CAMS

Center for Applied Mathematics and Statistics

ANNUAL REPORT

2020 – 2021

July 1, 2020 – June 30, 2021

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 35th 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 this year included several undergraduate research publications.

This has been another 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. We were able to run a vigorous Applied Math Colloquium schedule which, thanks to Webex, included a number of well-known international speakers. Highlights and significant achievements in this past year, include:

·Four major grants awarded by the National Science Foundation and other agencies.

·The oversight of an additional twenty eight 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, and other state and local agencies, along with private industry.

·The submission of 3 major large group grants, including a Research Training Grant (RTG) in mathematical biology

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, Eliza Michalopoulou, 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 the significant contribution of CAMS to the university's 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.

Department of Mathematical Sciences

Advisory Board

Dr. John S. Abbott	**Corning Incorporated**
Mr. Ben Appleby	**Prudential**
Dr. James Cai	**Roche Innovation Center New York**
Dr. Ned J. Corron	**U.S. Army AMCOM**
Mr. Erik Gordon	**Trillium Trading, LLC**
Dr. Richard Silberglitt	**Rand Corporation**

Department of Mathematical Sciences

Afkhami, Shahriar	Jiang, Shidong
Ahluwalia, Daljit S.	Johnson, Kenneth
Askham, Travis	Kappraff, Jay
Bechtold, John	Kondic, Lou
Blackmore, Denis	Loh, Ji Meng
Booty, Michael	Luke, Jonathan
Bose, Amitabha	Lushi, Enkeleida
Boubendir, Yassine	Matveev, Victor
Bukiet, Bruce	MacLaurin, James
Bunker, Daniel	Michalopoulou, Zoi-Heleni
Chiu, Shang-Huan	Milojevic, Petronije
Choi, Wooyoung	Muratov, Cyrill
Cummings, Linda	Nadim, Farzan
Deek, Fadi	Oza, Anand
Dhar, Sunil	Petropoulos, Peter
Diekman, Casey	Russell, Gareth
Frederick, Christina	Shang, Zuofeng
Golowasch, Jorge	Shirokoff, David
Goodman, Roy	Siegel, Michael
Guo, Wenge	Subramanian, Sundarraman
Hamfeldt, Brittany	Turc, Catalin
Horntrop, David	Wang, Antai
Horwitz, Kenneth	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 11, **Cecilia Freire**, Drexel University
Rates of Convergence to Statistical Equilibrium: A General Approach and Applications

September 18, **Dwight Barkley**, University of Warwick
Mechanisms and Universality in the Subcritical Route to Turbulence

September 25, **Dominic Vella**, University of Oxford
Buffering by Buckling: New Wrinkles on Gauss' Pizza Theorem

October 2, **Jonathan Weare**, NYU Courant Institute
Long Timescale Behavior from Trajectory Data

October 9, **Kui Ren**, Columbia University
Computational Inversion with the Quadratic Wasserstein Metrics

October 16, **Richard Tsai**, University of Texas at Austin
Implicit Boundary Integral Methods and Applications

October 23, **Mason Porter**, University of California, Los Angeles
Topological Data Analysis of Spatial Systems

October 30, **Ann Almgren**, Lawrence Berkeley National Laboratory
Low Mach Number Modeling

November 13, **Vlad Vico**l, NYU Courant Institute
Shock Formation and Vorticity Creation for Compressible Euler

November 20, **Lou Kondic**, New Jersey Institute of Technology
Modeling Liquid Crystal Films on Nanoscale

December 4, **Thomas Anderson**, University of Michigan
Hybrid Frequency-Time Analysis and Numerical Methods for Time-Dependent Wave Propagation

January 29, **Jeff Calder**, University of Minnesota
Random Walks and PDEs in Graph-Based Learning

February 5, **Alex Gittens**, Rensselaer Polytechnic Institute
An Algorithm for Two-Cost Budgeted Matrix Completion

February 12, **Denis Silantyev**, NYU Courant Institute
Obtaining Stokes Wave with High-Precision Using Conformal Maps and Spectral Methods on Non-Uniform Grids

February 19, **Haomin Zhou**, Georgia Institute of Technology
Optimal Transport on Graphs with Some Applications

February 26, **Nigel Mottram**, University of Glasgow
Active Nematic Liquid Crystals

March 5, **Horacio Rotstein**, New Jersey Institute of Technology
Resonance-Based Mechanisms of Generation of Oscillations in Networks of Non-Oscillatory Neurons

March 12, **Chad Higdon-Topaz**, Williams College
Quantitative Approaches to Social Justice

March 26, **Robert Style**, ETH Zürich
Phase Transformation in Soft Materials

April 9, **David Anderson**, University of Wisconsin
An Introduction to Stochastic Reaction Networks

April 16, **Chris Rycroft**, Harvard SEAS
Uncovering the Rules of Crumpling with a Data-Driven Approach

April 23, **Haimin Wang**, New Jersey Institute of Technology
Data Intensive Study of Space Weather using Advanced Observations and Machine Learning

April 30, **Casey Diekman**, New Jersey Institute of Technology
Data Assimilation and Dynamical Systems Analysis of Circadian Rhythmicity and Entrainment

Applied Statistics Seminar

October 12, **Sumit Mukherjee**, Columbia University
Joint Estimation of Parameters in Ising Models

November 5, **Pan Xu**, New Jersey Institute of Technology
Matching Algorithms in E-Commerce

November 12, **Yang Feng**, New York University
RaSE: Random Subspace Ensemble Classification

November 19, **Ruiqi Liu**, Texas Tech University
A Computationally Efficient Classification Algorithm in Posterior Drift Model: Phase Transition and Minimax Adaptivity

December 3, **Fangfang Wang**, Worcester Polytechnic Institute
On Modelling High-dimensional Continuous-Time Vector Time Series via Latent CARMA Processes

March 4, **Peijun Sang**, University of Waterloo
A Reproducing Kernel Hilbert Space Framework for Functional Data Classification

April 8, **Yang Chen**, University of Michigan
Statistical and Computational Problems in Space Weather Data Challenges

April 22, **Guan Yu**, University of Buffalo
Locally Weighted Nearest Neighbor Classifier and Its Theoretical Properties

Mathematical Biology Seminar

September 8, **Patrick Murphy**, Rice University
Modeling Rapid Diffusion State Switching During Cellular Polarization of a C. Elegans Zygote

September 22, **Gregory Handy**, University of Chicago
Digging through DiRT: Investigating how Trap Recharge Time Influences the Statistics of Particle Diffusion

October 6, **Tom Wooley**, University of Cardiff
Patterns, Cellular Movement and Brain Tumours

October 13, **Nicholas Russell**, University of Delaware
Phytoplankton Aggregations: A Run-and-Tumble Model with Autochemotaxis

October 27, **Tom Chou**, University of California Los Angeles
Dynamics of Structured Populations: From Aging Demographics to Cell Size Control

November 10, **Robert Rosenbaum**, University of Notre Dame
Spatiotemporal Dynamics and Reliable Computations in Recurrent Spiking Neural Networks

November 24, **Henry Shum**, University of Waterloo
Modeling Differences in Motility of Flagellated Bacteria near Walls

February 2, **Jonathan Cannon**, Sinha Lab at MIT
Rhythmic Entrainment as Dynamic Inference

February 16, **Cliff Kerr**, Institute for Disease Modeling
Rhythmic Entrainment as Dynamic Inference

March 2, **Andrea Barreiro**, Southern Methodist University
Dissecting the Mechanisms of Retronasal Olfaction

March 9, **Hanspeter Herzel**, Institute for Theoretical Biology, Charité and Humboldt University Berlin
The Circadian Clock as a System of Coupled Oscillators

March 30, **Morgan Craig**, Universite de Montreal
Understanding Immune Communication Networks using Empirical Dynamics

April 6, **Chun Liu**, Illinois Institute of Technology
Energetic Variational Approaches (EnVarA) for Active Materials and Reactive Fluids

April 7, **Calvin Zhang-Molina**, University of Arizona
Modeling Synaptic Dynamics with Randomness and Plasticity

April 13, **Qixuan Wang**, University of California, Riverside
Modeling of Growth: What Do We Learn from Hair Follicles?

