

Research Areas

The five main areas of concentration are **Algebra, Analysis, Combinatorics, Geometry/Topology,** and **Statistics/Probability**. Below are more specific research areas along with the names of faculty members most closely involved for the 2018–2019 academic year.

Algebraic and Geometric Topology

- [Laura Anderson](#)
- [Robert Bieri](#)
- [Michael Dobbins](#)
- [Casey Donovan](#)
- [Ross Geoghegan](#)
- [Cary Malkiewich](#)
- [Pedro Ontaneda](#)
- [Russell Ricks](#)
- [Jenya Sapir](#)
- [Jonathan Williams](#)

Geometry of Manifolds

- [Pedro Ontaneda](#)
- [Russell Ricks](#)

Graph Theory

- [William Kazmierczak](#)
- [Thomas Zaslavsky](#)

Algebra related to logic and computer science

- [Fernando Guzman](#)

Group Theory

- [Robert Bieri](#)
- [Benjamin Brewster](#)
- [Matthew Brin](#)
- [Ross Geoghegan](#)
- [Fernando Guzman](#)
- [Luise-Charlotte Kappe](#)
- [Marcin Mazur](#)
- [Hung Tong-Viet](#)

Arithmetic Algebraic Geometry

- [Alexander Borisov](#)
- [Vaidehee Thatte](#)
- [Adrian Vasiu](#)

Number Theory

- [Alexander Borisov](#)
- [Luise-Charlotte Kappe](#)
- [Marcin Mazur](#)
- [Vaidehee Thatte](#)
- [Adrian Vasiu](#)

Combinatorial Geometry

- [Laura Anderson](#)
- [Michael Dobbins](#)
- [Thomas Zaslavsky](#)

Combinatorics

- [Laura Anderson](#)
- [Michael Dobbins](#)
- [William Kazmierczak](#)
- [Thomas Zaslavsky](#)

Partial Differential Equations

- [Paul Loya](#)
- [Xiangjin Xu](#)
- [Lu Zhang](#)
- [Gang Zhou](#)

Descriptive Set Theory

- [Phillip Wesolek](#)
- [Casey Donovan](#)

Probability

- [Vladislav Kargin](#)
- [David Renfrew](#)

Geometric Analysis

- [Paul Loya](#)
- [Pedro Ontaneda](#)
- [Russell Ricks](#)
- [Xiangjin Xu](#)
- [Gang Zhou](#)

Representation Theory

- [Alex Feingold](#)
- [Dikran Karagueuzian](#)
- [Hung Tong-Viet](#)

Geometric Group Theory

- [Robert Bieri](#)
- [Matthew Brin](#)
- [Casey Donovan](#)
- [Ross Geoghegan](#)
- [Fernando Guzman](#)
- [Russell Ricks](#)
- [Jenya Sapir](#)
- [Phillip Wesolek](#)

Statistics

- [Sanjeena Dang](#)
- [Vladislav Kargin](#)
- [Aleksey Polunchenko](#)
- [Xingye Qiao](#)
- [Anton Schick](#)
- [Ganggang Xu](#)
- [Qiqing Yu](#)

Statistical Machine Learning

- [Sanjeena Dang](#)
- [Xingye Qiao](#)
- [Ganggang Xu](#)

Faculty research interests

Laura Anderson

My research focuses on interactions between combinatorics and topology, particularly those involving oriented matroids, convex polytopes, and other concepts from discrete geometry. Much of my work involves combinatorial models for topological structures such as differential manifolds and vector bundles. The aims of such models include both combinatorial answers to topological questions (e.g., combinatorial formulas for characteristic classes), and topological methods for combinatorics (e.g. on topology of posets).

Robert Bieri

My original interest in homological methods for infinite groups (cohomological dimension and Poincare type duality) shifted towards geometric and – more recently – asymptotic methods. I find it interesting to relate geometric properties at infinity of groups and G -spaces with algebraic properties of these groups, their group rings and their modules. The focus is on familiar groups like metabelian, soluble, free and linear ones, or fundamental groups of 3-manifolds, but I also met Thompson's group F and other PL-homeomorphism groups on the way, and had an encounter with tropical geometry.

Alexander Borisov

My general research area is algebraic geometry and number theory, broadly interpreted. Particular topics of interest include birational geometry, toric geometry and convex discrete geometry, polynomial morphisms, integer polynomials, Arakelov geometry.

