# $44^{th}$ Annual New York State Regional Graduate Mathematics Conference

Syracuse University


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2019

# Contents

# Welcome!

Welcome and thank you for attending the $44^{\text{th}}$ NYSRGMC. The Annual New York State Regional Graduate Mathematics Conference (ANYSRGMC) is the longest running graduate mathematics conference in the country, and is organized entirely by graduate students. ANYSRGMC is a Mathematics conference dedicated to providing an opportunity for mathematics graduate students in any field to present their research or give an expository talk. The ANYSRGMC allows students from many fields and schools, who normally are not given a chance to interact, an opportunity to come together and explore a wide variety of mathematical topics simultaneously. Students have a unique chance to explore their interests, gain new insights across fields, and explore possible cross-disciplinary collaborative efforts. This is a unique opportunity for beginning graduate students to see a broad range of current mathematical research simultaneously and explore their interests. Though the focus of ANYSRGMC is on graduate students, advanced high school students or undergraduates, post-docs, and professors are welcome to attend and give talks. It is our goal to develop careers, broaden horizons, and engage the mathematics community at large. We hope you enjoy the conference!

# Internet Access

While at the university, you may access the internet via your own university login through eduroam. Participating institutions typically broadcast the "eduroam" wireless network name (SSID), and students, faculty and staff from other eduroam institutions can use their home network credentials (email address and password) to authenticate to this network. As an alternative to eduroam, visitors who need Internet access while at Syracuse University can connect using AirOrangeGuest.

Remember, a copy of the schedule, this conference packet, and all other conference related things can be found on the conference webpage: http://mgo.syr.edu/conferences-talks/conference/upcoming-conferences/

# Conference Lunch and Dinner

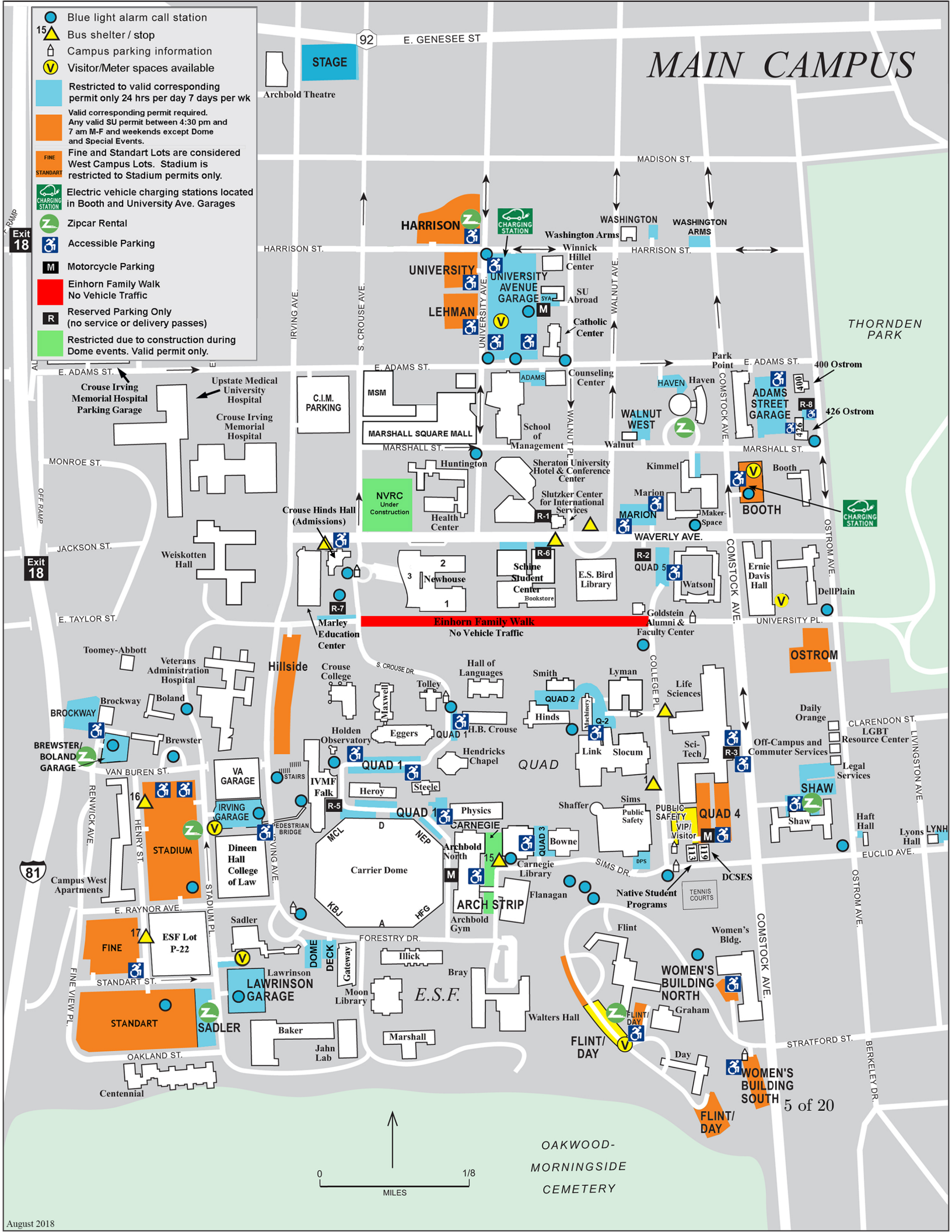
There will be a lunch, hosted on the first floor of Carnegie Hall, and a dinner, hosted at the Inn Complete starting at 6 p.m., that is free for all registered conference attendees. There is a cash bar at the Inn Complete. We thank the Graduate Student Organization for generously supporting these events.