April 27, **Giovanna Guidoboni**, University of Missouri
Multiscale/Multiphysics Modeling of Ocular Physiology: The Eye as a Window on the Body

Fluid Mechanics and Waves Seminars

September 14, **Justin Jaworski**, Lehigh University
Poroelastic Trailing-Edge Noise and the Silent Flight of Owls

September 23, **David C. Venerus**, New Jersey Institute of Technology
Tears of Wine: New Insights on an Old Phenomenon

October 12, **Rayanne Luke**, University of Delaware
Parameter Identification for Tear Film Thinning and Breakup

October 26, **Xin Yong**, SUNY Binghamton
Colloids at Evaporating Fluid Interfaces: Transport and Assembly

November 9, **Charles Puelz**, Baylor College of Medicine
Fluid-Structure Interaction Models for Describing the Physiology of Human Hearts

December 7, **Angelo Tafuni**, New Jersey Institute of Technology
Gridless Simulation of Fluid Flow

February 16, **Ofer Manor**, Israel Institute of Technology
Strange Dynamics of Wetting

March 1, **Siddhartha Das**, University of Maryland, College Park
Ionics and Electroosmosis at Polyelectrolyte-Brush-Functionalized Interfaces

March 29, **Joseph Cousins**, University of Strathclyde
Governing Equations and Solution Multiplicities for a Static Ridge of Nematic Liquid Crystal

April 12, **Florencio Balboa Usabiaga**, Basque Center for Applied Mathematics
Rheotaxis and Gravitaxis of Artificial Swimmers

April 26, **Sean Carney**, University of California, Los Angeles
Low-Mach Number Fluctuating Hydrodynamics Model for Ionic Liquids

V. PUBLICATIONS, PRESENTATIONS, AND REPORTS

A. PUBLICATIONS

Journal Publications

Denis L. Blackmore

Generalized attracting horseshoe in the Rössler attractor (with K. Murthy, I. Jordan, P. Sojitra, and A. Rahman), *Symmetry*, Vol 13, December 2020.

Interesting bifurcations in walking droplet dynamics (with A. Rahman), *Communications in Nonlinear Science and Numerical Simulation*, Vol 90, pp. 105348, November 2020.

Walking droplets through the lens of dynamical systems (with A. Rahman), *Modern Physics Letters B*, Vol 34, pp. 20320009, November 2020.

Geometric aspects of isentropic liquid dynamics and vorticity invariants (with A. Balinsky, R. Kycia, and A. Prykarpatski), *Entropy*, Vol 22, pp. 1241, October 2020.

Amitabha K. Bose

A one-dimensional map to study multi-seasonal coffee infestation by the coffee berry borer (with M. Marcano and P. Bayman), *Mathematical Biosciences*, Vol 333, March 2021.

Entrainment dynamics of forced hierarchical circadian systems revealed by 2-dimensional maps (with G. Liao and C. O. Diekman), *SIAM Journal of Applied Dynamical Systems*, Vol 19, Issue 3, September 2020.

Order-indeterminant event-based maps for learning a beat (with Á. Byrne and J. Rinzel), *Chaos*, Vol 30, Issue 8, August 2020.

Wooyoung Choi

Linear stability of transversely modulated finite-amplitude capillary waves on deep water (with S. Murashige), *Studies in Applied Mathematics*, Vol 146, pp. 498-525, February 2021.

Two-dimensional resonant triad interactions in a two-layer system (with M. Chabane and T. M. Taklo), *Journal of Fluid Mechanics*, Vol 907, pp. A5: 1-41, January 2021.

Linda J. Cummings

On the performance of multilayered membrane filters (with D. Fong, S. J. Chapman, and P. Sanaei), *Journal of Engineering Mathematics*, Vol 127, Issue 1, April 2021.

On efficient asymptotic modelling of thin films on thermally conductive substrates (with R. Allaire and L. Kondic), *Journal of Fluid Mechanics*, Vol 915, pp. A133, April 2021.

The role of phase separation on Rayleigh-Plateau type instabilities in alloys (with R. Allaire, L. Kondic, P. Rack, and M. Fuentes-Cabrera), *Journal of Physical Chemistry C*, Vol 125, pp. 5723, February 2021.

Dielectrowetting of a thin nematic liquid crystal layer (with E. Mema and L. Kondic), *Physical Review E*, Vol 103, pp. 32702, February 2021.

Effects of spatially-varying substrate anchoring on instabilities and dewetting of thin Nematic Liquid Crystal films (with M. Lam and L. Kondic), *Soft Matter*, Vol 16, pp. 10187, October 2020.

Sunil K. Dhar

Assessment and Comparison of The Slippage and Unintentional Opening of Epidural Catheters and Their Connectors (with A. Gonzalez Fiol, R. Horvath, and A. Alian), *Anesthesia & Pain Research*, Vol 4, Issue 1, December 2020.

Casey O. Diekman

Circadian rhythms of early afterdepolarizations and ventricular arrhythmias in a cardiomyocyte model (with N. Wei), *Biophysical Journal*, Vol 120, pp. 319-333, January 2021.

Entrainment dynamics of forced hierarchical circadian systems revealed by 2-dimensional maps (with G. Liao and A. K. Bose), *SIAM Journal of Applied Dynamical Systems*, Vol 19, Issue 3, September 2020.

Christina A. Frederick

Flow rectification in loopy network models of bird lungs (with Q. Nguyen, A. U. Oza, J. Abouezzi, G. Sun, S. Childress, and L. Ristroph), *Physical Review Letters*, Vol 126, Issue 114501, pp. 6, March 2021.

Seabed classification using physics-based modeling and machine learning (with S. Villar and Z.-H. Michalopoulou), *Journal of the Acoustical Society of America*, Vol 148, pp. 859-872, August 2020.

Roy H. Goodman

Solitary waves in mass-in-mass lattices (with T. E. Favor and J. D. Wright), *Zeitschrift für Angewandte Mathematik und Physik*, Vol 71, Issue 6, pp. 44216, November 2020.

Wenge Guo

Adaptive controls of FWER and FDR under block dependence (with S. Sarkar), *Journal of Statistical Planning and Inference*, Vol 208, pp. 13-24, September 2020.

Lou Kondic

Correlating the force network evolution and dynamics in slider experiments (with C. Cheng and A. Zadeh), *European Physical Journal Web of Conferences*, Vol 140, pp. 2007, June 2021.

How Frost Forms and Grows on Lubricated Micro- and Nanostructured Surfaces (with L. Hauer, W. Wong, V. Donadei, K. J. Hegner, and D. Vollmer), *ACS Nano*, Vol 15, pp. 4658-4668, April 2021.

On efficient asymptotic modelling of thin films on thermally conductive substrates (with R. Allaire and L. J. Cummings), *Journal of Fluid Mechanics*, Vol 915, pp. A133, April 2021.

Simultaneous Decomposition and Dewetting of Nanoscale Alloys: A Comparison of Experiment and Theory (with J. Diez, A. Gonzalez, D. Garfinkel, P. Rack, and J. Mckeown), *Langmuir*, Vol 37, pp. 2575-2585, March 2021.

The role of phase separation on Rayleigh-Plateau type instabilities in alloys (with R. Allaire, L. J. Cummings, P. Rack, and M. Fuentes-Cabrera), *Journal of Physical Chemistry C*, Vol 125, pp. 5723, February 2021.

Dielectrowetting of a thin nematic liquid crystal layer (with E. Mema and L. J. Cummings), *Physical Review E*, Vol 103, pp. 32702, February 2021.

Quantitative measure of memoryloss in complex spatiotemporal systems (with M. Kramar, L. Kovalcinova, and K. Mischaikow), *Chaos*, Vol 31, pp. 33126, January 2021.

