Faculty Research Interests

Core Faculty

Noga Alon

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.

Emily Carter

Development and application of quantum mechanical simulation techniques to enable discovery and design of molecules and materials for sustainable energy.

Maria Chudnovsky

Graph theory and combinatorics; Structural graph theory

Peter Constantin

Analysis; Mathematical physics; Applied mathematics

Guillermo Sapiro

Theory and applications in computer vision, computer graphics, medical imaging, image analysis, machine learning, and ML for health.

Paul Seymour

Discrete math, mostly in graph theory; currently working on the structure of graphs with certain induced subgraphs forbidden. In particular in the Erdos-Hajnal conjecture and in the various conjectures of Gyarfas about chi-boundedness.

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.

Howard Stone

Fluid mechanics; complex fluids; differential equations and asymptotics

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Romain Teyssier

Computational astrophysics and fluid dynamics, with particular interest in understanding the physics of galaxy and star formation in a cosmological context. He uses computational means to study the physical processes that govern the formation, evolution and observed properties of galaxies. He has developed innovative new computational techniques to efficiently numerically investigate the relevant partial differential equations on large computer clusters.

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.

Ryan Adams

Machine learning, artificial intelligence, and computational statistics, with applications across science and engineering. Probabilistic methods and approximate Bayesian inference.

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

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Carlos Brody

Neurophysiology; Dynamics of neural systems, (both experimental and in neural models)

Adam 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.

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

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Bernard Chazelle

Natural algorithms; Multiagent dynamics; Iterated Learning, Evolutionary complexity

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Jianqing Fan

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

Jason 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.

Marc Gilles

Applied mathematics particularly problems involving numerical linear algebra. Algorithms for cryogenic electron microscopy (cryo-EM). RECOVAR, a software tool for reconstructing flexible proteins from large and noisy cryo-EM datasets.

Mikko 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 Hammett

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

Boris Hanin

Machine learning- theory of neural networks: approximation power, statistical physics of initialization, guarantees for optimization, and generalization probability- mathematical physics,

random matrix theory, Gaussian processes arising in spectral theory/quantum mechanics, and random polynomial.

Elad Hazan

Automation of the learning mechanism and its efficient algorithmic implementation; mathematical optimization, game theory, statistics and computational complexity.

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.

Pravesh Kothari

Algorithms and computational thresholds for average-case computational problems, random matrices, extremal combinatorics.

Naomi 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.

Simon Levin

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

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 multi physics design optimization (MDO) of aircraft and aircraft subsystems.

William 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.

Jonathan Pillow

Point process regression models, latent variable models for spike train and imaging data, receptive field estimation, inference for detailed biophysical models, spike sorting, statistical signal processing for calcium imaging data, active learning/closed-loop experimental design, Bayesian optimization, perceptual decision making, and visual motion perception.

H. Vincent Poor

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

Frans Pretorius

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

Herschel 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 Ramadge

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

Elizaveta Rebrova

High-dimensional probability, randomized algorithms, numerical linear algebra, matrix and tensor methods, mathematics of data, robust and interpretable learning, non-asymptotic random matrix theory

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Jennifer Rexford

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

Clarence 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 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.

Frederick 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.

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 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.

Joseph E. Subotnik

Focuses on the electronic processes in the condensed phase. Using tools from electronic structure theory (with an emphasis on excited states), nonadiabatic dynamics, perturbation theory, and statistical mechanics, we seek a comprehensive theoretical and computational platform for studying electronic relaxation, electron and energy transfer, and multilinear spectroscopy.

Sankaran Sundaresan

Granular flows, Fluid-particle flows

Ludovic Tangpi

Data structures; graph algorithms; combinatorial optimization; computational complexity; computational geometry; parallel algorithms.

Robert Tarjan

Stochastic analysis (stochastic control, SDEs, BSDEs, FBSDEs, probabilistic representations of parabolic/elliptic PDEs); Mathematical Finance (risk management, model uncertainty, optimal investment); Probability theory (optimal transportation, functional inequalities).

Corina 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 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).

Matt Weinberg

Algorithmic Mechanism Design: algorithm design in settings where users have their own incentives. Algorithmic Game Theory, Algorithms under Uncertainty, and Theoretical Computer Science.

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