newark, DE
"Coarse-grained Models for Schooling Swimmers"

July 16, 2019: International Congress on Industrial and Applied Mathematics, Valencia, Spain
"A Free-streamline Model for a Liquid Film in a Fast Flow"

Anthony Rosato

July 6, 2019: Traffic and Granular Flow 2019, Pamplona, Spain
“Energy dissipation in forced silo discharges”

Zuofeng Shang

October 13, 2019: Fall Eastern Sectional Meeting, American Mathematical Society, Binghamton University, Binghamton, NY
"Statistical Optimality of Deep Neural Networks in Regression and Classification"

October 4, 2019: Department Colloquium, New York University, New York, NY
"Statistical Optimality of Deep Neural Networks in Regression and Classification"

September 20, 2019: Department Colloquium, Auburn University, Auburn, AL
"Statistical Optimality of Deep Neural Networks in Regression and Classification"

David G. Shirokoff

June 4, 2020: NJIT Graduate Student Summer Series, NJIT, Newark, NJ **Virtual**
"Stability and Numerics in Differential Equations,"

July 22, 2019: The International Conference on Scientific Computation and Differential Equations (SciCADE), University of Innsbruck, Innsbruck, Austria
"Unconditional Stability Proofs for Multistep Imex Schemes"

July 16, 2019: International Congress on Industrial and Applied Mathematics (ICIAM), Valencia, Spain
"High-order Time Stepping for the Navier-stokes Equations Via Pressure Poisson Reformulations"

July 15, 2019: International Congress on Industrial and Applied Mathematics (ICIAM), Valencia, Spain
"Unconditional Stability for Multistep Imex Schemes"

Michael S. Siegel

October 25, 2019: Workshop on Complex Analysis in Mathematical Physics and Applications, Newton Institute, Cambridge, UK
"Complex Variable Techniques Applied to Two Problems in Stokes Flow: Rotation of a Superhydrophobic Cylinder, and Evolution of Multiple Drops With Surfactant"

July 23, 2019: NJIT DMS Summer Graduate Student Seminar, NJIT, Newark, NJ
"Rotation of a Superhydrophobic Cylinder in a Viscous Liquid"

July 19, 2019: International Conference on Industrial and Applied Mathematics (ICIAM), Valencia, Spain
1. "Rotation of a Superhydrophobic Cylinder in a Viscous Liquid"
2. "Singularities and Near Singularities in the Deformation of a Viscous Electrolyte Drop"

Sundarraman Subramanian

July 30, 2019: Joint Statistical Meetings, Colorado Convention Center, Denver, CO
“Function-based Hypothesis Testing in Uncensored and Censored Two-sample Location-scale Models"

Pedro Vilanova

June 2020: SIAM Life Sciences Biological Oscillators Minisymposium, **Virtual**
"Synchronization in Stochastic Biochemical Oscillators Subject to Common Extrinsic Noise"

October 2019: Ki-Net Young Researchers Workshop, University of Maryland, College Park
"Information-Based Variational Model Reduction of High-Dimensional Reaction Networks"

September 2019: European Conference on Numerical Mathematics and Advanced Applications (ENUMATH 2019)
"Model Reduction of High-Dimensional Reaction Network”

Yuan-Nan Young

April 7, 2020: Applied Math Seminar at University of Delaware, Department of Math, University of Delaware, Newark, DE
"Active Porous Fluids: Modeling and Simulation (postponed Due to Covid19)"

January 6, 2020: Applied Physics Seminar at Academia Sinica,Institute of Physics, Academia Sinica, Taipei, Taiwan
"A Hybrid Approach for Collective Hydrodynamics of Amphiphiles in a Viscous Solvent"

January 2, 2020: Workshop on Analysis and its Applications in Biology and Physiology, National Center for Theoretical Studies, National Taiwan University, Taipei, Taiwan
"Helfrich Free Energy and Beyond"

November 26, 2019: APS/DFD 2019, APS, Seattle, WA
"Nanoscale Capillary Bridges and the Role of Hydration Forces"

November 24, 2019: APS/DFD 2019, APS, Seattle, WA
"Linear Instability and Nonlinear Dynamics of a Drop and Thin Film of Active Fluid"

October 14, 2019: Multiscale Modeling Seminar at IIT, Department of Applied Math,
Illinois Institute of Technology, Chicago, IL
"Modeling the Fluid-structure Interac- Tions in Cellular Mechanics: Elastic Membranes, Poroelastic Media, and Activities"

October 13, 2019: Society of Engineering Sciences Technical Meeting in St. Louis, MO, Society of Engineering Sciences, St. Louis, MO
"A Deformable Poroelastic Particle in Linear Flows"

September 24, 2019: Department of Mathematics Applied Math Seminar at MIT, Massachusetts Institute of Technology, Cambridge, MA
"Modeling the Fluid-structure Interactions in Cellular Mechanics: Elastic Membranes, Poroelastic Media, and Activities"

August 22, 2019: Fields Institute Workshop on Ion Transport, Fields Institute, Toronto, Canada
"Nanoscale Liquid Bridge"

VI. EXTERNAL ACTIVITIES AND AWARDS

A. FACULTY ACTIVITIES

Shahriar Afkhami

Associate Editor, Journal of Engineering Mathematics, January 2016 - Current

Denis Blackmore

Associate Editor, Mechanics Research Communications, 2007 - Current Editorial Board,

Universal Journal of Physics and Application, 2015 - Current

Editorial Board, Atlantis/Springer Advanced Book Series: Studies in Mathematical Physics: Theory and Applications, 2011 - Current

Editorial Board, Journal of Nonlinear Mathematical Physics, 2010 - Current

Editorial Board, Differential Equations and Applications, 2008 - Current

Editorial Board, Regular and Chaotic Dynamics, 2006 - Current

Editorial Board, Mathematical Bulletin of the Shevchenko Scientific Society, 2005 - Current

Bruce G. Bukiet

Backpage Problem Editor, Association of Math Teachers of New Jersey, 2007 - Current

Linda J. Cummings

Associate Editor of IMA Journal of Applied Mathematics, Institute of Mathematics and its Applications, London, July 2011 - Current

Roy H. Goodman

Long Term Visitor, New York University Tandon School of Engineering, September 2018 - Current

Shidong Jiang

Editorial Board, Journal of Scientific Computing, 2020 - Current

Jay M. Kappraff

President of NJIT chapter, Sigma Xi, September 2007 - Current

Member of the Editorial Board of ISIS Symmetry Journal, ISIS Symmetry, September 2003 - Current

Lou Kondic

Fellow, American Physical Society

Simone Marras

Associate Editor, Quarterly Journal of the Royal Meteorological Society, 2018 - Current

Topical Editor, Geoscientific Model Development, Copernicus EGU, 2014 - Current

Luis Pugnaloni

Managing Editor, Papers in Physics, 2009 - Current

Michael Siegel

Associate Editor, Journal of Engineering Mathematics

B. FACULTY AWARDS

Shahriar Afkhami

Open Affordable Textbook (OAT) at NJIT, November 2019

Travel Award at Max Planck Institute for the Physics of Complex Systems, August 2019

Casey Diekman

Fulbright Scholarship at US-UK Fulbright Commission, September 2019

Enkeleida Lushi

Visiting Fellowship at the Kavli Institute of Theoretical Physics, Santa Barbara, CA, April-May 2020

Cyrill Muratov

Visiting Fellowship at CNRS, Laboratoire de Physique et Chimie des Nano-objets, INSA, Toulouse, France, July 2019

VII. FUNDED RESEARCH

A. EXTERNALLY FUNDED RESEARCH

Continuing Funded Projects

The Study of Hele-Shaw Viscoelastic Two-Phase Flows
American Chemical Society: January 1, 2019 – August 31, 2021
Shahriar Afkhami

Recent Advances in Numerical Wave Propagation
National Science Foundation: August 1, 2018 - July 31, 2019
Yassine Boubendir

Efficient High Frequency Integral Equations and Iterative Methods
National Science Foundation: August 1, 2017 - July 31, 2020
Yassine Boubendir

NSF INCLUDES DDLP: Leadership and iSTEAM for Females in Elementary school (LiFE): An Integrated Approach to Increase the Number of Women Pursuing Careers in STEM
National Science Foundation: April 1, 2018 - August 31, 2021
Bruce Bukiet

Collaborative Research: Nonlinear Interactions between Surface and Internal Gravity Waves in the Ocean
National Science Foundation: September 15, 2016 - August 31, 2019
Wooyoung Choi

Liquid Crystal Films Across Scales: Dewetting & Dielectrowetting
National Science Foundation: September 1, 2018 - August 31, 2021
Linda Cummings (PI), Lou Kondic (Co-PI)

GOALI: Predicting Performance & Fouling of Membrane FiltersNational Science Foundation: September 15, 2016 - August 31, 2020
Linda Cummings (PI), Lou Kondic (Co-PI)

CAREER: Neuronal Data Assimilation Tools and Models for Understanding Circadian Rhythms
National Science Foundation: July 1, 2016 - June 30, 2021
Casey Diekman

Numerical Methods for Multiscale Inverse Problems and Applications to Sonar Imaging
National Science Foundation: September 1, 2017 - August 31, 2020
Christina Frederick

CAREER: Generated Jacobian Equations in Geometric Optics and Optimal Transport
National Science Foundation: July 1, 2018 - June 30, 2023
Brittany Hamfeldt

Meshfree Finite Difference Methods for Nonlinear Elliptic Equations
National Science Foundation: September 1, 2016 - August 31, 2020
Brittany Hamfeldt

Numerical Methods for Optimal Transportation
Simons Foundation: September 1, 2016 - August 31, 2021
Brittany Hamfeldt

Collaborative Research: Efficient High-Order Algorithms for Nonequilibrium Microflows over the Entire Range of Knudsen Number
National Science Foundation: July 1, 2017 - June 30, 2020
Shidong Jiang

Conference on Frontiers in Applied and Computational Mathematics
National Science Foundation: May 1, 2019 – April 30, 2020
Lou Kondic (PI), Denis Blackmore (Co-PI), Linda Cummings (Co-PI), Michael Siegel (Co-PI)

Stick-Slip Dynamics and Failure in Granular Materials
Army Research Office: July 15, 2018 – July 14, 2020
Lou Kondic

Collaborative Research: Computations, Modeling and Experiments of Self and Directed Assembly for Nanoscale Liquid Metal Systems
National Science Foundation: July 1, 2016 – June 30, 2020
Lou Kondic (PI), Shahriar Afkhami (Co-PI)

Collaborative Research: Computational and Data-Enabled Science and Engineering
National Science Foundation: September 15, 2015 – August 31, 2019
Lou Kondic

Scalable Inference of quantile Regression for Large-Scale Health Care Data
National Institutes of Health: May 15, 2019 – April 30, 2022
Ji Meng Loh

Collaborative agreement with Meadowlands Environmental Research Institute - Benthic Project
Rutgers University: January 1, 2018 – September 30, 2019
Ji Meng Loh

Geoacoustic Inversion in Shallow Water
U.S. Navy: Office of Naval Research: March 1, 2018 - February 28, 2021
Zoi-Heleni Michalopoulou

Shallow Water Inversion with Optimization and Direct Methods
Office of Naval Research: April 1, 2016 - September 30, 2019
Zoi-Heleni Michalopoulou

Magnetization Dynamics at Nanoscale
National Science Foundation: July 1, 2016 - June 30, 2020
Cyrill Muratov

Wave-Coupled Active Matter
Simons Foundation: September 1, 2018 - August 31, 2023
Anand Oza

US-Israel Research Proposal: Network Resonance: Spiking Mechanisms and Behavioral Implications
National Science Foundation: September 15, 2016 - August 31, 2020
Horacio Rotstein

Collaborative Research: Overcoming Order Reduction and Stability Restrictions in High-Order Time-Stepping
National Science Foundation: August 1, 2017 - July 31, 2023
David Shirokoff

Penalty Methods and Computational Material Science
Simons Foundation: September 1, 2015 - August 31, 2020
David Shirokoff

Efficient Solutions of Wave Propagation Problems in Multi-Layered, Multiple Scattering Media
National Science Foundation: September 1, 2016 - August 31, 2021
Catalin Turc

Collaborative Research: Theoretical, Computational and Experimental Investigations on the Interaction Between a Lipid Bilayer Membrane and a Solid Substrate or Particle
National Science Foundation: September 1, 2016 - August 31, 2019
Yuan-Nan Young

Continuing Funded Training Programs

EXTREEMS-QED: Research and Training in Computational and Data-Enabled Science and Engineering for Undergraduates in the Mathematical Sciences at NJIT
National Science Foundation: September 1, 2013 - August 31, 2021
Michael Siegel, David Horntrop, Ji Meng Loh, Zoi-Heleni Michalopoulou, and Marvin Nakayama

Projects Funded During the Present Academic/ Fiscal Year

Collaborative Research: A Two-Week Mentored Program to Prepare Graduate Students for Industrial Careers
National Science Foundation: July 1, 2019 - June 30, 2020
Linda J. Cummings

A High-Order Kernel-Independent Fast Direct and/or Iterative Solver for Integral Equations in Two Dimensions
Simons Foundation: January 2, 2020 - May 15, 2020
Shidong Jiang

Modeling and Simulations of Problems in Active Matter
Simons Foundation: September 1, 2019 - August 31, 2024
Enkeleida Lushi

Geoacoustic Inversion in Shallow Water – Analytic and Optimization Methods
U.S. Navy: Office of Naval Research: March 1, 2020 - February 28, 2023
Eliza (Z.-H.) Michalopoulou

Coherent Structures in Nanomagnetism
National Science Foundation: July 1, 2019 - June 30, 2022
Cyrill Muratov

Phase Transitions in Colloid-Polymer Mixtures in Microgravity
National Aeronautics and Space Administration: November 5, 2019 - November 4, 2021
Anand Oza

Computational and Data-Enabled Science and Engineering: Collaborative Research: Scalable Nonparametric Learning for Massive Data with Statistical Guarantees
National Science Foundation: August 1, 2019 - July 31, 2021
Zuofeng Shang

Collaborative Research: Nonparametric Bayesian Aggregation for Massive Data
National Science Foundation: August 1, 2019 - August 31, 2020
Zuofeng Shang