Effects of spatially-varying substrate anchoring on instabilities and dewetting of thin Nematic Liquid Crystal films (with M. Lam, and L. J. Cummings), *Soft Matter*, Vol 16, pp. 10187, October 2020.

Failure of confined granular media due to pullout of an intruder: from force networks to a system wide response (with S. Shah, C. Cheng, and P. Jalali), *Soft Matter*, Vol 16, pp. 7685, August 2020.

Ji Meng Loh

Generalized Bagging (with W. Jang and J. Kim), *Journal of the Korean Statistical Society*, March 2021.

Spatial Sampling Design using Generalized Neyman-Scott Process (with C. YipYau, Z. Zhu, and S. H. Leung), *Journal of Agricultural, Biological and Environmental Statistic*s, September 2020.

Victor V. Matveev

Stationary Ca2+ nanodomains in the presence of buffers with two binding sites (with Y. Chen), *Biophysical Journal*, Vol 120, Issue 10, pp. 1942-1956, March 2021.

Efficient approximations for stationary single-channel Ca2+ nanodomains across length scales (with Y. Chen and C. B. Muratov), *Biophysical Journal*, Vol 119, Issue 6, pp. 1239-1254, August 2020.

Zoi-Heleni Michalopoulou

Matched field source localization with Gaussian processes (with P. Gerstoft and D. Caviedes-Nozal), *Journal of the Acoustical Society of America Express Letters*, pp. 44203, June 2021.

Seabed Classification using Physics-based Modeling and Machine Learning (with C. A. Frederick and S. Villar), *Journal of the Acoustical Society of America*, Vol 148, pp. 859-872, August 2020.

Cyrill B. Muratov

A quantitative description of skyrmions in ultrathin ferromagnetic films and rigidity of degree ±1 harmonic maps from R^2 to S^2 (with A. Bernand-Mantel and T. M. Simon), *Archive for Rational Mechanics and Analysis*, Vol 239, pp. 219-299, September 2020.

Efficient approximations for stationary single-channel Ca2+ nanodomains across length scales (with Y. Chen and V. V. Matveev), *Biophysical Journal*, Vol 119, Issue 6, pp. 1239-1254, August 2020.

Variational principles of micromagnetics revisited (with G. Di Fratta, F. Rybakov, and V. Slastikov), *SIAM Journal on Mathematical Analysis*, Vol 52, pp. 3580–3599, July 2020.

Anand U. Oza

Flow rectification in loopy network models of bird lungs (with Q. Nguyen, J. Abouezzi, G. Sun, S. Childress, C. A. Frederick, and L. Ristroph), *Physical Review Letters*, Vol 126, Issue 114501, pp. 6, March 2021.

The dynamics of parallel-plate and cone-plate flows (with D. C. Venerus), *Physics of Fluids*, Vol 33, Issue 23102, pp. 13, February 2021.

Hydrodynamic Quantum Analogs (with J W. M. Bush), *Reports on Progress in Physics*, Vol 84, Issue 17001, pp.1-41, December 2020.

Resonant interactions in bouncing droplet chains (with Lauren Barnes), *Comptes Rendus Mecanique*, Vol 349, Issue 44354, pp. 573-589, November 2020.

Zuofeng Shang

Nonparametric Testing under Randomized Sketching (with M. Liu, Y. Yang, and G. Cheng), *Transactions on Pattern Analysis and Machine Intelligence*, February 2021.

Nonparametric Distributed Learning under Random Design (with M. Liu, and G. Cheng), *Electronic Journal of Statistics*, Vol 14, No.2, 2020.

Identification and estimation in panel models with overspecified number of groups (with R. Liu, Y. Zhang, and Q. Zhou), *Journal of Econometrics*, Vol 15, No.2, 2020.

David Shirokoff

High-order Finite Element Methods for a Pressure Poisson Equation Reformulation of the Navier-Stokes Equations with Electric Boundary Conditions (with R. Rosales, B. Seibold, and D. Zhou), *Computer Methods in Applied Mechanics and Engineering*, Vol 373, pp. 113451, January 2021.

Sundarraman G. Subramanian

Median regression from twice censored data, *Statistics & Probability Letters*, Vol 168, January 2021.

Antai Wang

Estimation of the cumulative baseline hazard function for dependently right-censored failure time data (with X. Jia and Z. Jin), July 2020

Yuan-Nan Young

Effects of surfactant solubility on the hydrodynamics of a viscous drop in a dc electric field (with H. Nganguia, W. - F Hu, and M. - C. Lai) *Physical Review Fluids*, Vol 6, pp. 064004, June 2021.

Mechanical rotation at low Reynolds number via reinforcement learning (with Y. Liu, Z. Zou, A. C. H. Tsang, and O. S. Pak) *Physics of Fluids*, Vol 33, pp. 079902, June 2021.

The many behaviors of deformable active droplets (with M. J. Shelley, and D. B. Stein) *Mathematical Biosciences and Engineering*, Vol 18, Issue 3, pp. 2849-2881, March 2021.

Primary cilium: a paradigm for integrating mathematical modeling with experiments and numerical simulations in mechanobiology. (with Z. Peng and A. Resnick) *Mathematical Biosciences and Engineering*,Vol 18, Issue 2, pp. 1215-1237, January 2021.

Boundary conditions at a gel-fluid interface. (with J. J Feng) *Physical Review Fluids*, Vol 5, Issue 1, pp. 124304, December 2020.

Conferences

Christina A. Frederick

Emergent circulation in the loopy network of bird lungs (with Q. Nguyen, A. U. Oza, J. Abouezzi, G. Sun, S. Childress, and L. Ristroph), Bulletin of the American Physical Society: 73rd Annual Meeting of the APS Division of Fluid Dynamics, Vol 65, Issue 13, pp. Y02.00008, November 2020.

Lou Kondic

Modelling of colloid-polymer mixtures in microgravity (with L. Barnes, B. Khusid, W. V. Meyer, and A. U. Oza), American Society for Gravitational and Space Research, November 2020.

Anand U. Oza

Exploring diffraction with a pilot-wave model (with G. Pucci and A. Bellaigue), Bulletin of the American Physical Society: APS March Meeting 2021, Issue U71: Poster Session III, March 2021.

Resonance, instability and dynamical stabilization in bouncing droplet chains (with L. Barnes and G. Pucci), American Physical Society, November 2020.

Schooling of tandem flapping wings (with M. Guzraty), American Physical Society, November, 2020.

Emergent circulation in the loopy network of bird lungs (with Q. Nguyen, J. Abouezzi, G. Sun, S. Childress, C. A. Frederick, and L. Ristroph), Bulletin of the American Physical Society: 73rd Annual Meeting of the APS Division of Fluid Dynamics, Vol 65, Issue 13, pp. Y02.00008, November 2020.

Schooling of tandem flapping wings (with M. Guzraty), Bulletin of the American Physical Society: 73rd Annual Meeting of the APS Division of Fluid Dynamics, Vol 65, Issue 13, pp. U01.00005, November 2020.

Exact solutions for the unsteady motion of multiple wings in an inviscid fluid (with P. J. Baddoo, D. Crowdy, and N. Moore), Bulletin of the American Physical Society: 73rd Annual Meeting of the APS Division of Fluid Dynamics, Vol 65, pp. S02.00014, November 2020.

Resonance, Instability and Dynamical Stabilization in Bouncing Droplet Chains (with L. Barnes and G. Pucci), Bulletin of the American Physical Society: 73rd Annual Meeting of the APS Division of Fluid Dynamics, Vol 65, Issue 13, pp. S04.00003, November 2020.

Modelling of colloid-polymer mixtures in microgravity (with L. Barnes, B. Khusid, L. Kondic, and W. V. Meyer), American Society for Gravitational and Space Research, November 2020.

Zuofeng Shang

Non-asymptotic Theory for Nonparametric Testing (with Y. Yang and G. Cheng), 33rd Annual Conference on Learning Theory, 2020.

David G. 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 7.9.7, January 2021.