Benjamin Brewster

Algebra, group theory. Topics of particular interest:

1. Sylow subgroups, how the group acts on them via conjugation, and how they intersect.
2. Solvable groups-their conjugacy classes of subgroups.
3. Subgroup lattices-intervals in the lattice and the influence of permutable subgroups on this lattice.
4. Characterizing subgroups with embedding properties in direct products.

Matthew G. Brin

I am currently interested in the mathematical interactions of a collection of groups that arose first in logic and universal algebra. The groups are generalizations of three groups first discovered by Richard Thompson. The groups show up in a strong way in logic, homotopy and shape theory, dynamical systems, categorical algebra and its relation to physics, and the combinatorial group theory of the word problem and of infinite simple groups. They are a source of examples or potential examples in geometric group theory, cohomology of groups, string rewriting systems and abstract measure theory.

Sanjeena Dang

My primary research focus is on computational statistics with applications in bioinformatics. Most of my work focuses on clustering and classification algorithms suitable for high-dimensional data such as RNA-Seq data, microarray data, and microbiome data. Some of my work also involves methodological development for genome wide association studies.

Michael Dobbins

My research is primarily on discrete geometry, particularly geometric problems arising from computer science. I also work in computational geometry, complexity, convexity, combinatorics, and topology.

Casey Donovan My research interests span many areas of mathematics, including (geometric) group theory, fractal geometry, topology, and semigroup theory. Finite state automata are a major theme in my research, in relation to groups acting on Cantor space and characterizing fractal quotients of Cantor space. Prominent groups in my research are Thompson's group V and self-similar automorphism groups of trees. I am interested in generalizing notions in fractal geometry to 'non-traditional' metric and topological spaces, such as Cantor space and profinite groups. Lastly, semigroups are of growing interest to me, with an emphasis on subsemigroup structure.

Thomas Farrell

Differential topology, in particular on classifying manifolds of a given homotopy type. Related research interests in geometry and algebra. These interests include the study of discrete subgroups of Lie groups and algebraic K-theory.

Alex Feingold

Finite dimensional semisimple Lie algebras, tensor product decomposition of irreducible modules, representation theory of the infinite dimensional Kac-Moody Lie algebras, bosonic and fermionic creation and annihilation operators, affine and hyperbolic Kac-Moody algebras, topics in combinatorics, power series identities, modular forms and functions, Siegel modular forms, conformal field theory, string theory, and statistical mechanical models, vertex operator algebras, their modules and intertwining operators, the theory of fusion rules.

Ross Geoghegan

I am interested in the interplay between group theory and geometry/topology. In particular: geometric and homological group theory, fixed point theory, and certain parts of dynamical systems. Some of the questions motivating this work are algebraic, involving the algebraic K-theory of rings associated with the fundamental group; this is how I got interested in Nielsen fixed point theory, particularly parametrized versions of that theory. Other questions are about how an action by a discrete group on a non-positively curved space can lead to group theoretic information. I'm also interested in understanding the asymptotic topological invariants of a group. I have recently finished a book on that subject called "Topological Methods in Group Theory".

Fernando Guzman

My mathematical interests are algebraic in a broad sense. From universal algebra, lattice theory and ordered structures, through more classical algebraic topics like group theory and homology to interactions of algebra with computer science and logic.

David Hanson

Research interests: The Wiener process. Asymptotic properties of weighted sums of random variables. Certain problems in non-parametric statistics. Utility theory.

Tom Head

My published research has dealt with discrete, algebraic, linguistic, and biomolecular representations of information, computation, communication, and biological processes. Currently I am attempting to find a conceptual basis for attacking the virulence of pathogens by communicating with cells using their own chemical communication systems.

Luise-Charlotte Kappe

Group theory (properties of groups, Engel conditions, commutator calculus, supplementation, p -groups, nonabelian tensor products); ring theory (derivations, commutativity conditions in rings); number theory (transcendental

numbers, diophantine approximations).

kargin

I am particularly interested in random matrices and its applications, in particular,

1. statistical analysis of large data,
2. zeroes of zeta functions,
3. statistical mechanics of random media, and
4. free probability.