Numerical Methods and Analysis for Interfacial Flow with Ionic Fluids and Surfactants
National Science Foundation: August 1, 2019 - July 31, 2022
Michael Siegel

Optimized Domain Decomposition Methods for Wave Propagation in Complex Media
National Science Foundation: September 1, 2019 - August 31, 2022
Catalin Turc

B. PROPOSED RESEARCH

Projects Proposed During Present Fiscal Year

Shahriar Afkhami

Classified
NASA Solicitation and Proposal Integrated Review and Evaluation System, December 2019

Numerical algorithms for multi-scale viscoelastic multi-phase flows
National Science Foundation, September 2019

Travis Askham

Fast Integral Equation Methods for Navier-Stokes Equations with Complex, Moving Geometries
National Science Foundation, December 2019

Amitabha Bose

Collaborative Research: CRCNS US-German Research Proposal: How does the brain learn the pattern and beat of rhythmic sound?
National Science Foundation,November 2019

Yassine Boubendir

Collaborative: Novel Microlocal-Analysis and Domain-Decomposition Based Fast Algorithms for Elastic Wave Modeling and Inversion in Variable Media
National Science Foundation, November 2019

Wooyoung Choi

Nonlinear interactions between surface and internal waves
National Science Foundation, November 2019

Sunil Dhar

Finding Biomarkers For Severe Congenital Syphilis
New Jersey Alliance for Clinical and Translational Science, October 2019

Christina Frederick

Exploiting and uncovering multiscale structures in data
National Science Foundation, November 2019

Deep Learning and Multiscale Modeling for Inverse Scattering Problems
US Department of Energy, March 2020

Wenge Guo

Collaborative Research: New Methods and Theory for Simultaneous and Selective Inference
National Science Foundation, December 2019

Kenneth Horwitz

New Jersey Institute of Technology Active Learning Academy
National Science Foundation, November 2019

Shidong Jiang

A High-Order Kernel-Independent Fast Direct and/or Iterative Solver for Integral Equations in Two Dimensions
Simons Foundation, November 2019

Lou Kondic

Employing surface acoustic waves and substrate wettability for active phase separation of oil/water emulsi
American Chemical Society, March 2020

Collaborative Research: Thermal and Phase Separation Effects during Assembly of Nanoscale Liquid Metal Alloys
National Science Foundation, December 2019

Predicting spreading of contagion using topological data analysis
University of Oklahoma, June 2020

Predicting avalanching based on dynamic data and machine learning
US Department of Energy, May 2020

Ji Meng Loh

New spatio-temporal point analysis methods with application to large multi-year New York City Stop-and-Frisk data
National Science Foundation, January 2020

Enkeleida Lushi

Fast simulations of active suspensions in complex confinement
US Department of Energy, Pre-Application, January 2020

Modeling how the macroscopic behavior of bacterial colonies emerges from the microscopic coupled dynamics of the individuals.
DARPA YFA, September 2019

James MacLaurin

Spontaneous macroscopic transitions in the brain
National Science Foundation, September 2019

Stochastic Neural Networks with Slow Stochastic Interaction Dynamics
National Science Foundation, September 2019

Dynamics of Large Disordered Networks
National Science Foundation, November 2019

Simons Collaboration Grants for Mathematicians: Collaboration in Mathematical Biology
Simons Foundation, January 2020

Victor Matveev

FACM-2020: New Perspectives in Mathematical Biology National Science Foundation,10/13/2019

Anand Oza

Structure and Dynamics of Particle Ensembles in Viscoelastic Fluids
American Chemical Society, October 2019

Collaborative Research: Active surfers on a vibrating bath - self-propulsion and collective motion
National Science Foundation, October 2019

Zuofeng Shang

SaTC: CORE: Medium: Collaborative Research: A Statistical Framework for Aggregating Cybersecurity Metrics with Uncertainty Quantification
National Science Foundation, September 2019

CDS&E: Collaborative Research: Scalable Nonparametric Learning for Massive Data with Statistical Guarantees
National Science Foundation, October 2019

Collaborative Research: Nonparametric Bayesian Aggregation for Massive Data
National Science Foundation, October 2019

Collaborative Research: Nonparametric Theory of Deep Learning
National Science Foundation, December 2019

David Shirokoff

CAREER: Unveiling bifurcations and phase transitions in variational material models
National Science Foundation, July 2019

Collaborative Research: Euler-based PDE time-stepping with optimal stability and accuracy
National Science Foundation, December 2019

Sundarraman Subramanian

Model checks for single-index location-scale and quantile regression models\
National Science Foundation, December 2019

Catalin Turc

Optimized Schwartz methods for wave propagation problems in complex media
National Science Foundation, July 2019

Innovative Physics-based modeling tool for application to passive radio frequency identification system on rotorcraft [phase II]
Office of Naval Research, August 2019

Antai Wang

Analysis of dependent censored data using copula models
National Science Foundation, December 2019

Yuan-Nan Young

Collaborative Research: Mathematical, numerical and experimental investigation of flow sensing by the primary cilium
National Science Foundation, September 2019

Collaborative Research: Mathematical modeling and coarse-grained simulations of self-assembly of amphiphilic janus particles in a solvent
National Science Foundation, November 2019

VIII. COMMITTEE REPORTS AND ANNUAL LABORATORY REPORT

A. COMPUTER FACILITIES

Computing Equipment

High quality facilities supporting numerical computation are essential for the Department of Mathematical Sciences (DMS) and the Center for Applied Mathematics and Statistics (CAMS) at NJIT to fulfill their educational and research missions. Thus DMS and CAMS, with the help of SCREMS, CSUMS, UBM, and MRI grants from NSF, together with the generous support of NJIT, have maintained the CAMS Math Computation Laboratory (CMCL) for the research needs of their members since 1989.

Computational support provided by CMCL for the proposers consists of the workstations and desktop PC's that are networked and available to investigators in their offices, plus other more major, shared facilities of the CMCL (see Table 1).

Table 1: Main CAMS Math Computation Laboratory facility, Stheno cluster

Model	Cores	Processor & speed/GPU & max flops	Storage / RAM
Intel multi-core	**368**	**Intel Xeon, 2.2 to 2.53 GHz**	**9872 GB**
Nvidia multi-GPU	**15,320**	**NVIDIA Tesla K20(m), 1.17 Tflops**	**32 GB**

The DMS has expanded its "Stheno" cluster in stages since its first server became operational in 2011. The cluster is intended to be used to test, debug, and run message-passing interface (MPI) codes. It now has 30 nodes and 368 cores, 3,840 GB of RAM, and 9,872 GB of local disk storage. Two servers of the cluster contain GPU's, which now total 6, with a total of 32 GB of GPU RAM. The GPU's are currently CUDA capable and are intended for general purpose computation on GPU-accelerated computing nodes.

The DMS also has its "Gorgon" cluster, which has been expanded sequentially since it became operational in 2010. This cluster is intended for jobs that require large memory, and for parallel computations that use the OpenMP application programming interface. It is now a 32 core system, with AMD Opteron 6134 processors running at 2.3 GHz, and a total of 64 GB of shared memory.

All computational facilities are maintained by the Academic and Research Computing Systems (ARCS) group, headed by its director, David Perel.

Recognizing the need to support the scientific and engineering computing that is essential to research efforts across the campus, NJIT provides all faculty, postdocs, and graduate students access to centralized computing servers for research purposes. These recently received a significant upgrade as part of a substantial donation by Linode, which is a Linux-based cloud hosting company based in New

Jersey. The NJIT cluster, “Kong”, now has a total of 348 nodes, 3,128 CPU’s, 27,008 GB of RAM, and a disk storage of 342,770 GB. Processors are all AMD Opteron or Intel Xeon models, with speeds from 2.2 GHz to 2.8 GHz. It also features total of 18 GPU’s (NVIDIA Tesla K20X and NVIDIA Tesla P100), amounting to 60,928 GPU cores and 248 GB of RAM. Stheno and Kong nominally aggregate of approximately 55 TFLOPS computing power.

Office

The DMS assigns an individual office to faculty and postdoctoral associates, and assigns common offices with networked computers and other equipment to graduate students. In addition, a conference room and the CAMS Reading Room are available for formal and informal research meetings. Academic visitors are welcome and are assigned the same facilities.

Other

CAMS: The DMS is the base of the Center for Applied Mathematics and Statistics (CAMS) to which all investigators belong. CAMS supports research in the mathematical sciences at NJIT by preparing a CAMS Annual Report, a series of CAMS Technical Reports (available in electronic form at the CAMS website http://math.njit.edu/research/index.php). CAMS maintains a weekly colloquium on Applied Mathematics and Statistics, and in most weeks there is a seminar in each of mathematical biology, fluid mechanics and waves, and statistics. DMS and CAMS also sponsor a major conference on “Frontiers in Applied and Computational Mathematics,” which has been held annually at NJIT since 2004 (but was cancelled in 2020 due to Covid-19).

B. STATISTICAL CONSULTING LABORATORY REPORT

July 2019 – June 2020

The Statistical Consulting Lab serves the NJIT community and external organizations and aims to offer high quality statistical consulting for the purposes of promoting research, collaboration and statistical education.

Ji Meng Loh worked with Dr. S. Pal in his grant submission to the DoD and the VA. The DoD grant pre-application was approved in July 18, 2019, and the grant submitted on Sep 9, 2019. The title of the DoD grant is “Using big data analytics to develop new biomarkers to identify persons with SCI at high risk of long-bone fractures during robotic exoskeletion ambulation”. The VA grant “Identification of new biomarkers for determining risk of lower extremity fracture during exoskeleton-assisted ambulation: developing a personal rehabilitation approach to optimize function after SCI”, was submitted on Dec 6, 2019.

Ji Meng Loh also worked with M. Dasilva and V. Chandran, undergraduate and graduate assistants with Dr. Pal on statistical analyses of muscle co-contraction data. A manuscript “Ankle muscle co-contractions increase during walking over uneven compared to even surfaces in older females” is in preparation.

Zuofeng Shang worked with Dr. Shouhuai Xu (UT-San Antonio) and Dr. Pang Du (Virginia Tech) for a NSF grant submission that was to be due in Sep 2020. The proposal title is “Quantifying Dynamic Uncertainties in the Absence of Ground Truth: Statistical Framework and Applications”.

The SCL also provided consulting support to graduate students in their research:

1. Ji Meng Loh and PhD student C. Tyagi met with K. Nacamuli (Mar 5, 2020), a research assistant, to provide statistical advice on statistical analyses for an Informatics research project.

2. Ji Meng Loh met with B. Yilmaz (Feb 13, 2020) to discuss a repeated measures multiple linear and non-linear regression analysis.

IX. CURRENT AND COLLABORATIVE RESEARCH

A. RESEARCH AREAS IN CAMS

Mathematical Biology

Researchers in CAMS working on problems related to Mathematical Biology: Booth, Bose, Bunker, Diekman, Golowasch, Holzapfel, Lushi, MacLaurin, Matveev, Nadim, Rotstein, Russell, Vilanova and Young.

Mathematical Biology broadly refers to the branch of mathematics that is devoted to the theoretical study of biological processes and the development of novel mathematical tools to understand these processes. Recently, there has been quite a bit of emphasis on the intersection of mathematics with developmental biology, neurophysiology, systems biology and genomics. Moreover, mathematicians are applying their modeling and analytical skills to the study of various diseases, such as diabetes, Parkinson's disease, schizophrenia, multiple sclerosis, Alzheimer's disease, and HIV-AIDS. The kinds of mathematics needed to describe and address problems in these areas of Mathematical Biology are quite vast and include dynamical systems, partial differential equations, fluid dynamics, mechanics, parameter estimation, and statistics, to name only a few. Researchers in Mathematical Biology at NJIT have strong interdisciplinary research programs that involve, in most cases active collaborations with experimentalists at the NJIT and Rutgers campuses, and other universities both in the US and abroad.

A primary focus of the Mathematical Biology group is in experimental, computational, and mathematical neuroscience. The experimental research in neuroscience within CAMS is headed up by Jorge Golowasch and Farzan Nadim. Both researchers run labs in which they conduct experiments on various aspects of the crustacean stomatogastric nervous system. Various aspects of Computational and Mathematical neuroscience are being studied by Victor Matveev, Horacio G. Rotstein, Casey Diekman and Amitabha Bose. Matveev uses analytical and computational techniques to study intracellular calcium signals controlling synaptic neurotransmitter release, endocrine hormone release and other physiological processes. He is particularly interested in the dynamics of calcium diffusion and buffering underlying changes in synaptic transmission strength termed synaptic plasticity. Rotstein is interested in understanding the mechanisms of generation of neuronal rhythmic oscillations in various areas of the brain (e.g., hippocampus, entorhinal cortex, neocortex, prefrontal cortex, striatum, olfactory bulb) and how this results from the cooperative activity of the dynamic and biophysical properties of the participating neurons, the synaptic connectivity and the network topology. A primary focus of this research is the study of the effects that single cell and network resonances (emergent properties resulting from the interaction between neurons/networks and oscillatory inputs) affect the generation of network oscillations. Diekman creates multiscale models of the circadian (~24-hour) clock to understand the interaction of membrane excitability and daily rhythms in gene expression and behavior. He is also developing data assimilation techniques for parameterizing conductance-based models, and new methods for analyzing how circadian oscillators entrain to environmental cycles. Bose is interested in developing mathematical techniques to understand the role of short-term synaptic plasticity in producing multi-stable periodic solutions within neuronal networks. He is also interested in developing models that involve central pattern generating networks.

Another focus of CAMS members is in the area of computational and applied ecology. Dan Bunker is interested in how natural ecosystems cope with the ever increasing stresses placed on them by the forces of global change. Claus Holzapfel is interested in the creation of novel communities that consist of species that never occurred together, but are now being created through fast paced human impact. Gareth Russell studies complex ecological systems, including predictive models of wading bird species in the Everglades National Park.

In the area of biological fluid-structure interactions, Young has focused on the biomechanics of primary cilium, a cellular antenna that bends under a fluid flow around the cell. Young has also investigated the force from lipid (FFL) paradigm by constructing a continuum model for the activation of a non-selective mechanosensitive channel reconstituted in a vesicle under fluid stress.