B. PRESENTATIONS

Travis L. Askham

March 3, 2021: Society for Industrial and Applied Mathematics, **Virtual**
"A Fast Multipole Method for Continuous Charge Distributions"

December 2020: Canadian Mathematical Society, **Virtual**
"Fast Multipole Methods for Continuous Charge Densities"

July 2020: Society for Industrial and Applied Mathematics, **Virtual**
"Fast Multipole Methods for Continuous Charge Densities"

Denis L. Blackmore

May 24, 2021: Society for Industrial and Applied Mathematics, Portland, Oregon, **Virtual**
"Attractors in Walking Droplet Dynamics"

March 3, 2021: Department of Mathematical Sciences, NJIT, Newark, NJ
"Dynamical Systems Analysis of Walking Droplet Models"

Michael R. Booty

January 28, 2021: Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, NJ, **Virtual**
"Studies of Surfactant Solubility"

Linda J. Cummings

May 21, 2021: Society for Industrial and Applied Mathematics, **Virtual**
"Free Surface Dynamics of Nematic Liquid Crystal Films: Dewetting and Dielectrowetting"

April 10, 2021: Mathematics Graduate Organization, Syracuse University, Syracus, NY, **Virtual**
"Dewetting and Dielectrowetting in Thin Films of Nematic Liquid Crystals"

March 12, 2021: University of Warwick, UK, **Virtual**
"Dewetting and Dielectrowetting in Thin Films of Nematic Liquid Crystals"

February 1, 2021: Australian and New Zealand Industrial and Applied Mathematics, **Virtual**
"Dewetting and Dielectrowetting in Thin Films of Nematic Liquid Crystals"

Casey O. Diekman

June 17, 2021: Society for Mathematical Biology, **Virtual**
"Oxygen Handling and Parameter Space Interrogation in a Minimalist Closed-Loop Model of the Respiratory Oscillator"

May 26, 2021: Society for Industrial and Applied Mathematics, **Virtual**
"Circadian Reentrainment Dynamics Organized by Global Manifolds"

April 30, 2021: New Jersey Institute of Technology, Newark, NJ
"Data Assimilation and Dynamical Systems Analysis of Circadian Rhythmicity and Entrainment"

Christina A. Frederick

February 24, 2021: University of California LA, Los Angeles, CA

"Multiscale Ideas in Sampling Theory and Multi-Robot Path-Planning"

October 2020: Sarah Lawrence College Science Seminar, Sarah Lawrence College, Yonkers, NY
"Aliasing in Sampling Theory and Applications"

Roy H. Goodman

October 2020: Yeshiva University, New York, NY
"Instability and Breakup Dynamics of the Leapfrogging Vortex Quartet"

Wenge Guo

May 21, 2021: International Indian Statistical Association, Virtual
"A Modified Graphical Approach with Generalized Sequentially Rejective Principle to Control Familywise Error Rate"

March 25, 2021: International Seminar on Selective Inference, Virtual
"Discussion of Smoothed Nested Testing on Directed Acyclic Graphs"

March 29, 2021: University of North Carolina Greensboro, Greensboro, NC, **Virtual**
"Generalised Finite Difference Methods for Fully Nonlinear Elliptic Equations"

Lou Kondic

May 1, 2021: Society for Industrial and Applied Mathematics, Bilbao, Spain
"From Topology of Force Networks to Avalanche Prediction in Sheared Particulate Systems"

April 1, 2021: Institute of Mathematical and Statistical Innovation, Chicago
"Towards Understanding of Complex Spatio-Temporal Systems"

November 19, 2020: New Jersey Institute of Technology, Newark, NJ
"Modeling Liquid Crystal Films on Nanoscale"

November 18, 2020: University of Nottingham, Department of Mathematics, Nottingham, UK
"Modeling Liquid Crystal Films on Nanoscale"

September 1, 2020: Max-Planck Institute for Polymer Research, Mainz, Bonn, Germany
"Wetting on Thermally Conductive Substrates"

Ji Meng Loh

April 2021: Baruch College, NY
"Spatial Sampling Design using the Generalized Neyman-Scott Process"

April 2021: University of Binghamton, NY
"Spatial Sampling Design using the Generalized Neyman-Scott Process"

Enkeleida Lushi

August 2020: International Congress of Theoretical and Applied Mechanics, Milan, Italy
"Minisymposium on Low Reynolds Number Flows"

July 2020: World Congress in Computational Mechanics, Paris, France
"Minisymposium on Biological Fluid Dynamics"

Victor V. Matveev

June 15, 2021: Society for Mathematical Biology, **Virtual**
"Approximations of Stationary Calcium Nanodomains in the Presence of Buffers with Two Binding Sites"

August 19, 2020: Society for Mathematical Biology, **Virtual**
"Mass-Action vs Stochastic Modeling of First Passage Time to Neurotransmitter Vesicle Fusion"

July 20, 2020: Organization for Computational Neurosciences, **Virtual**
"Approximation of Stationary Ca2+ Nanodomains in the Presence of Cooperative Ca2+ Buffers"

Zoi-Heleni Michalopoulou

June 2021: Underwater Acoustics Conference and Exhibition, **Virtual**
"Source Tracking and Geoacoustic Inversion in the Seabed Characterization Experiment 2017"

June 2021: Acoustical Society of America, **Virtual**
"Source Detection and Localization in the Ocean with a Bayesian Approach"

Cyrill B. Muratov

June2021: The Institute of Electrical and Electronics Engineers, Moena, Italy
"An Interplay Between Dimensionality and Topology in Thin Ferromagnetic Films"

May 2021: Society for Industrial and Applied Mathematics, Bilbao, Spain
"Ferromagnetism at Nanoscale"

May 2021: Carnegie Mellon University, Pittsburgh, PA
"One-Dimensional Domain Walls in Thin Film Ferromagnets: An Overview"

March 2021: California Institute of Technology Pasadena, CA
"Magnetic Skyrmions in the Conformal Limit"

March 2021: University of California LA, Los Angeles, CA
"Magnetic Skyrmions in the Conformal Limit"

February 2021: Institute for Mathematical and Statistical Innovation, University of Chicago, Chicago, IL
"Magnetic Skyrmions in the Conformal Limit"

September 2020: Carnegie Mellon University, Pittsburgh, PA
"Magnetic Skyrmions in the Conformal Limit"

August 2020: Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany
"Magnetic Skyrmions in the Conformal Limit"

Anand U. Oza

June 16, 2021: Society for Mathematical Biology, **Virtual**
"Coarse-Grained Models for Schooling Swimmers"

April 27, 2021: Massachusetts Institute of Technology, **Virtual**
"Orderly Formations and Traveling Waves Exhibited by Schooling Wings"

November 23, 2020: American Physical Society, **Virtual**
"Theoretical Modeling of Surfers on a Vibrating Bath"

October 23, 2020: Imperial College, London, UK
"Coarse-Grained Models for Schooling Swimmers"

July 10, 2020: Society for Industrial and Applied Mathematics, **Virtual**
"Lattices of Hydrodynamically Interacting Flapping Swimmers"

Luis Pugnaloni

March 1, 2021: American Physical Society, Chicago, IL
"Dynamics of an Intruder Moving Through a Confined Granular Medium: Rescaled Packing Fraction Yields Data Collapse for Different Intruder and System Sizes"

David G. Shirokoff

June 21, 2021: Waterloo University, Waterloo ON, Canada **Virtual**
"Where Models Fail: Stationary Probability Distributions of Stochastic Gradient Descent and the Success and Failure of the Diffusion Approximation"

May 6, 2021: Machine Learning Seminar, New Jersey Institute of Technology, Newark, NJ **Virtual**
"A Discussion of Open Problems Related to Stochastic Gradient Descent"

March 1, 2021: Society for Industrial and Applied Mathematics, Fort Worth,Texas
"Semi-Implicit (ImEx) Schemes for the Dispersive Shallow Water Equations"

October 16, 2020: Mathematical and Computational Engineering Seminar, Pontificia Universidad Católica de Chile **Virtual**
"Unconditional Stability for Multistep ImEx Schemes"