Dikran Karagueuzian

My research for the past few years has been primarily in the representations and cohomology of finite groups. For the past few years I have been studying problems in algebra that arise from techniques of algebraic topology. Sometimes there is a theorem hidden behind the feasibility of a well-known method. An example of this phenomenon is my most recent preprint, written in collaboration with Peter Symonds of the University of Manchester Institute of Science and Technology. In this case the theorem was uncovered through exploration with the computer algebra package Magma, which is well worth checking out. Often such software lets us investigate mathematical phenomena which would be very difficult to understand otherwise.

William Kazmierczak

My research interests lie in the general field of graph theory and specifically in the reliability and vulnerability of networks when the components of a network are susceptible to failure. Extremal graph theory results are also of particular interest in my work due to the need to maximize or minimize certain parameters of a graph when seeking best network models.

Hudson Kronk

In addition to graph theory my interests are: mathematical recreations, number theory, cryptology, and coding theory.

Paul Loya

The underlying theme of my research is the investigation of topological, geometric, and spectral invariants of (singular) Riemannian manifolds using techniques from partial differential equations. For example, the Euler characteristic of a surface is a topological invariant based its usual definition in terms of a triangulation of the surface. However, it may also be considered geometric in view of the Gauss-Bonnet theorem or spectral in view of the Hodge theorem. I am interested in such relationships on general singular Riemannian manifolds.

Cary Malkiewich My general research interest is in algebraic topology, and my work is broadly motivated by the study of manifolds and cell complexes by algebraic techniques. I have recently been focusing on topological Hochschild homology, algebraic K-theory, transfers, and stable homotopy theory. There is also an emerging connection between my work and homotopy-invariant properties of topological dynamical systems.

Marcin Mazur

My research interests concentrate around areas where number theory and group theory intersect. Topics of particular interest are group rings, group schemes over rings of algebraic integers, Galois module structures and Galois representations.

Patricia McAuley

My main research interests are fiber spaces of various sorts and local properties of topological spaces with particular interest in “local-implies-global” theorems. A secondary interest is in topological transformation groups, especially group actions on manifolds.

Pedro Ontaneda

My general interest is the geometry and topology of aspherical spaces. I have done some work in the study of the relationship between exotic structures and (negative, non-positive) curvature, and its applications to the limitations of PDE methods in geometry. Other interests: geometric group theory, K-theory, mechanics.

Aleksey Polunchenko

Mathematical statistics and specifically the problem of sequential (quickest) change-point detection, currently focusing on the case of composite hypotheses.

David Renfrew

My research lies in Probability and Random Matrices. I am particularly interested in non-Hermitian random matrices and the interplay between random matrices and free probability. I am also interested in applications to biologic systems.

Russell Ricks

I am interested in geometry and dynamics. This includes studying the ergodic theory of the geodesic flow as a means of understanding the geometry of a space. I am also particularly interested in the geometry of CAT(0) spaces.

Xingye Qiao

My main research interest focuses on statistical machine learning, a rapidly growing area of research. Many techniques in statistical machine learning have become essential in big data analytics. Some of my recent works include novel large-margin based classification methods, the classification stability, the subsampling strategy for massive and high-dimensional data sets, and learning data with special structures.

Anton Schick

Uses of large sample theory in statistics, the characterization and construction of efficient estimators and tests for semiparametric and nonparametric models, statistical inference for Markov chains and stochastic processes, estimation and comparison of curves, the behavior of plug-in estimators, optimal inference for bivariate distributions with constraints on the marginal, modelling with incomplete data, and the theory and application of finite and infinite order U-statistics.

Hung Tong-Viet

My main research interests lie in the representation and character theory of finite groups, permutation groups and applications to number theory and combinatorics, and finite group theory in general. I am interested in studying groups or group structures using several important numerical invariants of the groups such as character degrees (ordinary and modular), p -parts of the degrees or character values such as zeros of characters. In permutation group theory, I study derangements, that is, permutations without fixed points, and their applications in number theory and graph theory, permutation characters and permutation polytopes. Recently, I am also interested in studying the influence of real conjugacy class sizes on the group structures.

Adrian Vasiu

My area of research is Arithmetic Algebraic Geometry, which is the common part of Number Theory, Algebra, and

Geometry. I am very much interested in moduli spaces, group schemes, Lie algebras, formal group schemes, representation theory, cohomology theories, Galois theory, and the classification of projective, smooth, connected varieties. My research is focused on:

1. Shimura varieties of Hodge type (which are moduli spaces of polarized abelian varieties endowed with Hodge cycles),
2. arithmetic properties of abelian schemes,
3. classification of p -divisible groups,
4. representations of Lie algebras and reductive group schemes,
5. crystalline cohomology of large classes of polarized varieties, and
6. Galois representations associated to abelian varieties.

