



Faculty Research Interests

Faculty

Emmanuel Abbe

Information theory, learning theory, networks and discrete probability; In particular, topics at the intersection of these areas such as community detection, probabilistic network models, and coding

René A. Carmona

Financial mathematics & financial engineering; Stochastic analysis; Statistical Data Analysis (including signals and images)

Maria Chudnovsky

Graph theory and combinatorics; Structural graph theory

Peter Constantin

Analysis; Mathematical physics; Applied mathematics

Weinan E

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

Paul Seymour

Graph theory, particularly minors of graphs, and structural properties of graphs of use for algorithms; matroid theory; discrete optimization

Amit Singer

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

Faculty

Howard A. Stone

Fluid mechanics; Chemical engineering and complex fluids

James M. Stone

Numerical methods for hyperbolic conservation laws, MHD, and radiation transport, including adaptive mesh refinement, as applied to astrophysical gas dynamics; High-performance computing on shared and distributed memory parallel systems; Visualization of very large four-dimensional data sets representing scalar and vector fields on regular grids

Jeroen Tromp

Theoretical & computational seismology; Development and implementation of numerical methods for forward & 'adjoint' simulations of wave propagation in acoustic, elastic, and poroelastic media over a broad range of spatial & temporal scales

Sergio Verdú

Information theory: Algorithms and fundamental limits for compression and reliable transmission of information; Signal processing for communications

Associated Faculty

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; The theory of real computation; Machine learning; Algorithms; Game theory: Applications of computer science in healthcare and medicine

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 magnetohydrodynamics

Associated Faculty

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

Emily A. Carter

Ab initio quantum mechanics-based predictions of energetics, kinetics, and dynamics of atomic and molecular ion scattering, adsorption, diffusion, and reactions on surfaces, and of heterogeneous interface formation and failure for semiconductors, metals, and ceramics; Multi-scale modeling of the response of materials to chemical and mechanical stresses; Recent emphasis on applications related to energy conversion and conservation; Development of new saddle point search algorithms, electron correlation, pseudopotential, embedding, and density functional methods, linear scaling electronic structure methods, as well as the development of simulation tools to bridge length scales

Bernard M. Chazelle

Lower bounds; Data-powered algorithms; Data reconstruction, self-improving algorithms, natural algorithms

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

Statistical methods in financial econometrics and risk managements, computational biology, biostatistics, high-dimensional statistical learning, data-analytic modeling, longitudinal and functional data analysis, nonlinear time series, wavelets and their applications; Primary research focuses on developing and justifying statistical methods that are used to solve problems from the frontiers of scientific research

Associated Faculty

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

Mikko P. Haataja

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 ("lipid rafts") in the plasma membrane of mammalian cells

Gregory W. Hammett

Theory and computer simulations of plasma turbulence in fusion and astrophysical plasmas, and advanced computational algorithms

Isaac M. Held

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

Sergiu Klainerman

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

Naomi E. Leonard

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

Associated Faculty

Simon A. Levin

Spatial heterogeneity and problems of scale; Dynamics of populations and communities; Evolutionary, mathematical, and theoretical ecology; Dynamics of disease; Ecological economics

Elliott H. Lieb

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

Luigi Martinelli

Computational fluid dynamics: Development of mathematical models, algorithms, and computer codes for the simulation of complex fluid flows in complex geometries; Design of algorithms and computer codes suitable for vector and parallel processing; Simulation of three-dimensional turbulent flows on aircraft components in subsonic, transonic, supersonic and hypersonic regimes

William A. Massey

Dynamical queueing systems; Communication systems and services; Analysis of stochastic networks

H. Vincent Poor

Stochastic analysis, statistical signal processing, signal detection, estimation and filtering; Information theory; Statistical change detection; and Multiple-access digital communications; Specific applications in wireless networking, security, sensor networks, mathematical finance, and related areas

Warren Powell

Energy: Conservation, policy & security, renewable, systems analysis, technology; Environmental economics, climate and energy, sustainability

Frans Pretorius

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

Associated Faculty

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, forward and inverse molecule scattering theory, time and space dependent relaxation processes, biomolecular modeling, 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

Frederik J. Simons

Various aspects of solid-earth geophysics; More specifically, the physical properties of the terrestrial lithosphere, focusing on the elastic and thermo-mechanical properties of the continents, by seismic tomography and the (cross-) spectral analysis of gravity and topography

Associated Faculty

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 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

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

Associated Faculty

Salvatore Torquato

Statistical mechanics and materials science; Theory and computer simulations of disordered heterogeneous materials, liquids, amorphous solids and biological materials; Sphere packing problems; Optimization in materials science; Modeling the growth of tumors

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)

Ramon van Handel

Probability theory—the mathematical description of random phenomena—plays an increasingly fundamental role in numerous areas of mathematics and science; Development of probabilistic principles and methods that explain the common structure in a variety of pure and applied mathematical problems; Recent research focus has been on conditional phenomena, high-dimensional probability, and ergodic theory

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