Michael S. Siegel

February 22, 2021: Department of Mathematical Sciences, New Jersey Institute of Technology, Newark, NJ
"Finite-Time Singularity Formation in the Generalized Constantin-Lax-Majda Equation"

Yuan-Nan Young

June 11, 2021: Workshop on Modeling and Analysis in Molecular Biology and Electro- physiology, Zu Chongzhi Center for Mathematics and Computational Sciences, Kunshan, China, **Virtual**
"The Many Behaviors of Active Droplets"

May 19, 2021: SIAM Conference on Mathematical Aspects of Materials Science, **Virtual**
"The Many Behaviors of Active Droplets"

April 19, 2021: Fluid Mechanics, Combustion, & Engineering Physics Seminar Series, UCSD
"The Many Behaviors of Active Droplets"

March 15, 2021: American Physical Society, March Meeting 2021, **Virtual**
"Coarse-Grained Modeling of Centrosome Dynamics"

January 12, 2021: IACM Eccomas Congress 2020 & 14th WCCM, **Virtual**
"Hydrodynamics of a Semipermeable Inextensible Membrane Under Flow and Confinement"

January 8, 2021: SIAM Joint Meeting with AMS, **Virtual**
"Boundary Conditions at the Gel-Fluid Interface"

November 24, 2020: 73rd Annual Meeting of the American Physical Society Division of Fluid Mechanics, **Virtual**
"Generating Net Rotational Motion at Low Reynolds Number via Reinforcement Learning"

November 23, 2020: 73rd Annual Meeting of the American Physical Society Division of Fluid Mechanics, **Virtual**
"Boundary Conditions on a Hydrogel-Fluid Interface"

November 23, 2020: 73rd Annual Meeting of the American Physical Society Division of Fluid Mechanics, **Virtual**
"Effects of Surfactant Solubility on the Hydrodynamics of a Viscous Drop in a DC Electric Field"

November 23, 2020: 73rd Annual Meeting of the American Physical Society Division of Fluid Mechanics, **Virtual**
"Hydrodynamics of Small Unilamellar Vesicles (sUVs) Simulated Using a Hybrid Approach"

November 23, 2020: 73rd Annual Meeting of the American Physical Society Division of Fluid Mechanics, **Virtual**
"Semipermeable Vesicle in Stokes Flows"

November 22, 2020: 73rd Annual Meeting of the American Physical Society Division of Fluid Mechanics, **Virtual**
"Dynamics of Active Droplets of Nematic Fluid Immersed in a Viscous Fluid"

November 19, 2020: Department of Chemical Engineering Seminar, **Virtual**
"Fluid - Structure Interactions: Hydrodynamics of Vesicles with Adhesion and Permeability"

July 2, 2020: Society for Industrial and Applied Mathematics, **Virtual**
"Linear Instability and Nonlinear Dynamics of Droplets and Layers of Active Fluid"

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

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

Associate Editor, Crystals, 2021 - Current

Associate Editor, Nanomaterials, 2021 - Current

Associate Editor, Journal of Engineering Mathematics, 2020 - Current

Associate Editor, Papers in Physics, 2019 - Current

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

Zoi-Heleni Michalopoulou

Associate Editor, Journal of the Acoustical Society of America

Associate Editor, IEEE Journal of Oceanic Engineering

Michael Siegel

Associate Editor, Journal of Engineering Mathematics

B. FACULTY AWARDS

Christina Frederick

CSLA Undergraduate Teaching Award Nomination at NJIT, 2021

Lou Kondic

Sigma Xi Invited Membership, Sigma Xi Scientific Research Honors Society, October 2020

Excellence in Research Prize and Medal, New Jersey Institute of Technology, September 2020

Anand Oza

CSLA Rising Star Research Award, New Jersey Institute of Technology, May 2021

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

Efficient High Frequency Integral Equations and Iterative Methods
National Science Foundation: August 1, 2017 - June 30, 2021
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

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 Filters
National Science Foundation: September 1, 2016 - August 31, 2021
Linda Cummings (PI), Lou Kondic (Co-PI)

CAREER: Neuronal Data Assimilation Tools and Models for Understanding Circadian Rhythms
National Science Foundation: July 1, 2016 - September 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, 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, 2021
Shidong Jiang

Conference on Frontiers in Applied and Computational Mathematics
National Science Foundation: May 1, 2019 – October 31, 2021
Lou Kondic (PI), Denis Blackmore (Co-PI), Linda Cummings (Co-PI), Michael Siegel (Co-PI)

Stick-Slip Dynamics and Failure in Granular Materials
Duke University: July 15, 2018 – July 14, 2021
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, 2021
Lou Kondic (PI), Shahriar Afkhami (Co-PI)

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

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

Geoacoustic Inversion in Shallow Water
U.S. Navy: Office of Naval Research: March 1, 2018 - February 28, 2022
Zoi-Heleni Michalopoulou

Geoacoustic Inversion in Shallow Water - Analytic and Optimization Methods
U.S. Navy: Office of Naval Research: March 1, 2020 - February 28, 2023
Zoi-Heleni Michalopoulou

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

Wave-Coupled Active Matter
Simons Foundation: September 1, 2018 - August 31, 2021
Anand Oza

Phase Transitions in Colloid-Polymer Mixtures in Microgravity
NASA: November 5, 2019 - November 4, 2021
Anand Oza

US-Israel Research Proposal: Network Resonance: Spiking Mechanisms and Behavioral Implications
National Science Foundation: September 15, 2016 - August 31, 2021
Horacio Rotstein

CDS&E: Collaborative Research: Scalable Nonparametric Learning for Massive Data with Statistical Guarantees
National Science Foundation: August 1, 2019 - July 31, 2021
Zuofeng Shang

Collaborative Research: Overcoming Order Reduction and Stability Restrictions in High-Order Time-Stepping
National Science Foundation: August 1, 2017 - July 31, 20231
David Shirokoff

EXTREEMS-QED: Research and Training in Computational and Data-Enabled Science and Engineering for Undergraduate in the Mathematical Sciences at NJIT
National Science Foundation: September 1, 2013 - August 31, 2021
Michael Siegel

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

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

Optimized Domain Decomposition Methods for Wave Propagation in Complex Media
National Science Foundation: September 1, 2019 - August 31, 2022
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, 2021
Yuan-Nan Young

Projects Funded During the Present Academic/ Fiscal Year

Collaborative Research: Novel Microlocal-Analysis and Domain-Decomposition Based Fast Algorithms for
Elastic Wave Modeling and Inversion in Variable Media
National Science Foundation: August 1, 2020 - July 31, 2023
Yassine Boubendir

Collaboration in Mathematical Biology
The Simons Foundation: September1, 2020 - August 31, 2025
James Maclaurin

Collaborative Research: Euler-Based Time-Stepping with Optimal Stability and Accuracy for Partial
Differential Equations
National Science Foundation: August 15, 2020 - July 31, 2023
David Shirokoff

Collaborative Research: Mathematical, Numerical, and Experimental Investigation of Flow Sensing by the
Primary Cilium
National Science Foundation: August 1, 2020 - July 31, 2023
Yuan-Nan Young

B. PROPOSED RESEARCH

Projects Proposed During Present Fiscal Year

Shahriar Afkhami

HDR DSC: Training and Education of Data Scientists at the Interface of Mathematical and Computer Sciences
National Science Foundation, December 2021

Travis Askham

Efficient and High-Order Methods for the Navier-Stokes Equations in Complex Geometries
National Science Foundation, December 2020

Amitabha Bose

Collaborative Research: CRCNS US-German Research Proposal: How Does the Brain Learn the Pattern and Beat of Rhythmic Sound?
National Science Foundation, October 2020

Yassine Boubendir

Collaborative: Novel Microlocal-Analysis and Domain-Decomposition Based Fast Algorithms for Elastic Wave Modeling and Inversion in Variable Media
National Science Foundation, September 2020