Fluid Dynamics

Researchers in CAMS working on problems related to Fluid Dynamics: Afkhami, Askham, Bechtold, Booty, Bukiet, Choi, Chiu, Cummings, Diez, Huang, Jiang, Kondic, Luke, Lushi, Oza, Papageorgiou, Petropoulos, Rosato, Shirokoff, Siegel, Vanden-Broeck, Wang, Wylie, and Young.

A large group of members within the Department of Mathematical Sciences (DMS) and Center for Applied Mathematics and Statistics (CAMS) have research interests in fluid dynamics or the closely related area of combustion. This group of fluid dynamics scientists is one of the largest contained within a department of mathematics in the United States.

Fluid dynamics is concerned with the motion of fluids and gases. Many beautiful and striking phenomena occur in fluid flows. Familiar examples include the giant vortices shed by airplane wings, the persistent red spot of Jupiter, and the formation of crystalline patterns in solidifying fluids (i.e., snowflakes).

The basic equations of inviscid fluid dynamics have been known for over 250 years and viscous flow equations were derived over 180 years ago. They are nonlinear partial differential equations and are simply written. However, analyzing the solutions to these equations is extremely challenging. Mathematicians have played a leading role in the development of analytical, asymptotic and numerical methods for solving the equations of fluid dynamics. Mathematical techniques originally developed to study fluid phenomena have found wide application in other areas of science and engineering. Examples include asymptotic methods, the inverse scattering transform, numerical methods such as boundary integral methods and level set methods, and theoretical techniques to study the qualitative nature of solutions to nonlinear differential equations. Mathematical research in fluid dynamics continues to drive broad advances in mathematical methods, numerical methods and mathematical analysis.

The fluid dynamics group in the Department of Mathematical Sciences at NJIT has an active research program covering interfacial fluid dynamics, thin films, electrohydrodynamics, hydrodynamic stability theory, sedimentation, granular flow and combustion. A particular focus for several of the faculty members is the study of free and moving boundary problems. These are particularly challenging problems in that partial differential equations have to be solved in a region which is not known in advance, but must be determined as part of the solution. A famous example is the Stefan problem for melting ice or freezing water, but also the dynamics of bubbles, jets, shock waves, flames, tumor growth, crack propagation and contact problems all can be classified under this heading. CAMS fluid dynamics researchers are also pursuing applications of their work in Biology and Nanotechnology.

Wave Propagation

Researchers in CAMS working on problems related to Wave Propagation: Ahluwalia, Askham, Booty, Boubendir, Choi, Erneux, Frederick, Goodman, Jiang, Michalopoulou, Moore, Petropoulos, and Turc.

The analysis of wave propagation has a long and storied tradition in the history of applied mathematics, and the exploration of wave behavior has been a source of countless problems that have changed our understanding of acoustics, hydrodynamics, electromagnetics, optics, and even matter itself. These studies also have led to the development of powerful new mathematical and computational techniques, which have on occasion revolutionized entire fields of study. Several members of the CAMS faculty have research interests in the area of wave propagation; the following is a brief overview of the field and of their particular interests.

One field that has been affected very profoundly by the relatively new science of nonlinear waves is optical communications. Richard Moore is currently using perturbation theory and statistical techniques to develop efficient ways to characterize the effect of perturbations on solitons used for optical communications. Roy Goodman uses Hamiltonian mechanics and asymptotic methods to explore how light can be slowed, delayed, or "trapped"' by engineering defects in nonlinear periodic structures.

The treatment of transient electromagnetic signals such as those arising in signal analysis, spectroscopic applications, and the nondestructive testing of structures requires sophisticated numerical techniques that are stable, fast, and accurate, and that have reasonable memory requirements. Peter Petropoulos is conducting research on a variety of approaches that address these restrictions, including high-order finite difference schemes, boundary integral methods, and perfectly matched layers. Shidong Jiang employs fast algorithms, including the fast multipole method, iterative solvers, and integral equation formulation of boundary value problems for such problems and for related large-scale problems in physics and engineering. Yassine Boubendir and Catalin Turc develop multi-scale and efficient methods, including domain decomposition methods, for the study of wave scattering.

Even in cases where deterministic wave propagation is relatively well understood, the related inverse problem is far more challenging. The identification of certain characteristics of a source of acoustic waves, such as its location and intensity, is of obvious use in national defense, in environmental studies, in seismology, etc. In particular, Zoi-Heleni Michalopoulou and Christina Frederick work on developing powerful new algorithms for inverse problems in acoustics. Their research brings forward state-of-the-art techniques, including machine learning, to these challenging problems.

Finally, the propagation of waves through materials is often influenced by parameters that depend on the waves in a way that requires fundamentally different physics. The microwave heating of ceramics or the passage of optical fields through photorefractive crystals, for instance, couples hyperbolic equations to parabolic equations governing the evolution of thermal profiles and chemical species. Gregory Kriegsmann and Richard Moore are investigating asymptotic and numerical methods to treat such coupled hyperbolic-parabolic systems.

Numerical Methods

Researchers in CAMS working on problems related to Numerical Methods: Afkhami, Askham Boubendir, Bukiet, Choi, Chiu, Frederick, Goodman, Hamfeldt, Horntrop, Jiang, Kondic, Luke, Lushi, Matveev, Michalopoulou, Moore, Muratov, Papageorgiou, Petropoulos, Rosato, Shirokoff, Siegel, Tao, Turc, and Young.

Given the rapidly increasing computing power and capacity in recent decades, the use of computation as a means of scientific inquiry has also greatly increased and now is ubiquitous in most areas of applied mathematics. CAMS researchers are actively involved in all aspects of this scientific revolution from the development of new, more efficient and accurate numerical algorithms to the creation of computational packages for use by researchers throughout the world. The computational work of CAMS researchers is supported by state of the art facilities including numerous workstations and a 134 processor cluster.

Virtually every CAMS member uses computation in some aspect of their research. Some of the specific computational tools that are being used and developed by CAMS researchers are described below. Boundary integral methods are being used to study moving interfaces in materials science and fluid dynamics. Computational solutions of nonlinear partial differential equations are used in studies of the formation of finite-time singularities in aerodynamic and interfacial problems. A wide variety of finite difference methods for ordinary and partial differential equations, often in conjunction with iterative solvers and conjugate gradient methods, are used in studies of advection-diffusion problems, wave propagation, blood circulation, the visual cortex, as well as synaptic function and intracellular spatio-temporal calcium dynamics. Level set methods are used to study interfaces in materials. Novel techniques for differential difference equations are also used to better understand materials. Convergence of fast multipole methods is analyzed and these methods are used to study wave propagation. Novel techniques to remove spurious reflections of waves at computational boundaries are being developed. Signal detection and estimation techniques rely upon global optimization techniques used and developed by CAMS researchers. Finite element methods are used to study mechanical systems; the hybrid immersed boundary/immersed interface method is being developed and refined in order to high order accuracy and efficiency near interfaces.

Stochastic computation also receives a great deal of attention by CAMS researchers. Monte Carlo methods based upon the principles of statistical mechanics are used in studies of granular materials. Efficient and consistent coarse-grain algorithms are designed to simulate the dynamics of DNA molecules and lipid bilayer membranes in viscous flows. Monte Carlo simulation is used to study molecular biology and bioinformatics.

Stochastic models of sedimentation are being developed and refined through a combination of analysis and simulation. Markov Chain Monte Carlo methods are used in studies in statistics and biostatistics. Simulations taking advantage of variance reduction techniques are being used to study the effects of stochastic perturbations on solitons. New computational techniques for stochastic partial differential equations based upon spectral methods are being developed and applied to multiscale models of surface processes.

Statistics

Researchers in CAMS working on problems in Applied Probability and Statistics: Dhar, Guo, Loh, Shang, Subramanian, and Wang.

Applied Probability and Statistics/Biostatistics is concerned with the study of processes in which uncertainty plays a significant role. In today's data driven environment, the utility and need for modeling and statistical analysis of uncertainty is assuming increasing importance in virtually every field of human interest. Typical examples are in the comparative study of DNA databases, evaluation of drug safety and effectiveness, design and analysis of modern communication protocols, stochastic models in finance, study of aging and performance analysis of components and complex systems.

While Applied Probability and Statistics/Biostatistics are driven by the need to solve applied problems, their progress and development comes from basic research and from their applications to solve specific problems arising in practice. This interplay of basic and applied research has benefited both. Real life applied problems have often posed new theoretical challenges which had to be solved by developing new methods (e.g., survival analysis and clinical trials). Conversely, theoretical ideas and methods which were developed in a specific applied context were later seen to be of much broader applicability (e.g., nonparametric aging ideas which owe their origins to research in stochastic modeling of reliability of physical systems were later seen as useful constructs in many other areas such as in the study of queuing systems, stochastic scheduling, branching processes as well as in modeling economic inequality). Biostatistics, an increasingly important area of statistics, focuses on developing new statistical methods, as well as applying existing techniques, to interpret data about the medical and life sciences. The importance of biostatistics stems from its wide use in the pharmaceutical and health-care industries, and in medical schools, e.g. in the area of cell biology and molecular medicine empirical survival distributions of mice in both placebo and treatment groups are typically compared to look for significant difference in new chemical treatments when compared with placebo.

The Statistical Consulting Laboratory (SCL), which operates under the umbrella of CAMS, provides data analysis and statistical modeling consulting services to the University community, as well as to external clients. Consulting on statistical and biostatistics problems channeled through the SCL, are provided by statistics faculty. The current coordinator of the SCL is Ji Meng Loh.

The current research interests of the Statistics faculty are in the following broad and overlapping areas: applied probability models (Dhar), bioinformatics and computational biology (Fang, Guo), bootstrap methods (Subramanian), censored time-to-event data analysis (Dhar and Subramanian), computational statistics (Fang, Guo and Subramanian), discrete multivariate distribution/reliability models and inverse sampling (Dhar), distribution theory and statistical inference (Dhar and Subramanian), empirical processes (Dhar, Subramanian), high dimensional inference (Fang, Guo, Loh, and Wang), machine learning and data mining (Fang), minimum distance estimation (Dhar), multiple imputations methods (Subramanian), multiple testing (Guo), semiparametric estimation and inference (Dhar and Subramanian), spatial statistics and spatial point patterns (Loh), statistical issues in clinical trials (Guo and Dhar), and statistical theory of reliability and survival analysis (Dhar, Subramanian, and Loh).

Several CAMS members have active research programs in Biostatistics. This includes the application of non- and semi-parametric statistical inference and computational methods, such as the bootstrap, in biostatistics.

B. RESEARCH DESCRIPTIONS

Shahriar Afkhami

Shahriar Afkhami's research focuses on computational and mathematical modeling of real-life engineering phenomena including biomedical systems, polymers and plastics, microfluidics, and nanomaterials. His current research thrusts include studies of existence of solutions, flow stability, asymptotic behavior, and singularities of complex flow problems. Currently, he is working on 3D computations of drop dynamics and breakup in polymer processing, microfluidics, and electrowetting. Motivated by biomedical and pharmaceutical applications, Shahriar Afkhami has been studying the dynamics of magnetic particles in a blood flow for drug delivery applications. His current materials related projects involve directed assembly of metallic nanostructures.

Daljit S. Ahluwalia

The research of Daljit S. Ahluwalia is in the field of applied mathematics, mainly in the areas of asymptotics and wave propagation. Using analytic and asymptotic methods, he has addressed a wide range of phenomena including scattering, diffraction, reflection, guided waves, dispersion and shock waves. Applications of this work include ocean acoustics, water waves, electromagnetics, and elastic waves.

Travis Askham

Travis Askham's primary research interests are in the field of scientific computing, with a focus on fast algorithms for the numerical solution of partial differential equations (PDEs). In particular, he has developed novel integral equation representations for the clamped plate problem in mechanics and for computing the eigenvalues and eigenfunctions of the Stokes operator. Further, he has developed fast algorithms for solving the linear systems that arise from integral equation representations of PDEs, including a fast multipole-type method for the modified Stokes equations. In other work, he has developed sparse-regression algorithms and exponential fitting algorithms for applications in the data-driven discovery of governing equations for physical systems.

John Bechtold

The research of John K. Bechtold has focused on the modeling and analysis of physical problems, primarily in the area of theoretical combustion. His studies cover a wide range of topics in both premixed and nonpremixed combustion, including stability, ignition, extinction, and complex flame/flow interactions. His current projects include the development of new generalized models of near-stoichiometric flames, stability of expanding and converging flames, and radiation-driven flows in microgravity.

Denis Blackmore

Dynamical systems (nonlinear dynamics) theory is a rich amalgam of techniques from algebra, analysis, chaos theory, differential equations, differential geometry, differential topology, fractals, geometry, singularity theory, and topology, and has important applications in every branch of science and

engineering. Denis Blackmore's research is primarily in the theory and applications of dynamical systems and closely related fields. He has studied a plethora of applications in such areas as acoustics, automated assembly, biological populations, computer aided geometric design, fluid mechanics, granular flows, plant growth (phyllotaxis), relativistic and quantum physics, and rough surface analysis. His theoretical work includes fundamental results on solution properties and integrability of differential equations, and analysis of hypersurface singularities. His current projects include particle dynamics, pilot-wave dynamics, strange chaotic attractors, exotic bifurcation theory, integrability of infinite-dimensional dynamical systems (PDEs), mathematical physics and vortex dynamics, and competing species dynamics

Victoria Booth

Victoria Booth is interested in applying mathematical modeling techniques to further our understanding of the brain. Her research focuses on different spatial and temporal scales of brain function, from single neuron spiking, to activity of large-scale spiking neuron networks, to networks of interacting neuronal populations. The consistent theme of her research is to utilize mathematical modeling to understand the physiological mechanisms generating experimentally observed neural activity, thus providing the neuroscience community with quantitative support of experimental hypotheses and a rigorous theoretical framework for exploring and developing experimentally-testable predictions. Mathematically, understanding the mechanisms generating specific model behaviors requires complete analysis of stable and unstable solutions to the nonlinear ordinary differential equations of the model system. For this analysis, she utilizes numerical simulations and analysis techniques from dynamical systems, singular perturbation theory and bifurcation theory.

