Faculty Research Interests

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<tr>
<th>Faculty</th>
<th>Research Interests</th>
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<tbody>
<tr>
<td>Noga Alon</td>
<td>Combinatorics, Graph Theory and their applications to Theoretical Computer Science. Combinatorial algorithms and circuit complexity. Combinatorial geometry and Combinatorial number theory. Algebraic and probabilistic methods in Combinatorics</td>
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<tr>
<td>René A. Carmona</td>
<td>Stochastic Analysis; Mean Field Games &amp; Equilibrium Analysis of Large Stochastic Systems; Statistical Data Analysis; Financial Engineering</td>
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<tr>
<td>Maria Chudnovsky</td>
<td>Graph theory and combinatorics; Structural graph theory</td>
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<td>Peter Constantin</td>
<td>Analysis; Mathematical physics; Applied mathematics</td>
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<td>Weinan E</td>
<td>Machine Learning. Analysis of problems involving multiple scales and multi-levels of physics and systems driven by stochastic effects; Stochastic PDEs, computational material sciences and fluid mechanics</td>
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<tr>
<td>Paul Seymour</td>
<td>Graph theory, particularly structural properties of graphs with certain induced subgraphs or minors forbidden</td>
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<td>Amit Singer</td>
<td>Developing algorithms for three-dimensional structuring of macromolecules using cryo-electron microscopy; Mathematical interests: linear and non-linear dimensionality reduction of high dimensional data, signal and image processing, spectral methods, convex optimization and semidefinite programming; Applications: cryo-EM, NMR spectroscopy, structure from motion problem in computer vision, permeation of ions through protein channels</td>
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Howard A. Stone

Fluid mechanics; complex fluids; differential equations and asymptotics

Jeroen Tromp

Primary research areas are in theoretical & computational seismology. Research topics include seismic tomography, numerical simulations of acoustic, (an)elastic, and poroelastic wave propagation, and seismic hazard assessment. Recent research has been directed towards adaptation of adjoint-state methods for ultrasonic tomography in medical and nondestructive-testing application.

Ramon van Handel

My interests lie broadly in probability theory and its interactions with other fields, such as analysis and geometry. Probability theory—the mathematical description of random phenomena—plays an increasingly fundamental role in numerous areas of mathematics and science. I am particularly fascinated by the development of principles and methods that explain the common structure in a variety of pure and applied mathematical problems. My recent focus has been on high-dimensional phenomena; I also have a long-standing interest in conditional phenomena in probability and ergodic theory, and in noncommutative probability.
Amir Ali Ahmadi  
Optimization: algebraic methods in optimization, semidefinite programming, polynomial optimization; Computational aspects of dynamics and control: Lyapunov theory and optimization-based algorithms for robustness and stability analysis; Algorithms and complexity: Computational complexity in numerical optimization, convex relaxations in combinatorial optimization. Applications in systems theory, statistics, robotics, and economics

Yacine Aït-Sahalia  
Financial economics, investments and derivative pricing; Time series econometrics, nonparametric statistics and statistical methods for stochastic processes

Michael Aizenman  
Mathematical physics: - Mathematical analysis of issues arising in statistical mechanics and quantum field theory

William Bialek  
Neural coding and computation; Statistical physics and information theory; Information flow in genetic networks

Mark Braverman  
Complexity theory; Algorithms; Game theory with applications to mechanism design; Information theory

Carlos D. Brody  
Neurophysiology; Dynamics of neural systems, (both experimental and in neural models)

Adam S. Burrows  
The theory of supernova explosions, with a particular focus on the mechanism of explosion and multi-dimensional radiation/hydrodynamic simulations of collapse dynamics; The theory of the atmospheres, spectra, structure, and evolution of extrasolar giant planets (and of exoplanets in general), and its comparison with data; The theory of brown dwarfs in all their particulars; High-energy astrophysics, with an emphasis on gravitational wave physics, neutrino astrophysics, and gamma-ray line astronomy; Tools and methodologies developed in support of these studies include numerical hydrodynamics, radiative transfer, nuclear and particle physics, chemistry, molecular spectroscopy, equations of state of exotic matter, and magneto-hydrodynamics
Roberto Car
Chemical physics and materials science; Electronic structure theory and ab-initio molecular dynamics; Computer modeling and simulation of solids, liquids, disordered systems, and molecular structures; Structural phase transitions and chemical reactions

Bernard M. Chazelle
Natural algorithms; Multiagent dynamics; Iterated Learning, Evolutionary complexity