Bruce Bukiet

STEM for Success Scholars
National Science Foundation, April 2021

Wooyoung Choi

Nonlinear Interactions Between Surface and Internal Waves in Stratified Flows
National Science Foundation, November 2020

Nonlinear Interactions Between Surface and Internal Waves in Stratified Flows
Simons Foundation, September 2020

Linda Cummings

GOALI: Predicting Performance & Fouling of Membrane Filters
National Science Foundation, May 2021

Collaborative Research: Building an Industrial Mathematical Modeling Ecosystem
National Science Foundation, May 2021

Casey Dlekman

GOALI: Merging Deep Learning and Mechanistic Modeling to Investigate Circadian Rhythms in the Brain, Heart, and Immune System
National Science Foundation, August 2020

RTG: Transdisciplinary Training in Mathematical and Computational Biology at NJIT: From Data to Theory and Back
National Science Foundation, June 2021

Christina Frederick

Multiscale Inverse Scattering Problems in Ocean Acoustics
National Science Foundation, January 2020

Strategies, Algorithms, and Analysis for Autonomous Mobile Sensor Deployment
Office of Naval Research, December 2020

Collaborative Research: Robustness, Precision, and Uncertainty Limit of Scientific Machine Learning"
National Science Foundation, May 2021

Lou Kondic

Tracking and Predicting Pandemic Hot Spots by Topological Data Analysis
United States Office of the Director of National Intelligence, July 2020

CDS&E Collaborative Research: Dense Suspension Flows - Topological Methods to Deduce Statistical Physics from Computational Simulation
National Science Foundation, September 2020

Collaborative Research: Guided Assembly of Nanoscale Liquid Metal Alloys: Fundamental Modeling and Targeted Experiments
National Science Foundation, November 2020

Phase Separation of Two-Fluid Mixtures using Surface Acoustic Waves: Developing Basic Principles in a Quest for Enhanced Water Recovery
United States-Israel Binational Science Foundation, July 2020

James MacLaurin

Emergent Dynamics of the Primary Visual Cortex
National Science Foundation, August 2020

Aging of Spin Glass
National Science Foundation, November 2020

Experimental and Computational Study of Calcium Signaling in Dendritic Cells
Rutgers University, March 2021

Anand Oza

Modeling and Simulation of Interacting Wings: Collective Dynamics in Inertial Fluid Flows
National Science Foundation, November 2020

DMS-EPSRC: Capillary Surfers: From Individual to Collective Dynamic
National Science Foundation, February 2021

Zuofeng Shang

Collaborative Research: SaTC: CORE: Medium: Quantifying Dynamic Uncertainties in the Absence of Ground Truth: Statistical Framework & Applications
National Science Foundation, September 2020

Collaborative Research: Hypothesis Testing, Model Selection and Optimal Estimation in Hypergraphs
National Science Foundation, December 2020

CDS&E: Collaborative Research: Scalable Nonparametric Learning for Massive Data with Statistical Guarantees (Supplement)
National Science Foundation, May 2021

Michael Siegel

Flows about Grooved Superhydrophobic Surfaces
United States-Israel Binational Science Foundation, September 2020

Antai Wang

Analysis of High Dimensional and Competing Risks Data Using Copula Models (II)
Simons Foundation, January 2021

Yuan-Nan Young

Collaborative Research: Mathematical Modeling and Coarse-Grained Simulations of Self-Assembly of Amphiphilic Janus Particles in a Solvent
National Science Foundation, November 2020

Collaborative Proposal: Theoretical, Computational, and Experimental Investigations on the Interaction Between a Lipid Bilayer Membrane and a Solid Substrate or Particle (Supplement)
National Science Foundation, May 2021

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 the Kong.njit.edu cluster was replaced with the far more powerful Lochness.njit.edu cluster. Lochness utilizes a shared infrastructure model with public, private, and Stheno nodes supported. The public portion of Lochness consists of 35 nodes and 3360 cores. Each node has

- 385GB RAM

- 2x Intel Xeon Gold 6226R CPU @ 2.90GHz

- 1TB of SSD storage

- 100Gb/sec Infiniband network interface

- 10GigE Ethernet interface

- CentOS Linux 7 (Core)"operating system

Statistical Consulting Laboratory Report

July 2020 - June 2021

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.

Sunil Dhar worked with Miosotis Hernandez, Assistant Director, Office of University Admissions, New Jersey Institute of Technology (NJIT), and Gordon Thomas, Physics Department, NJIT to increase retention rates in universities. The project involved analyzing data collected by the client to help increase retention rates in universities using a method of learning called Active Learning. In Active Learning, students develop learning skills and are highly engaged during the class. The experimental group is compared with a control group, which consists of classes of students taught using a traditional method. The data are grade distributions over four semesters (Fall 2016, Spring 2017, Fall 2017, and Spring 2018) in Physics 111 and 112, over several sections. Dr. Sunil K. Dhar, Ph.D. provided a selection of proper response variables, developed research hypotheses, data analysis methods, and statistical validity of the methods.

Antai Wang consulted with researchers from St. Joseph's University Medical Center, New York Medical College and the Department of Pharmacy Practice and Administration (Rutgers) to study opioid prescription at hospital discharge after traumatic injury. Their paper titled "Opioid prescribing at discharge I in opioid-naive trauma patients" is now accepted in The American Surgeon.

Zuofeng Shang worked with Dr. Mingao Yuan (North Dakota State University) to submit an NSF grant "Statistical Inference in Hypergraph Models" in Dec 2020.

Ji Meng Loh, together with graduate students Xiao Han and Gan Luan, met with Asst Prof Kum-Biocca (School Architecture) and Prof Biocca (Information Systems) to discuss their project studying relationships between loneliness and social media usage during the pandemic.

1. Ji Meng Loh met with PhD student Aida Lopez Ruiz (Chemical Engineering) in May 2021 to discuss methods for propagation of errors in repeated measurements of a chemical system at each of several time points. Methods discussed include regression, pooled variances and Analysis of Variance.

2. Ji Meng Loh met with PhD student Dhalia Musa and Dr. Salam Daher (Informatics) in Mar 2021 to discuss the use of t tests and Analysis of Variance methods for their research paper.

3. Ji Meng Loh met with Justine Krawiec (staff at NJIT) in Jan 2021 to discuss statistical analysis for her dissertation research on the impact of interaction types in online learning (learner-content, learner-instructor, learner-learner and learner-interaction) on student satisfaction. Statistical methods considered included hierarchical multiple regressions and two-way Analysis of Variance (ANOVA).

IX. CURRENT AND COLLABORATIVE RESEARCH

A. RESEARCH AREAS IN CAMS

<u>Mathematical Biology</u>

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.

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.

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 achieve 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 the 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 themes 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 in 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 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 stream function-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 the 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 composed 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 a 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.

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.

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 concluded at the end of AY 20/21. 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 final student cohort consisted 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--both by working with individual professors and by participating in REU programs such as the RIPS program at UCLA.