Currently, her research activities are primarily concentrated in two major directions: construction and analysis of mathematical models of the sleep-wake regulatory network and investigation of the interactions of single neuron properties and network structure on spatio-temporal activity patterns in large-scale spiking neuron network models.

Michael Booty

Michael Booty's research interests are in mathematical modeling and analysis, by approximate or exact analytical techniques or by numerical methods. Much of his work is motivated by applications in fluid mechanics, including heat transfer, chemical, and electromagnetic effects. His studies on combustion have focused on time-dependent and multidimensional dynamics of reaction waves in mixed and multiphase systems, prototype reaction-diffusion models, dynamics of fast reaction waves, and droplet burning. He has studied conditions that minimize pollutant formation in the thermal oxidation of common materials, in collaboration with faculty of the Department of Chemistry and Environmental Science at NJIT. Current research interests include: studies on interfacial flows with surfactants, elastic membranes, and electrostatic fields (with Michael Siegel and Yuan-Nan Young), thermal waves in microwave heating and processing (with Greg Kriegsmann), and in fluid-structure interaction.

Amitabha Bose

The research of Amitabha Bose focuses on development and application of dynamical systems techniques to address problems arising in mathematical and computational neurophysiology. A major focus of his work has been on uncovering the role of synaptic plasticity in neuronal networks. This has led to a better understanding of how multistability of periodic solutions arise within a neuronal network as well as how some networks maintain phase relationships across a range of frequencies. These findings have

been applied, for example, to circuits that are involved with REM sleep, to the crustacean pyloric and gastric mill networks, and other central pattern generating networks. More recent studies have focused on circadian rhythms and sustained activity in random graphs. Underlying much of this work is the rigorous analysis of one-dimensional, discontinuous maps that often arise as a result of model reduction.

Yassine Boubendir

Yassine Boubendir's general interests are in the numerical and the mathematical analysis of Partial Differential Equations. More specifically, he is interested in the design, implementation and analysis of numerical algorithms for problems of electromagnetic, acoustic and elastic wave propagation. In recent years, he introduced a new non-overlapping domain decomposition algorithm that combines a boundary element and finite element methods. In addition, he developed an appropriate Krylov subspace method, at high frequency regime, in the context of multiple scattering situations. Currently, his research is devoted to the acceleration of the iterative methods corresponding to these two algorithms.

Daniel Bunker

Global change poses a strong challenge to ecologists, environmental scientists, and conservation biologists: even as our natural and managed ecosystems become more stressed by the forces of global change, humans require that these ecosystems produce both a greater quantity and a greater variety of ecosystem services. for instance, we may expect a forested ecosystem to produce timber, provide clean water, sequester carbon, support wildlife, and provide recreational opportunities, yet at the same time the forest community is being buffeted by climate change, invasive species, and land-use change. In order to ensure that our ecosystems provide the services society demands, we must be able to predict how ecological communities will respond to these global forces, and in turn how changes in community composition will affect ecosystem services. To develop this predictive framework, I employ a mix of observation, experimentation, modeling and synthesis, within a diverse array of biological communities.

Bruce Bukiet

Bruce Bukiet's research concerns mathematical modeling of physical phenomena and issues in improving education, both at the K-12 level and post-secondary. He has studied the dynamics of detonation waves, including curved detonations and detonation models of discrete mixtures and he currently researches questions involving biological systems relating to balance and cancer. In the area of education, he is extensively involved in NJIT’s Collaborative for Leadership, Education and Assessment Research (CLEAR) and its projects involving enhancing digital learning through the Future Ready Schools – New Jersey effort, its online educational resource repository and in research concerning connecting math classes to the real world. Finally, he continues to work on understanding and optimizing aspects of baseball from a mathematical modeling perspective.

Shang-Huan Chiu

The research interests of Shang-Huan Chiu focus on computational fluid dynamics, mathematical physics and biology, mathematical modeling and related numerical methods. The topics of the research in those areas include the study of the behavior of complex particulate fluid suspensions in viscoelastic fluids, the interfacial instability in the multilayer viscoelastic fluids, and the erosion problem of a porous medium investigated by the boundary-integral framework.

Wooyoung Choi

Wooyoung Choi's research interest lies mainly in fluid mechanics and nonlinear waves, in particular, with applications to geophysical flow problems. His recent research focuses on the development of simple but accurate mathematical models to describe various physical processes in the ocean and, in collaboration with physical oceanographers, their validation with field and laboratory measurements. His current research projects include the development of new asymptotic models and efficient numerical methods to study the short-term evolution of nonlinear ocean surface waves with enhanced physical parameterizations of wave breaking and wind forcing, and the dynamics of large amplitude internal waves in density stratified oceans and their surface signatures.

Linda Cummings

Linda Cummings works on a variety of physically-motivated free boundary problems, mostly fluid-dynamical in nature, many of which arise in industrial or biological applications. On the biological side her current work includes studies of fluid flow, nutrient transport and cell growth in tissue engineering applications; flow dynamics and bacterial biofilm formation in prosthetic devices such as urethral catheters and ureteric stents; and dynamics of lipids in cell membranes. Her current industrially-relevant projects include modeling and analysis of "bistable" nematic liquid crystal display devices; modeling of bubble dynamics in the manufacture of glass fibers; and the flow of thin liquid films (both Newtonian and non-Newtonian). She also works on classical low Reynolds number free boundary flows, such as Stokes flows and Hele-Shaw flows. Her mathematical approaches are wide-ranging, encompassing skills of mathematical modeling, discrete and continuum mechanics, complex analysis, and asymptotic and numerical methods.

Fadi P. Deek

Fadi Deek’s primary research interest is in learning systems and collaborative technologies, with applications to software engineering, and in computer science education. His approach to research involves a mixture of theoretical development, software system implementation, controlled experimental evaluation, and ultimately deployment of the systems developed. His interest in learning systems revolves around the development of new technologies that take into consideration the cognitive behavior and needs of end-users. The specific types of learning systems that he is interested in are related to computing which has motivated his work in software engineering. Because both learning and software engineering are highly collaborative activities, he has also become interested in understanding how collaboration works, ranging from the dynamics of collaborative groups to the technologies required for computer-supported work. His original interest in learning systems was sparked by a long standing interest in computer science education which continues to engage him. These underlying interests in learning systems and collaboration are the unifying theme for his publications, dissertation advisement, system development and professional involvement. Most of this research has been supported by grants where he has been the principal or co-PI.

Sunil K. Dhar

The research focus of Sunil Dhar has been on model building and inference. His ongoing research involves proving existence, computing and developing robust and efficient minimum distance estimators such as L2-distance type, under the following models: linear, AR [k], the additive effects outliers, and the two-sample location model. He also developed functional least squares estimators under the additive effects outliers model. An optimization technique for the general class of sums of absolute multivariate

linear functionals has been developed by him. He extended the negative multinomial distribution; this new model has many applications. His ongoing research in multivariate lifetime reliability models involves deriving new multivariate geometric and generalized discrete analogs of Freund's models, with demonstrated applications. Other discrete models developed by him are in the area of models of order k. He has wide and varied experience in statistical consulting.

Casey Diekman

Casey Diekman uses a combination of mathematical modeling, numerical simulation, and dynamical systems analysis to gain insight into biological systems. He is currently focused on creating a mathematical framework to understand how dynamic changes in gene expression affect the electrical properties of neurons and ultimately animal behavior. Circadian (~24-hour) rhythms offer one of the clearest examples of the interplay between these different levels of organization, with rhythmic gene expression leading to daily rhythms in neural activity, physiology and behavior. Diekman develops mathematical models of the master circadian clock in the mammalian brain. These models and the mathematical theory associated with them have led to counterintuitive predictions that have since been validated experimentally by his collaborators. The primary goal of his research program in mathematical biology is to uncover mechanisms underlying biological timekeeping, neuronal rhythm generation, and the disruption of rhythmicity associated with certain pathological conditions including sleep disorders, Alzheimer's disease, breathing problems, and ischemic stroke.

Javier Diez

Javier Diez's research focuses on free surface flows and interface phenomena. He is particularly interested in coating flows and the dynamics of the contact line, where the liquid, the solid substrate and the surrounding environment (gas or liquid) intersect. Current projects include using a combination of experimental measurements (usually by means of optical techniques) and numerical simulations of the fluid dynamic equations, with particular emphasis on the inclusion of intermolecular forces to account for hydrodynamical effects in nanoscale phenomena.

Thomas Erneux

The research of Thomas Erneux is mainly concerned with laser dynamical instabilities and their practical use in applications. More recently, he became interested in delay differential equations appearing in different areas of science and engineering. The response of lasers can be described by ordinary, partial, or delay differential equations. He uses a combination of numerical and singular perturbation techniques to investigate their solutions. A large part of his research is motivated by specific collaborations with experimental groups.

Christina Frederick

The research of Christina Frederick has encompassed multiscale computation and numerical homogenization for inverse problems based on elliptic PDEs, as well as sampling strategies that exploit special microstructures of functions to reduce the computation cost, and retain theoretical optimality in terms of efficiency and stability. Her recent work includes multiscale methods for sonar imaging, as well as robotics and stochastic differential equations.

Jorge Golowasch

The research of Jorge Golowasch focuses mainly on the cellular and network mechanisms of long-term regulation of electrical activity in a simple model neural network, the pyloric network of the stomatogastric ganglion of crustaceans. An undesirable consequence of plasticity is the potential instability of the system. In the nervous system, the activity of neurons and neural networks remains quite stable over very long periods of time. Conductances, however, also express plasticity. How this plasticity contributes to stability, however, is a question largely unexplored. Using both electrophysiological and computational tools, he and his students in the laboratory study mechanisms of neuronal plasticity and homeostasis of the ionic currents that determine the excitability and electric activity of neurons and simple neural networks. He is also interested in how neurons interact to form rhythmic pattern generating networks.

Roy Goodman

Roy Goodman's research focuses, broadly, on nonlinear wave phenomena. The tools he uses consist mainly of asymptotic methods, dynamical systems analysis, and numerical simulation. Physical applications he has studied include storm propagation in the atmosphere at middle latitudes and the interaction of light pulses in telecommunications optical fibers. Recently, he has been investigating the interaction of nonlinear waves with localized changes to the media through which they propagate. This includes the enticing possibility of "light trapping" at specified locations in optical fibers, as well as more abstract studies of classical nonlinear wave equations. Another area of application is the interaction of vortices in Bose-Einstein condensates.

Wenge Guo

Wenge Guo's research interests include large-scale multiple testing, high-dimensional inference, bioinformatics, machine learning, and statistical methods for clinical trials. The new theories and methods he derived are mainly used for controlling the false discovery rate (FDR) and other generalized error rates in large-scale multiple testing. Their main applications are on bioinformatics and computational biology. His current research projects include estimate and control of the FDR under dependence and development of new multiple testing methodologies for different biomedical areas such as microarray data analysis, design and analysis of clinical trials, and high throughput screening assay.

Brittany Hamfeldt

Brittany Hamfeldt’s research focuses on the development of numerical methods for solving nonlinear partial differential equations. A particular focus of her work is the solution of fully nonlinear elliptic equations and related applications to optimal mass transportation. She has introduced new formulations of the associated equations, which have led to the first PDE based methods for optimal mass transportation. These methods have enabled the development of new techniques for solving seismic inverse problems and for reshaping beams of light. She has also introduced a new framework for solving a large class of fully nonlinear elliptic equations on unstructured meshes.

Claus Holzapfel

As a community ecologist Claus Holzapfel is fascinated by the intriguing ways of how species interact with each other. Within that topic his research addresses ecological and evolutionary processes and their

outcome in plant populations and communities. The leading question is whether communities are more than simple chance assemblies. Perturbed systems - systems that are altered from their pristine state - are ideal study objects to address such a question, since here possible coevolved interactions are likely disrupted. Good examples are plant communities that are invaded by non-native organisms or systems otherwise heavily impacted by human activity (climate change, land-use change).

David J. Horntrop

The research of David J. Horntrop has focused on the development and numerical simulation of stochastic models of physical phenomena for problems ranging from materials science to fluid dynamics. His studies of turbulent diffusion were based on random field models for the advection of passive scalars and involved asymptotics, stochastic analysis, and the creation of novel wavelet-based Monte Carlo numerical schemes for the simulation of random fields. His current studies of materials involve the development and use of mesoscopic models to describe surface processes in order to gain insight on the importance of small scale phenomena on the creation of large scale patterns. He is presently developing and validating new spectral methods for the numerical solution of stochastic partial differential equations for these studies.

Huaxiong Huang

Huaxiong Huang's research interests include Fluid Mechanics, Scientific Computing, Mathematical Modeling and Industrial Mathematics. Recently, he has been working on problems on stress/defects reduction of InSb crystals, ruin probability and asset allocation related to personal finance, multiphase mass and heat transport problems in cloth assemblies, bread baking, and multiphase bubbly flow related to water purification; extensional viscous flow related to optical fiber drawing and pulling of microelectrodes; and finally in biologically related problems such as the spatial buffering and viral membrane fusion.

Shidong Jiang

Shidong Jiang's main research interests lie in the field of numerical analysis and scientific computing with particular emphasis on fast numerical algorithms and integral equation methods for solving initial/boundary value problems for various partial differential equations (PDEs). He has constructed second kind integral equation formulations for various problems including the open surface problems, the fourth order PDEs such as biharmonic and modified biharmonic equations, the unsteady Stokes equations, the dislocation climb in two dimensions, and the electromagnetic mode propagation of optical waveguides. He has also worked on the construction of sum-of-exponentials and sum-of-poles approximations and their applications including nonreflecting boundary condition for the Schrodinger equation, the Havriliak-Negami dielectric model, the Caputo fractional derivative, efficient separated sum-of-exponentials approximation of the heat kernel in arbitrary dimension, and the continuous time random walk transport equation. He is currently working on the efficient algorithms for large-scale photonics simulation.