Phillip Wesolek

My general research interests are combinatorial and geometric group theory and descriptive set theory. More precisely, I am interested in their application to the study of amenable groups, profinite groups, and the large-scale topological structure of locally compact groups. The large-scale topological structure of a locally compact group is the manner in which the geometric structure and topological structure interact. An interesting example of a property of locally compact groups which is sensitive to large-scale topological structure is amenability. Considering locally compact groups from this perspective is relatively new; however, it has proven to be a fruitful and exciting area of research.

Jonathan Williams

I am a low-dimensional topologist mainly interested in smooth 4-manifold topology. This entails a broad range of ideas like knot theory, symplectic topology, n -parameter deformations of Morse functions for $n < 4$, and special fibration structures like open books and Lefschetz fibrations.

Ganggang Xu

My current research interests include: post-model selection inference, model selection and model averaging, quantile regression, spatial statistics with large data sets, Gaussian and non-Gaussian random fields, etc.

Xiangjin Xu

1. Harmonic Analysis on Manifolds: eigenfunction estimates and multiplier problems on Riemannian manifolds, Gibbs' phenomenon and Pinsky's phenomenon for Fourier inversion and eigenfunction expansion.
2. Nonlinear differential equations: Well-posedness problems for nonlinear hyperbolic differential equations on manifolds; Boundary stabilization, controllability problems for (linear and nonlinear) parabolic and hyperbolic PDE's on manifolds; Periodic solutions, subharmonics and homoclinic orbits

Qiqing Yu

My research interests are mainly in three fields.

1. Survival analysis. Since 1987, I have been working in this field, in particular on modeling the interval censored data, studying consistency and asymptotic normality of the generalized maximum likelihood estimator (MLE) of survival function or the semi-parametric estimator under linear regression model.
2. Statistical decision theory. My thesis was on admissibility and minimaxity of the best invariant estimator of a distribution function.
3. Probability model and computing methods for pattern recognition in the Genome project.

Shelemyahu Zacks

During the last ten years my research in statistics and applied probability has been focused on four areas:

1. Prediction Theory for Finite Populations
2. Reliability Theory
3. Adaptive Procedures and Optimal Designs
4. Distributions of stopping Times Defined on Compound Poisson Processes.

Each one of these areas is very wide and rich with problems. The type of problems I have concentrated on are:

1. Optimal predictors of population quantities, like the population total or the population variance. These include Bayesian predictors, minimax admissible, etc.
2. Sequential methods for software testing (detection of errors). In addition I study the operating characteristics of sequential stopping rules for reliability testing and estimation.
3. Adaptive decision procedures are connected with various procedures which converge to the optimal ones, when essential parameters are unknown. These contain "Bandits Problems", the sequential search of optimal dosages in Phase I Clinical Trials, etc.
4. In this area of research I develop the distributions of stopping times, or first-exit times of compound Poisson processes. The results have wide applications in queuing theory (distribution of the length of the busy period), in inventory theory, dam theory and risk theory for insurance.

Thomas Zaslavsky

My research is in combinatorics, especially matroids and their connections with combinatorial geometry and graph theory. The main topic of my work is signed, gain, and biased graphs. These are graphs with additional structure that leads to new graphical matroids and other new kinds of graph theory, such as colorings and geometrical representations, of which ordinary graphical matroids, colorings, etc., are special cases. In combinatorial geometry I work on arrangements of hyperplanes and lattice-point counting. Other research interests are in graph theory and in generalizing Sperner's theorem.

Lu Zhang

Harmonic analysis: Fourier Multipliers, Pseudo-differential Operators, Fourier Integral operators. Partial Differential Equations: Trudinger-Moser inequalities.

Gang Zhou

1. mathematical physics: the long time behavior of Schrodinger-type equations, relations between quantum and PDE models, non-equilibrium statistical mechanics,
2. geometric analysis: mean curvature flow and Ricci flows by methods different from the classical ones, formation of singularities in finite time, flow through singularities.



Research interests of those who used to work in the department

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