Yuxin Chen
Mathematical foundations of data science, high-dimensional statistics, optimization, reinforcement learning, and their applications to medical imaging and computational biology

Erhan Çinlar
Theories of Markov processes, point processes, and stochastic calculus; Stochastic flows; Transport by flows

David P. Dobkin
Computer graphics, analysis of algorithms, computational geometry; Creating high-quality images of mathematical objects; Algorithms and models for image synthesis; Mathematical approaches to computational issues; Computer vision and face recognition

Jianqing Fan
High-dimensional Statistics
Machine Learning
Financial Econometrics and Risk Management
Bioinformatics and Biostatistics
Graphical and Network modeling
Nonparametric and semiparametric modeling

Jason W. Fleischer
Nonlinear optics within the broader context of general wave physics; The emphasis is on propagation problems that are universal to wave systems, taking advantage of the fact that optical systems allow easy control of the input and direct imaging of the output
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<tr>
<td>Mikko P. Haataja</td>
<td>Theoretical and computational materials science, physics of materials, and biophysics; Evolving microstructures from materials to biology; Studies of microstructure formation during solid-solid phase transformations and solidification, dislocation dynamics, recrystallization kinetics, signaling pathways in cells, self-assembly of surfactants and lipids, and thermodynamics and kinetics of spatial heterogeneities (&quot;lipid rafts&quot;) in the plasma membrane of mammalian cells</td>
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<tr>
<td>Gregory W. Hammett</td>
<td>Theory and computer simulations of plasma turbulence in fusion and astrophysical plasmas, and advanced computational algorithms</td>
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<td>Isaac M. Held</td>
<td>Atmospheric circulation, climate dynamics, and geophysical turbulence using a hierarchy of models ranging from comprehensive and realistic numerical circulation models to very idealized dynamical systems; Planetary scale responses of the atmospheric circulation to global warming, and a variety of idealized models of mid-latitude and tropical atmospheric flows</td>
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<tr>
<td>Sergiu Klainerman</td>
<td>Study of nonlinear hyperbolic equations arising in fluid mechanics and general relativity; Questions of regularity, formation of singularities, formation of black holes, and asymptotic behavior of general solutions to the initial value problem</td>
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<tr>
<td>Naomi E. Leonard</td>
<td>Nonlinear control theory and design, geometric mechanics, dynamical systems and feedback; Applications to cooperative control and sensing in robotic vehicle networks; Autonomous ocean sampling networks; Collective motion and decision-making in animal groups and decision dynamics in teams of humans and robots</td>
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<tr>
<td>Simon A. Levin</td>
<td>Spatial heterogeneity and problems of scale; Dynamics of populations and communities; Evolutionary, mathematical, and theoretical ecology; Dynamics of disease; Ecological economics</td>
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<tr>
<td>Elliott H. Lieb</td>
<td>Mathematical physics with emphasis on Schroedinger operators; Questions concerning stability of matter and atomic physics; Quantum electrodynamics; statistical mechanics; Problems arising from condensed matter physics</td>
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Luigi Martinelli
Computational fluid dynamics (CFD): Development of mathematical models, algorithms, and computer codes for the simulation of turbulent flows over realistic industrial configurations including Large eddy (LES) and direct numerical simulation (DNS) at the proper Reynolds number in subsonic, transonic and supersonic regimes. CFD software implementations on modern High Performance Computing platforms. Algorithms and software development for multiphysics design optimization (MDO) of aircraft and aircraft subsystems.

William A. Massey
Dynamical queueing systems; Communication systems and services; Analysis of stochastic networks.

Assaf Naor
Analysis. Probability. Quantitative geometry
Applications of the above to combinatorics, mathematical physics and theoretical computer science.

H. Vincent Poor
Information theory, machine learning and network science, with applications in wireless networks, energy system and related areas.

Warren Powell
Energy: Conservation, policy & security, renewable, systems analysis, technology; Environmental economics, climate and energy, sustainability lack holes, gravitational collapse, gravitational waves, gravitational wave sources, higher dimensional gravity, numerical solution methods, cosmology.

Frans Pretorius
Black holes, gravitational collapse, gravitational waves, gravitational wave sources, higher dimensional gravity, numerical solution methods, cosmology.