Lou Kondic

Research of Lou Kondic has concentrated on modeling and numerical simulations of various problems in fluid mechanics and material science, in particular granular materials. His focus is on modeling,

asymptotic methods, and scientific computing. The problems arising from fluid mechanics that he has worked on include interfacial flows for Newtonian and complex fluids (liquid crystals in particular), thin film instabilities, contact line dynamics, and pattern formation on the scales ranging from nano to macro. He has also worked in the field of compressible fluid mechanics, in particular bubble dynamics and sonoluminescence. In the field of granular matter, he has developed molecular dynamics/discrete element simulations for two and three dimensional granular systems. These simulations have been used to address granular statics and dynamics in various settings including microgravity environment, dense granular flows, silo discharge, to name a few. Recent focus has been on development of topological methods for describing structure of granular systems on mesoscale. His research is carried out in close collaboration with experimental researchers in the field.

Ji Meng Loh

Ji Meng Loh's primary research interest is in spatial statistics, in particular the analysis of spatial point patterns. He has developed methods for bootstrap of spatial data, anomaly detection and assessing data quality. Ji Meng has worked on statistical applications in many fields including cosmology, public health, fMRI analysis and telecommunication.

Jonathan H. C. Luke

The research of Jonathan H. C. Luke has focused on the modeling and analysis of physical problems primarily in the areas of low-Reynolds-number fluid dynamics and wave propagation in complex media. His studies in sedimentation theory cover the topics of velocity fluctuations, renormalization, the method of reflections, cluster dynamics, and variational and numerical methods. His studies of electromagnetic waves in highly dispersive media mainly concern energy deposition and numerical methods. His current projects include analysis of the stability of numerical implementations of no-slip boundary conditions for the Navier-Stokes equations in streamfunction-vorticity form, simulation and analysis of energy deposition from electromagnetic waves in dispersive materials, and effective boundary conditions for heating and scattering problems in microwave cavities.

Enkeleida Lushi

Dr. Lushi's research interests lie in the mathematical modeling and computer simulations of problems arising in soft active matter and biological physics. In particular, her work focuses on exploring the hydrodynamic and chemotactic interactions of active particle systems, as well as their emergent dynamics in viscous flows and complex confinements. She works closely with experimentalists to build robust computational models that are used to elucidate phenomena such as the self-assembly and guided transport of micro-scale colloids or the collective behavior of micro-swimmers.

James MacLaurin

James MacLaurin's work centers on understanding randomness in biology. He is particularly interested in understanding how order and synchrony arise from the interplay of noise and structure at the microscopic level. A lot of his work concerns understanding the collective dynamics of large networks of noisy interacting neurons. This typically involves the analysis of high-dimensional `mean-field' systems of interacting stochastic units; understanding how such systems give rise to emergent phenomena such as traveling waves and synchronization patterns. He has also done extensive work on the phase reduction of

stochastic biochemical oscillators. This includes the extension of classical methods of phase reduction for oscillators subject to continuous white noise, to the case where the oscillators are subject to discrete discontinuous forcing.

Victor Matveev

The research of Victor Matveev is in the area of computational neuroscience, and is focused primarily on biophysical modeling and numerical simulations of synaptic function and its mechanisms. In his work, Victor Matveev employs analytical methods as well as a variety of computational techniques, from stochastic modeling to numerical solution of partial and ordinary differential equations. Victor Matveev performs most of his work in collaboration with experimental neurophysiologists, and develops models to explain and fit the experimental data. His current projects include the study of the mechanisms of short-term synaptic facilitation and other calcium-dependent processes involved in neurotransmitter secretion, and the modeling of presynaptic calcium diffusion and buffering. To facilitate his research, Victor Matveev also has been working on the development of a software application designed for solving the reaction-diffusion equation arising in the study of intracellular calcium dynamics ("Calcium Calculator").

Jay Meegoda

Jay Meegoda's research can be best described as mechanics of geo-environmental engineering where he utilizes scientific concepts and engineering technologies in real world applications. Under the heading of mechanics of geo-environmental engineering, his research can be further subdivided into five main trust areas: engineering properties of contaminated soils; centrifugal modeling of contaminant transport; micro-mechanics of civil engineering materials; reuse of contaminated soils; and ultrasound research. Micromechanic models were used to explain the mechanical behavior of civil engineering materials. He received the best practice paper award in 2001 from the Environmental Multimedia Council of the Environmental and Water Resources Institute (EWRI) of the American Society of Civil Engineers (ASCE) for a publication resulting from the above research. Currently, his research is focused on use of a laser to detect segregation in asphalt pavements and development of smart pipes for drinking and waste water distributions.

Zoi-Heleni Michalopoulou

The research of Zoi-Heleni Michalopoulou focuses on inverse problems in ocean acoustics. The goal is to understand the properties of the propagation medium and detect and localize sound-emitting sources. To this end, methods are developed that combine ocean acoustic modeling and signal processing. Efforts are made to design direct (or exact) methodologies that return ocean medium property values using a set of measurements and the solution of an integral equation. In parallel, sound propagation modeling is combined with Bayesian models to provide a concurrent description of the water column and sediment and location of the source.

Petronije Milojevic

The research of P.S. Milojevic is focused on studying semilinear and (strongly) nonlinear operator equations using a combination of topological, approximation, and variational methods and applications to ordinary and partial differential equations. He has developed various fixed point results for condensing

and A-proper maps. His studies of semilinear operator equations with monotone and (pseudo) A-proper maps involve nonresonance and resonance problems with Fredholm and hyperbolic-like perturbations of single valued and multivalued nonlinear maps, and Hammerstein equations. He has widely applied these abstract theories to BVPs for (contingent) ordinary and elliptic PDEs, to periodic and BVPs for semilinear hyperbolic and parabolic equations and to nonlinear integral equations. His study of nonlinear and strongly nonlinear operator equations is concerned with the existence and the number of solutions of such equations involving condensing, monotone, and various types of approximation maps. His current research deals with Hammerstein equations and weakly inward A-proper and pseudo A-proper maps and applications to differential and integral equations.

Richard O. Moore

Richard Moore's research focuses on wave phenomena in optical communication systems and optical devices. He is particularly interested in how such systems and devices are disturbed by a variety of influences relevant to their operating environments. Current projects include using a combination of perturbation methods and importance sampling to simulate rare events in optical communication lines, and using dynamical systems techniques and rigorous reduction methods to analyze the impact of heating due to optical field absorption in devices that convert optical frequencies using parametric gain media. More recent work explores the intersection between data assimilation and optimal control, including the development of efficient algorithms to compute optimal paths for autonomous vehicles navigating in noisy environments.

Cyrill B. Muratov

Cyrill Muratov's research is mainly in the area of applied analysis and calculus of variations. The problems under consideration arise from a variety of applications from materials science, fluid mechanics and biology and give rise to systems of nonlinear partial differential equations exhibiting self-organizing behavior. These difficult mathematical problems can be approached by the direct method of calculus of variations and singular perturbation techniques. Currently, the ongoing projects include the asymptotic analysis of energy-driven pattern formation problems in the presence of non-local effects, with major applications to ultrathin ferromagnetic films and nanotechnology. Other projects involve modeling, analysis and simulations of rare events in noise-driven systems and studies of multiscale, multiphysics problems, with particular applications to NASA's space exploration systems.

Farzan Nadim

Farzan Nadim studies rhythmic motor activity generated in the central nervous system by combining experiments and computational techniques. Nadim has a joint appointment with the Federated Department of Biological Sciences and runs a laboratory that conducts experiments on isolated nervous systems of crustacea. These experiments involve electrophysiological recordings from multiple nerves and neurons, pharmacological manipulations of the system, and immunohistology. The neuronal circuits studied all produce oscillatory output of various frequencies. The lab also models these systems both at the detailed biophysical level and using analytic mathematical techniques. His current focus is on contribution of synaptic dynamics to network output and the interaction between multiple oscillatory systems.

Anand Oza

Anand Oza's primary research interests are fluid mechanics and physical applied mathematics, with applications to soft matter physics and biological systems. He uses a combination of modeling, analysis and numerical simulation, and typically works in collaboration with experimentalists in the field. His research has recently been directed towards understanding hydrodynamic interactions in active matter systems, in which collections of objects both generate and interact with fluid flows. Specifically, he has developed and analyzed mathematical models for the pilot-wave dynamics of droplets bouncing on a vibrating fluid bath, a system that offers a visualization of wave-particle coupling on a macroscopic scale. He has also developed a PDE model for liquid crystal-like assemblies comprised of microtubules and motor proteins in a fluid, a model system for studying the self-organization principles that underlie complex cellular structures. He is currently developing models for the interactions between flapping swimmers, with a view to understanding how hydrodynamics mediates schooling and flocking behavior in animal collectives.

Demetrios T. Papageorgiou

The research of Demetrios T. Papageorgiou focuses on the modeling, analysis, and computation of physical and technological problems that involve fluid dynamics and aerodynamics. His studies in surface tension driven flows cover the stability, dynamics, and breakup of single and compound liquid jets, both in the presence and absence of surface active agents, which affect interfacial tension. Analysis of finite-time-singularities has been used to motivate experiments for rheological measurements. His studies in bubble dynamics are a theoretical and experimental collaborative research effort to control the drag on rising bubbles using surfactants. Current projects include jet and bubble dynamics, nonlinear stability of core-annular flows when surfactants are present, nonlinear stability of electrified liquid films, and study of viscous flows in pulsating channels or tubes by construction of Navier-Stokes solutions both numerically and analytically with particular emphasis on chaotic regimes and their influence on applications.

Peter G. Petropoulos

The research of Peter G. Petropoulos has focused on the numerical modeling and asymptotic analysis of physical problems in the areas of transient electromagnetic wave propagation in complex media. His studies of pulsed electromagnetic waves in dispersive media mainly concern the asymptotic and numerical methods for studying the response of relaxing (Debye) and fractionally-relaxing (Cole-Cole) dielectrics, as well as the development fourth-order accurate finite difference methods for the time-domain Maxwell equations with discontinuous coefficients. His current projects include analysis of the error in problems where impedance boundary conditions are employed, development of numerical techniques to simulate pulse propagation in Cole-Cole dielectrics, analysis of perfectly matched absorbing boundary conditions in relation to exact absorbing boundary conditions, and the development of fourth-order accurate schemes in the presence of curved boundaries.

Anthony D. Rosato

Anthony Rosato's research is concerned with granular flows as related to the solids handling and processing industries. The flows are modeled using dissipative molecular dynamics simulations to identify governing mechanisms that affect observable behavior. Currently, he is studying the development of velocity field structures in boundary-driven flows, and how they may influence segregation behavior in polydisperse systems. He is also interested in the application of dynamical systems modeling to these systems.

Horacio G. Rotstein

The research of Horacio G. Rotstein focuses mainly on the study of the biophysical and dynamic mechanisms underlying the generation of rhythmic oscillatory activity in the brain, particularly in the hippocampus and entorhinal cortex. Rhythmic oscillations at theta (8 - 12 Hz) and gamma (30 - 80 Hz) frequencies in these areas of the brain have been correlated with various forms of learning and memory. In addition, alteration in particular sorts of brain rhythmic oscillations have been shown to correlate with the existence and progression of a variety of neuropsychiatric conditions, including schizophrenia and dementia. Rhythms differ not only in their frequency range, but also in the underlying biophysical mechanisms by which they are generated. These mechanisms usually vary in different brain areas, and may operate at a single cell level or may involve the coherent activity of many cells and cell types in a network. The primary goal of my research is to uncover and understand the underlying biophysical and dynamic principles that govern the generation of rhythmic activity in the brain. As secondary goals I hope to understand the functional implications for brain functioning of the previous results, the relation between disruption of rhythmic activity and diseases of the nervous system, and the effects that changes at a subcellular level have on rhythms observed at the single cell and network levels.

Zuofeng Shang

My general research aim focuses on statistical machine learning, primarily in developing statistical frameworks for data science objects, efficient learning algorithms for scientific tasks and theoretical understanding on the nature of the problems.

David Shirokoff

David Shirokoff's research focuses on two main areas. (i) Numerical methods for fluid dynamics in the presence of irregular boundaries and interfaces, and (ii) Numerical methods for the simulation and characterization of materials governed by energy driven pattern formation. In the first area, his developments include reformulations of the Navier-Stokes equations as pressure-Poisson systems for improved accuracy and efficiency in fluid dynamics computations, and active high order penalty methods as a means to improve the accuracy and efficiency of Fourier based methods that are used to solve PDEs on irregular geometries. In the second area, of computational materials science, his interests focus on designing new numerical techniques to characterize the underlying energy landscape. The techniques rely on replacing a complicated energy with a simpler, convex one, which can then be minimized using tools from optimization theory to systematically obtain low energy states for use in thermodynamic simulations.

Michael Siegel

The research of Michael Siegel is focused on the analysis and numerical computation of moving boundary problems that arise in fluid mechanics, materials science, and physiology. His research in fluid dynamics covers singularity formation on interfaces for inviscid and low Reynolds number (Stokes) flow, the dynamics of drops and bubbles, and effect of small regularization--such as surface tension--on mathematically ill-posed interfacial flow problems. His studies in materials science primarily involve crystal growth and diffusion controlled moving boundary problems.

Sundar Subramanian

The research of Sundar Subramanian focuses on non- and semi-parametric statistical inference for censored time-to-event-data analysis. His investigations involve study of the large sample behavior of estimators using techniques from counting processes and martingales, empirical processes, kernel estimation, and information bound theory. His interests on the computational side include bootstrap methods for model selection and bandwidth computation, and mis-specification studies using simulation. The procedures have strong theoretical basis and find applications in Biostatistics.

Louis Tao

The research of Louis Tao focuses on large-scale scientific computation, through a combination of numerical simulations, bifurcation theory, and asymptotics. He is mainly interested in the modeling and analysis of the dynamics of networks, with applications to specific problems in neuroscience and mathematical biology. His work in computational neuroscience has been in two distinct areas: a) how neurons in the visual cortex process elementary features of the visual scene and b) how recurrent networks perform computations. His current projects include the modeling of orientation selectivity in cortex and the analysis of the network dynamics that arises.

