# Faculty Research Interests

## 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

René A. Carmona

Stochastic Analysis; Mean Field Games & Equilibrium Analysis of Large Stochastic Systems; Statistical Data Analysis; Financial Engineering

Maria Chudnovsky

Graph theory and combinatorics; Structural graph theory

Peter Constantin

Analysis; Mathematical physics; Applied mathematics

Weinan E

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

Paul Seymour

Graph theory, particularly structural properties of graphs with certain induced subgraphs or minors forbidden

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 A. Stone

Fluid mechanics; complex fluids; differential equations and asymptotics

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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 adjooint-state methods for ultrasonic tomography in medical and nondestructive-testing application

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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

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## 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; 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 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 M. Chazelle

Natural algorithms; Multiagent dynamics; Iterated Learning, Evolutionary complexity

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Yuxin Chen

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

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Erhan Çinlar

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

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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

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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

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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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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

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Gregory W. Hammett

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

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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

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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

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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

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Simon A. Levin

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

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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

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

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William A. Massey

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

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Assaf Naor

Analysis. Probability. Quantitative geometry

Applications of the above to combinatorics, mathematical physics and theoretical computer science

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H. Vincent Poor

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

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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

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Frans Pretorius

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

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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

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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

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Peter J. Ramadge

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

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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

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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

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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

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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

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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

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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

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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

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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

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Mete Soner

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

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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

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Sankaran Sundaresan

Granular flows, Fluid-particle flows

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Robert Tarjan

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

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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

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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

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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)

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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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