Jean-Hervé Prévost
Computational solid mechanics; Dynamics; Wave propagation and transient effects in porous media; Nonlinear constitutive theories; Dynamic instabilities and localization of deformations in solids; Thermoelasticity; Electro-magneto-solid interaction effects; Finite element methods; Crack nucleation and propagation; Xfem finite element methods; Reservoir modeling.
Herschel A. Rabitz
Development and application of applied-mathematical tools, blending analytical and numerical techniques, especially including optimal control theory and sensitivity analysis for problems at the interface of engineering, physics, and chemistry; Particular applications include problems in quantum dynamics under control, forward and inverse molecule scattering theory, time and space dependent relaxation processes, bio-molecular modeling, Natural evolution landscape topological analysis, and chemical kinetics

Peter J. Ramadge
Advances in several fields of rapid technology development, notably wireless networks, social networks and smart grid

Jennifer Rexford
Internet routing, network measurement, and network management, with the larger goal of making data networks easier to design, understand, and manage

Clarence W. Rowley
Dynamical systems, model reduction, and control theory, especially with applications in fluid mechanics; Numerical methods, both for fluids simulations, and for analysis of dynamical systems; Geometric mechanics, symmetry reduction, and variational integrators

Szymon M. Rusinkiewicz
Work focuses on the interface between computers and the visual and tangible world: Acquisition, representation, analysis, and fabrication of 3D shape, motion, surface appearance, and scattering

Mykhaylo Shkolnikov
Various topics in probability theory, (stochastic) partial differential equations and mathematical physics, including interacting particle systems, random growth models, free boundary problems, and phase transition phenomena

Frederik J. Simons
Mathematical geophysics, computational inverse problems, wavelet analysis, spatial statistics, inference. Most of my applications are to the study of the solid Earth and planets: their physical properties such as can be recovered by seismic tomography, geodesy, and the cross-spectral analysis of planetary gravity, topography, and magnetic fields
Yakov G. Sinai
Various problems in the theory of dynamical systems, including the quantum chaos; Conservation laws with random initial data and random coefficients, connections with statistical mechanics and, in particular, theory of phase transition, probability theory

Jaswinder Pal Singh
Boundary of applications and high-performance (especially parallel) systems, with interest in both; Includes development of effective parallel and distributed applications on many high-performance platforms, and studying the implications of these applications for the design of multiprocessor architectures, programming models and software systems; Systems software, architecture, and programming environments for parallel and distributed systems; Solving problems on parallel and distributed systems with a recent focus in biology, medicine and internet services; Benchmarking and performance evaluation methodology for high-performance computing

Ronnie Sircar
Financial Mathematics, stochastic volatility models, energy markets and power systems, credit risk, asymptotic and computational methods, portfolio optimization and stochastic control problems, stochastic differential and mean field games

Mete Soner
Financial mathematics, stochastic models, stochastic control problems, asymptotic methods, differential games

John D. Storey
Development of statistical methods, theory, and algorithms for high-dimensional data analysis problems in genomics and other areas of biology; Statistics research directly motivated by and applied to problems in genomics and other areas of modern high-throughput quantitative biology; Examples include studies involving genome sequences of individuals from structured populations, genome-wide gene expression profiling measurements from next generation sequencing, and complex clinical genomics studies

Sankaran Sundaresan
Granular flows, Fluid-particle flows

Robert Tarjan
Data structures; graph algorithms; combinatorial optimization; computational complexity; computational geometry; parallel algorithms
Corina E. Tarnita

The dynamics of complex interactions and emergent phenomena in biological systems: approach involves mathematical modeling, but in collaboration with experimental and field ecologists, molecular biologists and evolutionary biologists to integrate modeling and empirical work.

Salvatore Torquato

Statistical mechanics, soft condensed matter, and materials science; Theoretical understanding of crystals, quasicrystals and disordered phases of matter, ordered and disordered jammed states of matter, sphere packings in high dimensions, hyperuniform states of matter, inverse statistical mechanics, self-assembly theory, percolation theory, degenerate ground states of many-particle and spin systems, and biophysics.

Olga G. Troyanskaya

Bringing the capabilities of computer science and statistics to the study of gene function and regulation in the biological networks through integrated analysis of biological data from diverse data sources—both existing and yet to come (e.g. from diverse gene expression data sets and proteomic studies); Currently designing systematic and accurate computational and statistical algorithms for biological signal detection in high-throughput data sets; Developing methods for better gene expression data processing and algorithms for integrated analysis of biological data from multiple genomic data sets and different types of data sources (e.g. genomic sequences, gene expression, and proteomics data).

Robert J. Vanderbei

Interior-point methods for constrained optimization, including both analysis and implementation of algorithms; Application of optimization techniques to problems with constraints in the Fourier-transform domain; Especially interested in designing high-contrast imaging systems to search for extrasolar planets.

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