Catalin Turc

Catalin Turc's research interests belong to the broad area of computational electromagnetics and acoustics. The main goal is the design and implementation of numerical methods that can be used for efficient simulation of electromagnetic and acoustic wave interactions with complex material structures. During the past few years, he has worked on a variety of problems related to fast, high-order frequency domain integral equation methods for acoustic and electromagnetic scattering problems in domains with complex material and geometrical features. He has developed analytical and computational tools that enable solutions for problems of fundamental significance involving applications such as electromagnetic interference and compatibility (electronic circuits), dielectric/magnetic coated conductors, composite metamaterials (photonic crystals and negative index materials), and solar cells.

Jean-Marc Vanden-Broeck

Jean-Marc Vanden-Broeck's research is concerned with fluid mechanics and the theory of free boundary problems. He uses a combination of numerical and asymptotic methods to investigate new properties of nonlinear solutions. A large part of his research focuses on the effects of surface tension and on the computations of waves of large amplitude. Interfacial flows generated by moving disturbances, three dimensional solitary waves, waves on electrified fluid sheets, and the stability of Stokes flows in the presence of electric fields are among his recent interests.

Pedro Vilanova

The main goal of my research is to understand the behaviour of complex multi-scale systems by studying and developing efficient mathematical and computational methods for stochastic dynamics. My work primarily focuses on i) Model reduction of high-dimensional stochastic reaction networks via optimal parametric coarse-grained techniques; ii) Efficient and accurate computation of quantities of interest for a class of pure jump processes; iii) Monte Carlo sampling for Markovian approximations of population

balance equations; iv) Statistical inference of stochastic reaction networks via EM algorithms and surrogate models; v) Phase reductions and synchronization of stochastic chemical oscillators; and vi) Multilevel stochastic optimizers.

Antai Wang

Antai Wang's research mainly focuses on survival data analysis, high dimensional data analysis and cancer data analysis. Currently his research goal is to develop new strategies to model dependent censored data or multivariate survival data using frailty models, copula models and nonparametric methods. For high dimensional data, Antai develops new methodologies to conduct variable selections for longitudinal data based on a Procrustes criterion which is used to extract data information while keeping the original data structure. The new research strategies are important and useful for correlated survival data analysis and microarray data analysis in medical research.

Yuan-Nan Young

The research of Yuan-Nan Young focuses on the multiphase flows in computational fluid dynamics (CFD), and relevant issues in numerical treatment of moving boundary problems. In particular he has numerically investigated how surfactants, both soluble and insoluble, can affect the pinch-off of bubbles in viscous fluids. He also investigates numerical schemes to optimize the accuracy of regularization of surface tension force in CFD codes. His current projects also include an investigation on the hysteretic behavior of drop deformation in highly viscous straining flows.

C. COLLABORATIVE RESEARCH

Shahriar Afkhami

"A Novel Numerical Method for Viscoelastic Two-phase Flows" with V. Barra (Graduate)

"Magnetophoresis of Ferrofluids in Magnetic Fields" with J. Feng (UBC)

"Marangoni Flows in Mixing of Miscible Liquids" with I. Seric (Graduate)

"Mechanisms of Cavitation in Insects" with A. Woods (UMontana)

"Microlayer Formation in Nucleate Boiling" with J. Buongiorno (MIT)

Travis L. Askham

"Equation Discovery in Active Fluids" with A. U. Oza and Connor Robertson (Graduate)

"Shape Optimization in Stellarator Design" with A. Cerfon (New York University), M. O'Neil (New York University), D. Malhotra (New York University), and G. Stadler (New York University)

"Three Panel Integration Rules" with A. Jiang, and R. Pei (NJIT, Graduate)

John K. Bechtold

"Theoretical Combustion" with C. K. Law (Princeton University), H. G. Im (University of Michigan), and M. Matalon (University of Illinois)

Denis L. Blackmore

"Application of Machine Learning to Discrete Interacting Particle Systems" with A. D. Rosato and U. W. Roshan

"Axial and Radial Pressure in Cylindrical Silos" with A. D. Rosato and X.Tricoche

"Density Relaxation in Granular Systems" with A. D. Rosato and D. J. Horntrop

"Dynamical Systems Modeling of Dilating/contracting Granular Systems" with A. D. Rosato, L. Zuo (NJIT, Graduate), N. Ching(NJT, Graduate), A. Harlow (NJIT, Graduate), X. Tricoche (Purdue University), and K. Urban (NJIT, Graduate)

"Wave Propagation in Granular Systems" with A. D. Rosato, B. Lau (NJIT, Graduate), and M. Lau (NJIT, Undergraduate)

"Dynamical Modeling and Analysis of Walking Droplets." with A. Rahman (NJIT, Graduate)

"A Gauge-theoretical Analysis of Magnetic Reconnection" with K. Urban (NJIT, Graduate)

"Analysis and Simulation of Infinite-dimensional Dynamical Systems" with H. Wu (NJIT, Graduate)
"Discrete Dynamical Modeling of Logical Circuits" with A. Rahman (NJIT, Graduate)

"Dynamical Systems Foundations of Entropy" with J. Tavantzis (NJIT, Emeritus) and Ray Addabbo (Vaughn College)

"Dynamical Systems, Differential Topology and Analysis: Theory and Applications" with A. Rosato, A. Prykarpatsky, A. Rahman, M. Brons, B. Shashikanth, and J. Lee

"Innovations in Strange Attractor Theory and Applications" with Y. Joshi (Kingsborough Community College)

"Integrability Analysis of Nonlinear Equations of Mathematical Physics" with A. Prykarpatski (AGH, Krakow, Poland)

"Local Periodic Pertubations of Limit Cycles" with J. Tavantzis (Rutgers-Newark)

"Solutocapillary Flows" with P. Singh and I. S. Fischer

"New Techniques for Analyzing Strange Attractors" with Y. Joshi (Kingsborough CC) and A. Rahman (NJIT)

"Perturbations of the Forced Van Der Pol Equation" with J. Tavantzis (NJIT, Emeritus)

Michael R. Booty

"Novel Approaches to Semiconductor Device Integration Using Magnetic Fields" with N. M. Ravindra and A.Fiory

Amitabha K. Bose

"Linear Conductance-based Mechanisms Underlying Oscillations in Neuronal Networks" with J. P. Golowasch and F. Nadim(NJIT)

"Role of Linear Currents on Slow Oscillation" with J. P. Golowasch, F. Nadim (NJIT), Y. Guan (NJIT, Graduate)

Yassine Boubendir

"Acceleration of an Iterative Method for the Evaluation of High-frequency Multiples Scattering Effects" with R. Fernando and F. Ecevit

"Coupling Finite and Boundary Element Methods Using Localized Adaptive Radiation Condition for Maxwell's Equations" with A. Bendali and N. Zerbib

"Well-conditioned Integral Equations for Acoustic Transmission Problems" with C. Turc

Bruce G. Bukiet

"Education Research" with J. M. Lipuma

"Math Modeling of Prostate Cancer Treatment" with H.Chaudhry (NJIT), T. Findley (VA Hospital East Orange), N. Gao (Rutgers-Newark), Z. Ji, and S. K. Dhar

Daniel E. Bunker

"Augmented Reality for Ecological Data and Processes" with G. J. Russell

"Cascading Effects of Urbanization on Pollinator and Plant Communities" with C. DeVan (Graduate), T. Blockus (Undergraduate), and D. Evangelista (Undergraduate)

"Effects of Generalist Herbivores on Plant Communities" with L. Rohleder (Graduate), T. Blockus (Undergraduate), D. Evangelista (Undergraduate), D. Waller, A. Royo, B. McShea, S. Cote, C. DeVan (Graduate), and B. Traw

"Life History Tradeoffs and Species Abundance" with B. Mitchell, T. Blockus (Undergraduate), and A. Madala

"Spontaneous Dispersion of Particles in Liquid Surfaces" with P. Singh

Linda J. Cummings

"Bistability and "gliding" in a Nematic Liquid Crystal Display Device "with L. Kondic and E. Mema (Graduate)

"Free Flows of Thin Films of Nematic Liquid Crystal" with L. Kondic and M. Lam(Coastal Hydraulics Laboratory)

"Hele-shaw Flow of a Nematic Liquid Crystal" with L. Kondic

"Liquid Metal Instabilities Driven by Pulsed Laser Heating" with L. Kondic and R.Allaire (NJIT, Graduate)

"Mathematical Models for Filtration" with P. Sanaei (New York University), G. Richardson (University of Southampton), L. Jordan, B. Gu (NJIT, Graduate), and Y. Sun (NJIT, Graduate)

"Mathematical Models for Interactions Between Immunoglobulins and Mono/bivalent Ligands" with R. Perez-Castillejos and E. Mack (BP)

"Mathematical Models for Tissue Engineering" with S. Waters (University of Oxford)

"Mathematical Models Related to the Drawing of Glass Sheets and Optical Fibers" with C. Breward (University of Oxford), J. Abbott (Corning, Inc.), and I. Griffiths (University of Oxford)

"Two-dimensional Stokes Flow in Doubly-connected Domains" with J. King (University of Nottingham, UK)

Sunil K. Dhar

"Multivariate Logistic-type Models Based on an Inverse Sampling Scheme" with Yalin Zhu (NJIT, Graduate)

"Robust Spatial Release from Masking for Spectrally Degraded Vocoded Speech" with A. Ihlefeld (NJIT)

"Assessment and Comparison of the Slippage and Unintentional Opening of Epidural Catheters and Their Connectors." with C. Anthony (Rutgers, New Jersey Medical School), R. Horvath (B. Horvath, LLC), and A. Gonzalez Fiol (Yale, New Haven Hospital)

Casey O. Diekman

"Correlated Expression of Ion Channel in Circadian Neurons" with J. P. Golowasch

"Involvement of Neural Oscillators and Proprioception in Locomotion of C. Elegans" with G. Haspel, J. Storm (NJIT, Graduate), and A. J. Jurko (NJIT, Graduate)

"Magnesium Regulates the Circadian Oscillator in Cyanobacteria" with Y. I. Kim, C. L. Dias, Y. Jeong (NJIT), and M. Kaur (NJIT, Graduate)

"Daylength Encoding by Circadian Clock Neurons" with M. Belle (University of Manchester) and H. Piggins (University of Manchester)

"Global Coupling of Genetic Oscillators" with A. Bose and H.G. Rotstein

"Ion Channel Expression in Scn2.2 Cell Line" with J. P. Golowasch and R. Deek (Undergraduate)

Christina A. Frederick

"Flow Rectification in Loopy Network Models of Avian Lungs" with Q. M. Nguyen (Courant Institute,Graduate), A. U. Oza (NJIT), J. Abouezzi (Courant Institute, Undergraduate), G. Sun (Courant Institute,Undergraduate), S. Childress (Courant Institute), and L. Ristroff (Courant Institute)

"Inverse Problems in Quantitative Photoacoustic Tomography" with S. Valellian (NC State) and K. Ren (UT Austin)

"Multiscale Inverse Problems in Sonar Imaging" with Z.-H. Michalopoulou and S. Villar (NYU)

"Optimal Control Strategies for Multirobot Path Planning" with H. Zhou (Georgia Tech) and M. Egerstedt (Georgia Tech)

"Sampling and Frame Theory" with K. Yacoubou Djima (Amherst College)

Roy H. Goodman

"Instabilities of Localized Solutions to Nonlinear Wave Equations With Defects." with M. Weinstein (Columbia University) and J. Marzuola (University of North Carolina)

"Interactions of Vortex Interactions in Bose-einstein Condensates" with P. Kevrekidis (University of Massachusetts) and R. Carretero (San Diego State University)

"Numerical Methods for Invariant Manifolds" with J. Wrobel (NJIT, Graduate), C. Basarab (NJIT, Undergraduate), and P. Shah (NJIT, Undergraduate)

Wenge Guo

"New Directions for Research on Some Large-scale Multiple Testing Problems" with S. K. Sarkar (Temple University)

"Optimal Classification Algorithms for Highly Imbalanced Datasets" with J. P. Romano (Stanford University)

Brittany D. Hamfeldt

"Efficient Numerical Methods for Monge-ampere Equations" with J. Brusca (NJIT, Graduate)

"Eigenvalue Problems for Fully Nonlinear Elliptic Pdes"with J. Lesniewski (NJIT, Graduate)
"Optimal Transport on the Sphere" with A. Turnquist (NJIT, Graduate)

"Pde Methods for Optimal Transport With General Costs" with M. Illingworth (NJIT, Graduate)

David J. Horntrop

"Density Relaxation in Granular Systems" with A. D. Rosato and D. L. Blackmore

"Modeling and Simulation of Credit Risk" with B. Ren (NJIT, Graduate) and W. Morokoff (Standard & Poors)

"Variance Reduction for Stochastic Differential Equations" with M. Billamoria (NJIT, Undergraduate) and S. Singh (NJIT, Undergraduate)

Lou Kondic

"Dynamics of an Intruder in Granular Matter" with X. Fang (Graduate)

"Instabilities of Fluid Films on Nanoscale" with T.-S. Lin (Graduate)

Ji Meng Loh

"Estimating the Survival Rate of Mutants" with A. Mili

Enkeleida Lushi

"Fluid Dynamics of Free Swimming Zebrafish Larvae" with K. E. Severi, and H. Zaki (Undergraduate)

"Separating Motile and Immotile Bacteria Through Confined Chemotaxis" with F. Zumpano (The College of New Jersey, Undergraduate)

"Motion of Phoretic Rods Under Flows, Gravity, or Around Obstacles" with Q. Brosseau (University of Pennsylvania), F. Balboa Usabiaga (Flatiron Institute), L. Ristroph (New York University), J. Zhang (New York University), M. Shelley (Flatiron Institute), Y. Wu (New York University, Undergraduate), and M. Ward (New York University)

"Collective Dynamics of Spermatozoa in Confinement" with V. Kantsler (University of Warwick) and P. Denissenko (University of Warwick)

"Large-scale Simulations of Active Particles" with W. Yan (Flatiron Institute) and M. Shelley (Flatiron Institute)

"Micro-swimmers in a Porous Medium" with Y. Almoteri (NJIT,Graduate)

James N. MacLaurin

"Autonomous Dynamics of Mean Field Spin Glasses" with C. MacLaurin (University of Queensland, Graduate)

"Coarse Graining of the Primary Visual Cortex" with B. Krekelberg (Rutgers University)