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 14 passed during the year. 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 Projects on Mathematical Epidemiology and COVID-19

Instructor: Casey Diekman   Teaching Assistant: Soheil Saghafi

Simulating the Spread of COVID-19 in New Jersey and Essex County using Differential Equations Based Models
Rushi Bhatt, Louise Callanta, Deva Craig, Maisha Manir, Camilo Enrique Martinez Moyano, Jay Patel, Nitya Shah,
Richard Woods, Kevin Yotongyos, and Mary Yousef

COVID-19, a highly communicable disease resulting from the novel coronavirus SARS-CoV-2, has been rapidly spreading around the world since late 2019 with devastating impacts on global health and economies, prompting the development of mathematical models to predict the spread of the disease. Infectious diseases are often modeled by assigning the population to compartments with labels, for example Susceptible (S), Infectious (I), or Recovered (R), with the flow of people between compartments governed by ordinary differential equations. The students developed an SEIAQRV (Susceptible, Exposed, Infectious Symptomatic, Infectious Asymptomatic, Quarantined, Recovered, Vaccinated) compartmental model to track the spread of COVID-19 across the state of New Jersey and in Essex County.
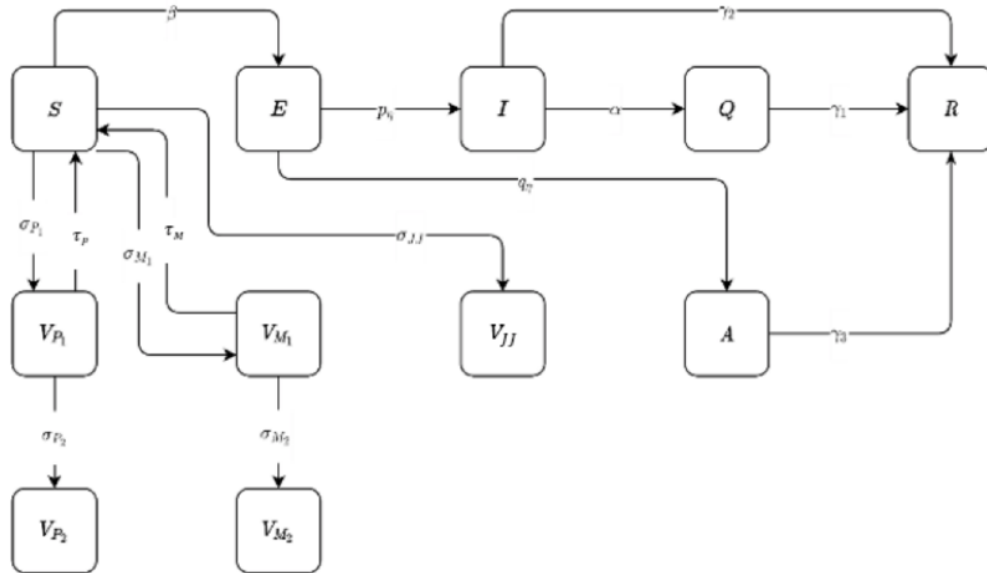

Figure 1. Schematic of a compartmental ODE model for predicting the spread of COVID-19 at the state and county level. The parameter β is the rate at which people move from Susceptible (S) to Exposed (E).

The model consisted of 11 ODEs and 16 parameters. Model parameters were fit to data on active cases and vaccination rates obtained from public databases. Model simulations and parameter fitting were performed using MATLAB. The students found that to accurately reproduce the data on active cases, it was necessary to allow β (see Fig 1) to vary as a function of time. This insight enabled them to predict a range of plausible infection levels for the remainder of 2021 based on β values corresponding to various hypothetical scenarios regarding people's behavior, mutations affecting the transmissibility of the virus, and vaccine efficacy.

The students also modeled the spatial spread of COVID-19 using an SIR model with New Jersey divided into 3 regions (northern, central, and southern) and partial differential equations describing the diffusion of infected people between regions. The system of PDEs was solved numerically using the leapfrog method and Neumann boundary conditions.

Simulating the Spread of COVID-19 in Essex County and at NJIT using Agent-Based Models
Samuel Carlos, Brandon Chin, Kristianna Gaw, Jacob Haynie, Mike Jeong, and David Kim

In contrast to compartmental equations-based modeling with ODEs or PDEs, which tends to focus on the overall macro-level behavior of a system, agent-based modeling (ABM) emphasizes the micro-level behavior of individual agents in the system with the macro-level dynamics emerging from the interactions of the agents. In the context of mathematical epidemiology, the agents are individual people that are simulated over a number of discrete time steps with probabilistic rules governing their interactions. The principal calculation is the probability that a given agent on a given time step will change from one state to another, for example from susceptible to infected or from infected to dead. The students used Covasim, an open-source Python package [1], to implement two ABMs: one at the level of Essex County, and one specific to the NJIT student population. Model parameters were fit to Essex County data using Optuna, a hyperparameter optimization framework [2]. The NJIT-level model was fit to data provided by NJIT's Pandemic Recovery Steering Committee. In this model, whenever a susceptible individual comes into contact with an infectious individual on a given day, transmission of the virus occurs according to the probability β. To reproduce the NJIT case data, the students adjusted β over time accounting for 5 different events between November 2020 and February 2021, such as a 10-day Newark city-wide lockdown and Student Appreciation Week. The students then used their model to predict the number of cases at NJIT throughout the Fall 2021 semester assuming in-person classes and several different vaccination scenarios. The students concluded that ABM is an effective tool for modeling universities and other small population sizes due to the flexibility of the ABM framework and the ease with which customized interventions can be incorporated into the model.

1. Kerr C et al (2020). Covasim: an agent-based model of COVID-19 dynamics and interventions. *medRxiv,* doi.org/10.1101/2020.05.10.20097469.

2. Akiba T et al (2019). Optuna: a next-generation hyperparameter optimization framework. *Proceedings of the 25th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, doi.org/10.1145/3292500.3330701.

B. GRADUATE PROGRAMS

Graduate Activities Report
Shahriar Afkhami, 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 in a relatively large incoming class of 12 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, and statistics. One of the incoming students was awarded a prestigious NJIT Gary Thomas Provost Fellowship. Several current students secured summer internships at government labs, as well as local pharmaceutical 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, Biostatistics, and Data Science. 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 theiraccomplishments 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, andthey regularly organize tea-time (virtual this year due to pandemic) as well academic, career-oriented, and social events under the banner of the NJIT SIAM Chapter, such as a new student organized seminar series in machine learning 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 Oak Ridge National Laboratory, Johns Hopkins Applied Physics Laboratory, as well as in private industries such as Bristol Myers Squibb, and Regeneron Pharmaceuticals.

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 faculty position at the West Point Academy, applied research mathematician position at NSA, and postdocs at Oxford University and NYU. Several recent graduates have obtained exciting positions in data science. This year, with the help of our faculty, two career panel sessions were held, where our past and recent Ph.D. graduates from our department presented their career experiences and discussed and answered students' questions.

PhDs Awarded in the Period Covered by the Report

Ryan Atwater
Studies of Two-Phase Flow with Soluble Surfactant
Advisor: Michael Booty

Brandon Behring
Dances and escapes of the vortex quartet
Advisor: Roy Goodman

Malik Chabane
Resonant triad interactions in one and two-layer systems
Advisor: Wooyoung Choi

Yinbo Chen
Efficient approximations for stationary single-channel calcium nanodomains
Advisor: Victor Matveev

Chao Cheng
Intermittent Dynamics of Dense Particulate Matter
Advisor: Lou Kondic

Linwan Feng
Efficient Time-Stepping Approaches for Dispersive Shallow Water Equations
Advisor: David Shirokoff, Wooyoung Choi

Ziyan Guo
Asymmetric Multivariate Archimedean Copula Models and Semi-Competing Risks Data Analysis
Advisor: Antai Wang

Emel Khan
Mechanisms of Oscillations and Polyglot Entrainment In Neuronal and Circadian Models
Advisor: Casey Diekman and Horacio Rotstein

Jacob Lesniewski
Eigenvalue Problems for Fully Nonlinear Elliptic Partial Differential Equations with Transport Boundary
Conditions
Advisor: Brittany D. Hamfeldt

Guangyuan Liao
Mathematical models and tools to understand coupled circadian oscillations and limit cycling systems
Advisor: Amitabha Bose

Keyang Zhang
Convergence of the Boundary Integral Method for Interfacial Stokes Flow
Advisor: Michael Siegel

Publications, Presentations, & Conferences

*Not Including FACM Participation or DMS Summer Student Talks

Yasser Almoteri

Presentations

March 2021: APS March Meeting
Minisymposium talk: Bacterial motion and spread in porous media

November 2020: APS DFD Annual Meeting
Minisymposium talk, Bacterial motion and spread in porous media

Lauren Barnes

Conference and Workshop Attendance

April 21, 2021: Modeling of Colloid-Polymer Mixtures in Microgravity, 2021 Dana Knox Student Research Showcase, New Jersey Institute of Technology, Newark, NJ, Virtual