"Effect of Sparse Connection Topology on Traveling Waves in Neural Networks" with G. Medvedev (Drexel University) and M. Mizuhara (TCNJ)

"Large Scale Stochastic Oscillations in the Brain" with D. Headley (Rutgers University)

"Modelling Plant Meristem Regeneration" with K. Birnbaum (NYU)

"Synchronization in Biochemical Oscillators With Common Environmental Noise" with P. Vilanova (NJIT)

Victor V. Matveev

"Calcium Nanodomains in Neurotransmitter and Hormone Release" with A. Sherman (NIH) and R. Bertram (Florida State University)

"Dynamics of Calcium-dependent Insulin Secretion in Pancreatic Beta Cells" with M. Gram Pedersen, A. Sherman, and M. Riz (Graduate)

"Properties of Synaptic Calcium Channels" with E. Stanley

Zoi-Heleni Michalopoulou

"Contaminant Behavior and Impacts to Environmental Systems " with L. B. Axe, L. Wei (NJIT), K. Jahan (Rowan University), J. Dyksen (United Water), B. Wang (NJIT, Graduate), N. Sandhu (NJIT, Graduate), Z. Shu (NJIT, Graduate), S. Zhang (NJIT, Graduate), and S. Gitungo (NJIT/Hatch Mott, Graduate)

"Detection of Weak Sources in Underwater Environments" with A. Abdi

"Sediment Layer Identification With Ambient Noise" with P. Gerstoft

"Sequential Particle Filtering" with C. Yardim and P. Gerstoft

"Statistical Modeling of the Invariance Principle for Tracking" with L. Zurk

Farzan Nadim

"Linear Conductance-based Mechanisms Underlying Oscillations in Neuronal Networks " with J. P. Golowasch and A. K. Bose (NJIT)

"Role of Linear Currents on Slow Oscillation" with J. P. Golowasch, A. K. Bose (NJIT), and Y. Guan (NJIT, Graduate)

"Temporal Fidelity of Axonal Action Potential Conduction and Its Neuromodulation" with D. M. Bucher

Peter G. Petropoulos

"A Preconditioner for Wave Problems Based on the Perfectly Matched Layer" with Y. Boubendir and D. Midura (Graduate)

"Algorithms for the Computation of Fractional Derivatives" with M. Causley

"Numerical Simulation of Pattern Formation in Systems With Global Feedback" with H. G. Rotstein

Horacio G. Rotstein

"Dynamic Compensation Mechanism Give Rise to Period and Duty Cycle Level Sets in Oscillatory Neuronal Models" with J. P. Golowasch and M. Olarinre (NJIT, Graduate)

"Coregulation of Conductances in Neuronal Models" with J. P. Golowasch and M. Olarinre (Graduate)

"Dynamics of Fronts in Bistable Systems With Delayed Global Feedback" with Y. Boubendir

"Dynamics of Medial Entorhinal Cortex Layer Ii Stellate Cells and Related Networks" with D. Kim (Graduate), J.White, and T. Kispersky

"Pattern Formation in Relaxation Oscillators With Inhibitory Global Feedback" with H. Wu (Graduate)

"Subthreshold and Superthreshold Frequency Preferences (resonance) in Nonlinear Neural Models" with D. Kim (Graduate), F. Nadim, N. Sheikholeslami (Graduate)

"The Canard Phenomenon in Piece-wise Linear Systems" with S. Coombes

David G. Shirokoff

"Fft Based Optimization for Variational Problems With Fourier Constraints" with M. Bandegi (Graduate)

"High Order Methods for a Pressure Poisson Equation Reformulation of the Navier-stokes Equations With Electric Boundary Conditions" with D. Zhou (Temple University), B. SeiboldTemple, and R. Rosales (MIT)

"High Order Semi-implicit Time Integration for the Dispersive Shallow Water Equations" with W. Choi and L. Feng (NJIT, Graduate)

"Resolving Order-loss in Runge-kutta Methods for Boundary Value Problems" with B. Seibold (Temple University), D. Zhou (Temple University), and R. Rosales (MIT)

Sundarraman Subramanian

"Model Checks for Single-index Location-scale"

"Model Checks for Two-sample Location-scale" with A. Javidialsaadi (NJIT, Graduate) and S. Mondal (Boeringer Ingelheim)

"Log-rank Test from Twice Censored Data" with A. Javidialsaadi (NJIT, Graduate)

Catalin C. Turc

"High-order Solutions of Integral Equation Formulations of Helmholtz Transmission Problems in Two-dimensional Domains With Corners" with V. Dominguez (U Navarra, Spain) and M. Lyon (U New Hampshire)

"Reduced Bases Simulation of Wave Propagation in Urban Environments" with O. Bruno (Caltech) and M. Lyon(U New Hampshire)

Antai Wang

"Analysis of Clustered Survival Data Using Frailty Models" with X. Jia (NJIT, Graduate)

"Analysis of Longitudinal Microarray Data" with J. M. Loh (NJIT), W. Guo (NJIT), X. Zhang (NJIT, Graduate), and X. (James) Li (Georgetown University)

Yuan-Nan Young

"Centrosome Oscillation"

"Collective Dynamics of Active Droplets”

"Dynamics and Rheology of a Compound Vesicle in Shear Flow" with J. Blazdziewicz, P. Vlahovska, S. Veerapaneni

"Dynamics of Primary Cilium" with C. Jacobs (Columbia University)

"Elastic Filament and Viscous Drop in Stokes Flow and Rheology of Soft-particle Suspensions" with M. Shelley

"Electrodeformation of a Surfactant-laden Viscous Drop" with H. Nguangia (NJIT, Graduate)

"Poration of a Lipid Bi-layer Membrane" with H. Nguangia (NJIT,Graduate)

"Surfactant Effects in Low Reynolds Number Flows" with M. R. Booty and M. S. Siegel

"Swimming of Bacteria With Two Flagella" with N. Patel (Northwestern University, Graduate

X. STUDENT ACTIVITIES

A. UNDERGRADUATE ACTIVITIES

Report on Undergraduate Studies
David J. Horntrop, Associate Chair for Undergraduate Studies

The undergraduate program of the Department of Mathematical Sciences continued to be very active during the past academic year.

In addition to their studies in our rigorous academic programs, many of our undergraduates also engaged in research. One of the main focuses of this research activity has been the NSF-funded EXTREEMS-QED program, which began in Fall 2013 and has now entered its fifth year. The PI is Michael Siegel and the Program Director is David Horntrop. Students in each year's cohort begin their research projects in January and complete them in December of the same year. The 2019 cohort consisted of four students: Manan Brahmbhatt, Brandon Chin, John Desalvo, and Justin Maruthanal with research mentors Shahriar Afkhami and Sundar Subramanian. The 2020 cohort consists of Noah Roselli and Yousef Sayes with research mentor Eliza Michalopoulou.

Many students have been engaged in research outside the EXTREEMS-QED program as well. Many of our students have industrial internships during the summer, particularly, but not exclusively, students in the Mathematics of Finance and Actuarial Science concentration. Each summer a number of students have internships at MetLife and Prudential Financial while some students intern at consulting firms such as Mercer Consulting and Oliver Wyman Actuarial Consulting. Companies such as Chubb, Aon, and Panasonic also employ our students as summer interns.

Our students have also received many honors and awards during the past year and have also found success on their actuarial examinations with more than 12 passed during the year. Especially noteworthy was that fact that two of our undergraduates were named Goldwater Scholars: Joseph Torsiello and Philip Zaleski. The department itself was honored by having its Mathematics of Finance and Actuarial Science program ranked fifth nationally in a study commissioned by SafecoInsurance.com.

Many students who graduate from our program continue either to enter graduate programs at other prestigious institutions or find gainful employment. Examples of graduate schools recently attended by our undergraduates include UTexas-Austin, UCLA, CalTech, RPI, Columbia, Northwestern, and the University of Delaware. Examples of employers of our recent graduates include MetLife, Prudential Financial, Chubb, NYLife, Aon, Buck Consultants, and Trillium Management.

Capstone Laboratory Projects on Nonlinear Long Water Waves

Instructor: Wooyoung Choi: Assistant: Guangyuan Liao
Participating students: Nishanth Gona, Jared Kacso, Justin Maruthanal, David Monroe, Raghav Patel, Krzysztof Skura, Takashi Yashiro

This Capstone Lab is designed to study the generation, propagation, and transformation of periodic and solitary waves in shallow water. The projects aim to provide the participating students opportunities to improve their mathematical and numerical modeling skills and to validate theoretical solutions through laboratory experiments. The students have developed numerical models using a finite difference method to solve the weakly nonlinear Boussinesq model (a system of two nonlinear PDEs describing the free surface motions in shallow water) with various types of boundary conditions. Their numerical solutions have been compared with available experimental data. Specific research projects include (1) the generation of solitary waves by lifting a gate at the end of a 2-D wave tank; (2) the generation of periodic waves by a piston-type wave maker; (3) the resonant generation of solitary waves by a disturbance moving with a near-critical speed; (4) the propagation and deformation of a single solitary wave over bottom topography.

Figure 1: Propagation of a solitary wave in a 2-D wave tank

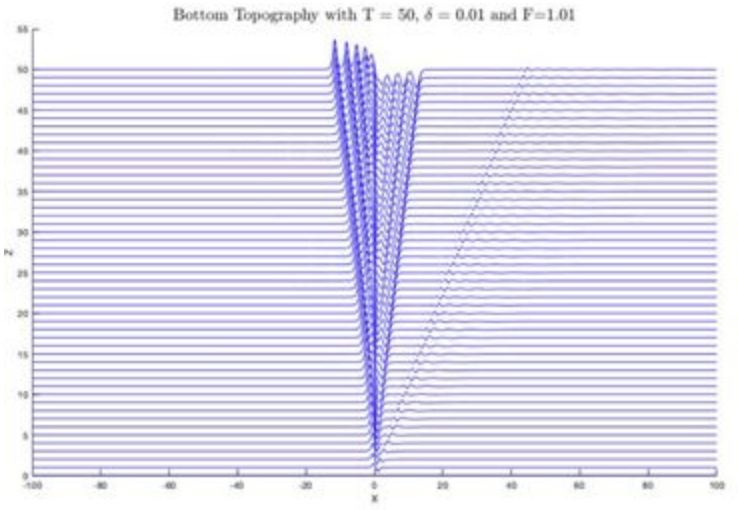
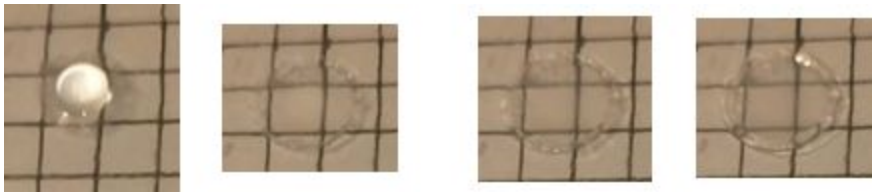


Figure 2: Numerical solution for the periodic generation of solitary waves by a translating resonant forcing.

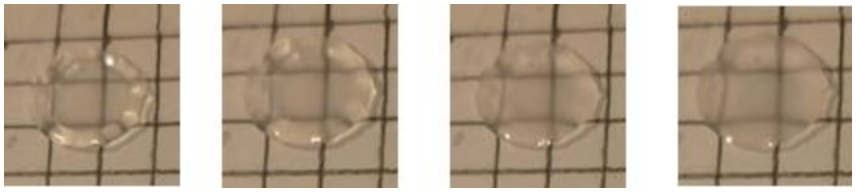
Study of Impact of Molten Wax Droplets on Substrates

Rachel Finger, Rebecca George, Yao Gu, William McCann, Natalie Mendez, Adriana Mons, Vladislav Rayskiy, Christine Thomas, Philip Zaleski, and Shahriar Afkhami

This capstone project was dedicated to the solidification and impact of a wax drop impacting a solid surface. In a first part, we established a 1D solidification model, derived from the Stefan problem and energetic arguments, that aimed at predicting the experimental observations. We then carried out experiments to study the parameters that determined the dynamics of droplets of paraffin wax impinging and freezing on a metal and a glass surface. The impacts were photographed and the spreading of the splat formed after freezing was measured. Photographs showed liquid wax droplet recoiling in the center followed by the solidification. By comparing to the simple model, we found that the early stage solidification did not affect the drop impact. A simple model was then used to predict the number of azimuthal instabilities that grew at the rim of the spreading drops upon impact. Future study will consider the contact line effects.

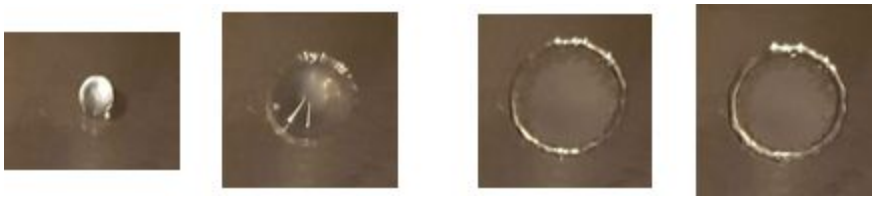


(a) Glass t = 0 (b) Glass t = 2 (c) Glass t = 4 (d) Glass t = 6



(e) Glass t = 8 (f) Glass t = 10 (g) Glass t = 12 (h) Glass t = 14

Figure 1: Individual frames of the wax impact on a glass substrate at various points in time. Time in this instance is split in units of frames, in which the di↵erence between two frames in time is seconds. At t = 0 you can see the initial impact of the droplet which spreads out over time before ”freezing” at a particular diameter. There is a noticeable moving wave on the top of a bottom layer of wax, that we analyzed in more depth for the metal experiment



(a) Metal t = 0 (b) Metal t = 2 (c) Metal t = 4 (d) Metal t = 6

(e) Metal t = 8 (f) Metal t = 10 (h) Metal t = 14 (g) Metal t = 12

Figure 2: Individual frames of the wax impact on a metal substrate at various points in time. Just like in the glass impact instances, is split in units of frames, in which the di↵erence between two frames in time is seconds. The first frame t = 0 represents the impact. It is also much more clear in these pictures that there is a secondary wave front that passes over the top of the wax.