November 22 – 24, 2020: Resonance, Instability and Dynamical Stabilization in Bouncing Droplet Chains 73rd Annual Meeting of the APS Division of Fluid Dynamics, Chicago, IL, Virtual

November 5 - 6, 2020: Modeling of colloid-polymer mixtures in microgravity, ASGSR 2020, Virtual

Yuexin Liu

Publications

Mechanical rotation at low Reynolds number via reinforcement learning (with Z. Zou, A. C. H. Tsang, O. S. Pak, Y.-N. Young), *Physics of Fluids*, 33 (6), 062007, 2021

Posters

November 22 – 24, 2020: 73rd Annual Meeting of the APS Division of Fluid Dynamics, Virtual
Generating net rotational motion at low Reynolds number via reinforcement learning

Conference and Workshop Attendance

SIAM-LS20
Virtual minisymposia on Swimmers and Active Particles

Gan Luan

Posters

December 14, 2020: ICSA Applied Statistics Symposium, Houston, Texas, USA, Virtual
Parameter Estimation and Inference of Spatial Autoregressive Model byStochastic Gradient Descent

Presentations

December 14, 2020:Joint Statistical Meetings, Philadelphia, PA, USA, Virtual
Application of Stochastic Gradient Descent in Parameter Estimation for Models with Spatial Correlation

Soheil Saghafi

Presentations

January 29, 2021: NSF Student Conference on COVID-19 Modeling

Kosuke Sugita

Presentations

2021: The 7th International Conference on Micro and Nano Flows, Imperial College London, Virtual
A Fast and Accurate Boundary Integral Method for Superhydrophobic Flow Computations

Conference and Workshop Attendance

2021: The 7th International Conference on Micro and Nano Flows, Imperial College London, Virtual

Axel Turnquist

Publications

Preprint 1: Hamfeldt, B. F., Turnquist, A. G. R. A Convergence Framework for Optimal
Transport on the Sphere March 9, 2021, https://arxiv.org/abs/2103.05739

Preprint 2: Hamfeldt, B. F., Turnquist, A. G. R. A Convergent Finite-Difference Method for
Optimal Transport on the Sphere May 7, 2021, https://arxiv.org/abs/2105.03500

Posters

1.) Optimal Transport on the Sphere - Canadian Mathematical Society Summer Meeting Poster Session -
Optimal Transport and Applications - Jun. 10, 2021, Ottawa, Ontario, Canada - Won CMS Award for
Poster Presentation

2.) Solution Guarantees for the Reflector Antenna Inverse Problem - Graduate Student Association
3-Minute Research Presentation, New Jersey Institute of Technology - Apr. 13, 2021, Newark, New
Jersey, USA

3.) A Convergence Framework for the Monge-Ampe`re PDE on the Sphere - IMA Workshop on Optimal
Control, Optimal Transport, and Data Science, Nov. 10, 2020, University of Minnesota, Minnesota, USA

Presentations

1.) Optical Inverse Problems and Optimal Transport - Entropic Regularization of Optimal Transport and
Applications, Jun. 21, 2021, Banff, Alberta, Canada

2.) Optimal Transport on the Sphere - Canadian Mathematical Society Summer Meeting StudC Research
Session - Optimal Transport and Applications - Jun. 11, 2021, Ottawa, Ontario, Canada

3.) Optimal Transport on the Sphere - Dana Knox Student Research Showcase - Apr. 21, 2021, New
Jersey Institute of Technology, Newark, New Jersey, USA

Conference and Workshop Attendance

1.) Jun. 2021 Entropic Regularization of Optimal Transport and Applications Banff, Alberta, Canada

2.) Jun. 2021 Canadian Mathematical Society Summer Meeting - Optimal Transport and Applications
Ottawa, Ontario, Canada

3.) Apr. 2021 East Coast Optimization Meeting 2021 George Mason University, Fairfax, Virginia, USA

4.) Nov. 2020 IMA Workshop on Optimal Control, Optimal Transport, and Data Science
University of Minnesota, Minneapolis, Minnesota, USA

Awards

Yasser Almoteri

Dana Knox Research Showcase Second Prize / Silver Award, NJIT

Full Graduate Fellowship of the Royal Embassy of Saudi Arabia Cultural Mission.

Jose Pabon

National Science Foundation. - ICorp. Award number 1450182.

Connor Robertson

Office of Science Graduate Student Research (SCGSR) Program 2021

Axel Turnquist

CMS Award for Poster Presentation Canadian Mathematical Society Summer Meeting 2021, $100 CAD

Student Talks - Summer 2021

Tuesday, June 1, Ryan Allaire
Detailed Thermal Modelling of Droplet Assembly in Nanoscale Molten Metal Films

Tuesday, June 10, Kosuke Sugita
A Fast and Accurate Boundary Integral Method for Superhydrophobic Flow Computations

Tuesday, June 10, Yuexin Liu
Mechanical Rotation at Low Reynolds Number via Reinforcement Learning

Thursday, June 15, Axel Turnquist
Optical Inverse Problems and Optimal Transport

Tuesday, June 15, Jose L. Pabon
Elucidating an Empirical Exposition of Diversity in U.S. Museums via Data Clustering and Optimization,
and Conglomerating Collective Motion Mechanics

Thursday, June 17, Diego Rios
Shallow Water Inversion

Tuesday, June 22, Yasser Almoteri
Bacterial Motion and Spread in Wet Porous Materials

Tuesday, June 22, Souaad Lazergui
High Frequency Asymptotic Expansions of the Helmholtz Equation Solutions Using Neumann to Dirichlet and Robin to Dirichlet Operators

Thursday, June 24, Binan Gu
A Graphical Representation of Membrane Filtration

Tuesday. June 29, Nicholas Dubicki
Variational Analysis of Magnetic Skyrmions in Thin-Film Materials

Tuesday. June 29, Tadanaga Takahashi
A Finite Element Domain Decomposition Method for Wave Scattering

Thursday, July 1, Mark Fasano
Spreading Dynamics of a Partially Wetting Water Film Atop a MHz Substrate Vibration

Thursday, July 1, Connor Robertson
Data-Driven Modeling for Active Nematic Systems

Tuesday, July 6, Matthew Illingworth
The Arrow of Time and Its Relation to Causality

Tuesday, July 6, Lauren Barnes
Modeling of Colloid-Polymer Mixtures in Microgravity

Thursday, July 8, Moshe Silverstein
An Introduction to Mathematical Neuroscience and Autonomous Field Equations for Balanced Neural Networks

Thursday, July 9, Joseph D'Addesa
Phase Separation of Two-Fluid Mixtures using Surface Acoustic Waves

Tuesday, July 13, Rituparna Basak
Application of Computational Topology to Analysis of Granular Material Force Networks in the Stick-Slip Regime

Tuesday, July 13, Zheng Zhang
Consistent Estimation of the Number of Communities in Nonuniform Hypergraph Model

Tuesday, July 15, Yixuan Sun
Modeling and Design Optimization for Membrane Filters

Thursday, July 15, Erli Wind-Anderson
The Integral equations of Sound-Soft and Sound-Hard Scattering

Tuesday, July 20, Soheil Saghafi
Deep Hybrid Modeling with cGAN as an Inverse Surrogate Model for Parameter Estimation in Morris-Lecar Model

Thursday, July 22, Xiao Han
Modeling the Flow of Nanoparticles in the Blood Vessel Guided by a Cylindrical Magnet

Thursday, July 22, Hewei Zhang
Predicting Solar Flare Index Using Statistical And Machine Learning Methods

Tuesday, July 27, Samantha Evans
The Effects of Combining the Sherman-Lauricella Integral Equation with Slow Convolution Method for Two-Phase Flow with Soluble Surfactant

Tuesday, July 29, Jimmie Adriazola
Optimal Control of Hamiltonian Systems Arising from Bose-Einstein Condensates

Thursday, July 29, Subhrasish Chakraborty
Classification of Imbalanced Multiple Class Datasets: A Statistical Approach

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