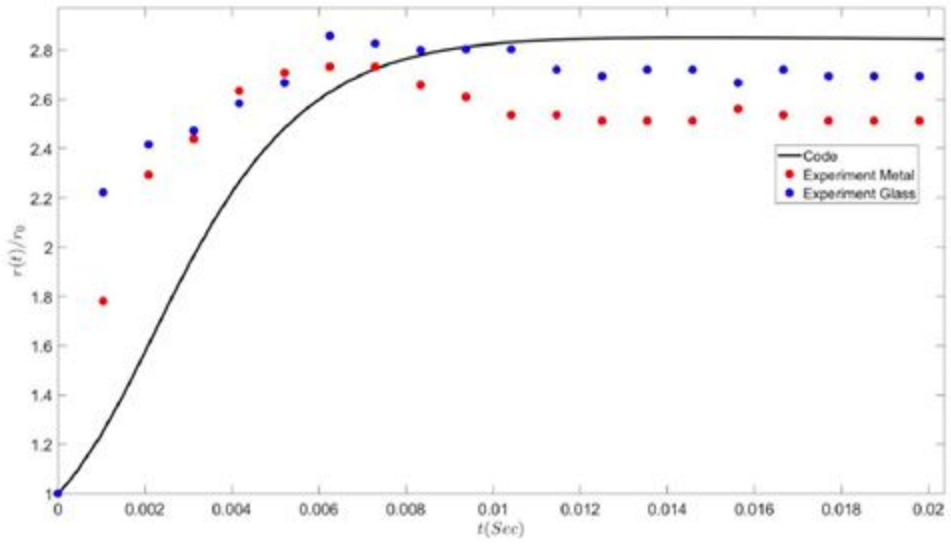
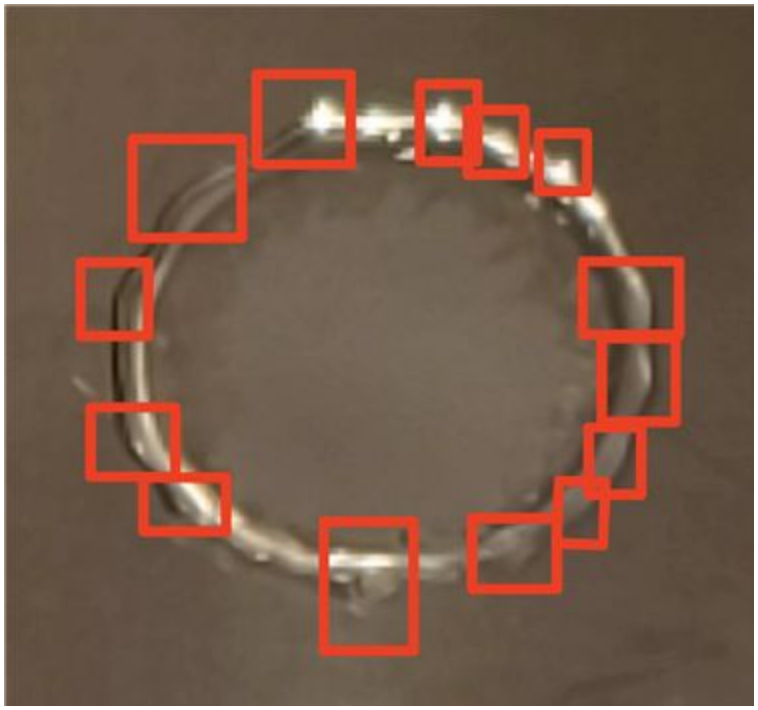


Figure 3: Comparison of the 1D model (solid line) with experimental measurements (symbols), for a wax droplet of 3.3mm. Blue is data gathered from our experiments for a glass substrate and Red is our experimental values for a metal substrate. The X-axis is time in seconds and the Y-axis is spread factor.



B. GRADUATE PROGRAMS

Graduate Activities Report
Michael Siegel, Associate Chair for Graduate Studies

This was a banner year for the graduate program in the Department of Mathematical Sciences. We had a historically high yield on our offers of graduate admissions, culminating a relatively large incoming class of 13 Ph.D. students in Applied mathematics and Applied Statistics. The new students have diverse backgrounds, coming from undergraduate and masters programs in mathematics (pure and applied), engineering, economics, and statistics. One of the incoming students was awarded a prestigious NJIT Provost Fellowship. Several current students secured summer internships at government labs such as the Johns Hopkins Applied Physics Laboratory, as well as local biopharmaceutical companies. The Masters program in Data Science (Statistics track) is up and running in our new Jersey City Campus and has attracted significant enrollment.

The Department of Mathematical Sciences takes great pride in the quality of its graduate programs. In addition to master's programs in Applied Mathematics, Applied Statistics, Biostatistics, and Data Science (Statistics track), our PhD program continues to attract high caliber students who work closely with faculty to conduct original research in applied and computational mathematics and statistics. We have recently introduced graduate certificates in Applied Statistics and Biostatistics, and a new certificate in Data Science became available this year. Each graduate certificate provides its students with a four-course set of specialized training that can be used to enhance an existing career or to explore advanced material prior to enrolling in a master's program.

Our doctoral students have an impressive collective record of presenting and publishing their research. Each year, they earn invaluable experience and recognition for their accomplishments at high-profile meetings such as those organized by SIAM and the APS. Almost all of our students also present posters at our annual Frontiers in Applied and Computational Mathematics conference, which unfortunately was postponed this year due to Covid-19. Most of our students have at least one high-quality publication accepted by the time of their graduation, which is essential for success in today's job market.

Our doctoral students are very engaged in departmental activities, and they regularly organize tea-time as well academic, career-oriented, and social events under the banner of the NJIT SIAM Chapter. A new student organized seminar series in machine learning began running this summer, in addition to the usual graduate student seminar series that runs over the summer (see below). Our students have had much recent success in finding internships, in governmental research facilities such as NASA, Oak Ridge National Laboratory, and Argonne National Laboratory or in private industries such as Pixar Animation Studios and Glaxo Smith-Kline. Students who performed internships participated in a special internship seminar at NJIT in October 2019.

It is ultimately the offers our students receive after graduation that indicate the health of our programs. New positions secured by our graduates in the past two years include a tenure track position at the New York Institute of Technology, a permanent appointment at the government supported Applied Physics Laboratory at Johns Hopkins, and postdocs at New York University Tanden School of Engineering, and in the Quantitative Systems Pharmacology group at Merck Pharmaceuticals. Several recent graduates have obtained exciting positions in data science.

PhDs Awarded in the Period Covered by the Report

Mathew Moye
Data assimilation methods for conductance-based neuronal models
Advisor: Casey Diekman

Mahdi Bandegi
Ground states for the Helmholtz free energy functional via conic programming
Advisor: David Shirkoff

Subha Datta
Dimension reduction techniques for high-dimensional and ultra-high-dimensional data
Advisors: Ji-Meng Loh and Yixin Fang

Andrew DeStefan
Optimal sampling paths for autonomous vehicles in uncertain ocean flows
Advisor: Richard Moore

Publications, Presentations, & Conferences

*Not Including FACM Participation or DMS Summer Student Talks

Yasser Almoteri

Conference and Workshop Attendance

June 15 - August 3, 2020: The Physics of Life Online Summer School 2020, Princeton University, **Virtual**

June 11 - July 2: SIAM Conference on the Life Sciences (LS20), Garden Grove, CA, **Virtual**

March 16, 2020 - May 29, 2020: Symmetry, Thermodynamics and Topology in Active Matter, Kavli Institute of Theoretical Physics, UC Santa Barbara, CA, **Virtual**

Rituparna Basak

Presentations

May 31, 2020 - June 3, 2020: Summer School on Soft Solids and Complex Fluids, UMass Amherst, MA
Application of Machine Learning Techniques to the Stick Slip Dynamics of a Particulate Media

Brandon Behring

Publications

Stability of leapfrogging vortex pairs: A semi-analytic approach (with R. H. Goodman), *Physical Review Fluids*, Vol. 4, Issue 12 4703, Dec 2019

Ultrasonic vocalization sex differences in 5-ht1a-r deficient mouse pups: Predictive phenotypes associated with later-life anxiety-like behaviors. T. Budylin, S. R. Guariglia, L. I. Duran, B. M. Behring, Z. Shaikh, L. S. Neuwirth, and P. Banerjee, *Behavioural Brain Research*, vol.196, 373:112062, 2019

Posters

May 19 - 23, 2019: SIAM Conference on Dynamical Systems, Snowbird, UT
Dynamics Near the Leapfrogging Vortex Quartet

Binan Gu

Publications

On the influence of pore connectivity on performance of membrane filters.
B. Gu, D. Renaud, P Sanaei, L Kondic and L Cummings. *Journal of Fluid Mechanic*s, vol. 902, (2020)

Presentations

November 26, 2019: American Physical Society Division of Fluid Dynamics, Seattle, WA
Stochastic Modelling of Sieving

July 9, 2019: UK Fluids Network Special Interest Group, Mathematical Institute, Oxford University, UK
Fluid Mechanics of Cleaning and Decontamination Network Theory for Filtration

Conference and Workshop Attendance

June 15 - 18, 2020: The 36th Annual Workshop on Mathematical Problems in Industry, University of Vermont, **Virtual**

November 23 - 26, 2019: American Physical Society Division of Fluid Dynamics, Seattle, WA

Yuexin Liu

Conference and Workshop Attendance

June 19, 2020: 13th Northeast Complex Fluids & Soft Matter Workshop, City College of New York, **Virtual**

May 5 - 8, 2020: Mathematical and Computational Methods in Biology, Ohio State University, **Virtual**

Gan Luan

Conference and Workshop Attendance

July 9 - 10, 2019: Celgene Biometric Global Meeting, Morristown, NJ, USA

Yixuan Sun

Publications

Modeling and design optimization for pleated membrane filters (wth P. Sanaei, L. Kondic, L. J. Cummings) *Physics Review Fluids*, Vol 5, Issue 4, 044306, April 2020

Conference and Workshop Attendance

June 19, 2020: 13th Northeast Complex Fluids & Soft Matter Workshop, City College of New York, **Virtual**

June 15 - 18, 2020: Mathematical Problems in the Industry workshop (MPI), University of Vermont, **Virtual**

January 17, 2020: 12th Northeast Complex Fluids & Soft Matter Workshop, Manhattan College

Awards

Brandon Behring

AY 2019 – 2020: CSLA Outstanding Graduate Student Award

Yinbo Chen

AY 2019 – 2020: Ahluwalia Doctoral Fellowship

Gan Luan

AY 2019 – 2020: Ahluwalia Doctoral Fellowship

Student Talks - Summer 2020

Tuesday, June 2, Ryan Allaire
Thermal Effects in Nanoscale Thin Liquids Heated by a Laser with Applications to Liquid Metal Assembly

Tuesday, June 2, Tadanaga Takahashi
Decomposition for a Wave Scattering Problem

Tuesday, June 9, Lauren Barnes
Image Analysis of Colloid-Polymer Mixtures in Microgravity

Tuesday, June 9, Emel Khan
Dynamics of a Cyanobacterial Circadian Clock Model

Thursday, June 11, Axel Turnquist
Elliptic PDE and Some Regularity Questions

Tuesday, June 16, Rituparna Basak
Application of Machine Learning Techniques for the Stick Slip Dynamics of a Particulate Media

Thursday, June 18, Chao Cheng
The Force Network Precursors to Slip Events in Sheared Granular Systems

Thursday, June 18, Guangyuan Liao
Model Reduction Techniques for Coupled Circadian Oscillators

Thursday, June 18, Diego Rios
Sound Propagation Modeling for Geoacoustic Inversion

Tuesday, June 23, Connor Robertson
Discovering the Governing PDE of an Active Nematic System from Video Data

Tuesday, June 23, Soheil Saghafi
Entrainment of Periodically Forced FitzHugh Nagumo Model

Thursday, June 25, Gan Luan
Parameter Estimation and Inference of Spatial Autoregressive Model by Stochastic Gradient Descent

Tuesday. June 30, Yinbo Chen
Closed-Form Approximations of Single-Channel Calcium Nanodomains in the Presence of Cooperative Calcium Buffers

Thursday, July 2, Zhongcheng Lin
Some Properties of Bivariate Archimedean Copula Models Under Left Censoring

Thursday, July 2, Linwan Feng
Numerical Methods for the Dispersive Shallow Water Equations

Tuesday, July 7, Ziyan Guo
Motivation & Brief Report on Projects of Competing Risks

Tuesday, July 7, Yasser Almoteri
Bacterial Motion and Spread in Porous Media

Thursday, July 9, Yixuan Sun
Membrane Filtration with Multiple Species of Particles

Thursday, July 9, Ruqi Pei
A New Panel-based scheme for the Discretization of Boundary Integral Equations

Tuesday, July 14 , Atefeh Javidialsaadi
Model Checks for Two-Sample Location-Scale

Tuesday, July 14 , Beibei Li
On Weighted Holm Procedures

Tuesday, July 14 , Yuexin Liu
How to Train Stokes Swimmer Using Machine Learning

Thursday, July 16, Erli Wind-Anderson
Introduction to Convolution Quadrature

Tuesday, July 21, Kosuke Sugita
Boundary Integral Equation Methods on Stokes Flow Equations in Two Dimensions

Thursday, July 23, Ryan Atwater
Studies of Two-Phase Flow with Soluble Surfactant

Thursday, July 23, Binan Gu
Graphical Representation of Membrane Filters

Tuesday, July 28, Brandon Behring
Dances and Escapes of the Vortex Quartet

Tuesday, July 28, Nicholas Dubicki
Electrostatics

Thursday, July 30, Hewei Zhang
Predicting CME and Solar Flares Using Machine Learning Methods

Tuesday, August 4, Jake Brusca
Finite Difference Method for The Monge-Ampère Equation

Thursday, August 6, Jose Pabon
Research Work Update - on the Hydrodynamics of Interacting Swimmers, Potential Flow Around Slender Bodies and Related Uniform Asymptotic Solutions.

Thursday, August 6, Subhrasish Chakraborty
Classification of imbalanced data & SMOTE : An introduction

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http://math.njit.edu/research/