# Acknowledgements

The organizers would like to thank the Graduate Student Organization, Syracuse University Mathematics Department, American Mathematical Society, and the National Science Foundation for generously supporting this conference. We would like to thank Julie O'Connor, Leah Quinones, Kelly Jarvi, and Jordan Correia for their help with all the conference details — both little and big. A special thanks to Casey Necheles and Erin Griffin for all their help with the conference organization and event planning. The organizers would also like to give a special thanks to Professor Graham Leuschke and Amy Graves for their work with the NSF Grant; for their knowledge and endless patience, we are enormously indebted. We would like to thank our speakers, Dr. Kathryn Mann and Dr. John Voight, for graciously accepting the invitation to speak at our conference. Finally, we would like to thank all the conference attendees for coming and giving such wonderful talks. This conference would truly be impossible without all of you.

# Funding

This conference is generously supported by the Mathematics Graduate Organization, Graduate Student Organization, Syracuse University Mathematics Department, American Mathematical Society, and the National Science Foundation.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COMSTOCK AVE.
ADAMS STREET GARAGE
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Health Center
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Sheraton University Hotel & Conference Center
Slutzker Center for International Services
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JACKSON ST.
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Schine Student Center
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E.S. Bird Library
QUAD 5
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WAVERLY AVE.
Ernie Davis Hall
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OSTROM AVE.
E. TAYLOR ST.
Marley Education Center
Einhorn Family Walk
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Goldstein Alumni & Faculty Center
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Hall of Languages
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COLLEGE PL.
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CLARENDON ST.
LGBT Resource Center
Off-Campus and Commuter Services
Legal Services
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Holden Observatory
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H.B. Crouse
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Sci-Tech
VAN BUREN ST.
VA GARAGE
IRVING GARAGE
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WOMEN'S BUILDING NORTH
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Moon Library
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**Conference Schedule**

| | Room | | | |
|---|---|---|---|---|
| Time | Carnegie 120 | Carnegie 200 | Carnegie 219 | Carnegie 100 |
| 7:30 - 8:45 | Registration, 1st Floor Carnegie Hall | | | |
| 9:00 - 9:15 | **Welcome and Opening Remarks (Shemin Aud, Shaffer)** | | | |
| 9:15 - 10:15 | **Invited Address - Dr. John Voight (Shemin Aud, Shaffer)**<br>**Ranks of elliptic curves: the boundedness countroversy** | | | |
| 10:35 - 11:00 | *Hermitian MaaßLift for General Level*<br>An Hoa Vu | *Blaschke Expansions for Functions in Hardy Spaces*<br>Stephen Farnham | *A Brief Look at the Volume Comparison Theorem*<br>Erin Griffin | |
| 11:05 - 11:30 | *Equivariant cohomology: a topological and an algebraic approach*<br>Sergio Chaves | *On certain canonical Jordan bases of H-selfadjoint matrices and its stability under small perturbations*<br>Anatasiia Minenkova | *Creative Mathematical Reasoning among Undergraduate Students*<br>Joash Geteregechi | |
| 11:30 - 11:45 | Coffee Break (1st Floor Carnegie Hall) | | | |
| 11:50 - 12:15 | *Cohomology of group theoretic Dehn fillings*<br>Bin Sun | *Another Thing Erdős Did*<br>Daniel Zackon | *Laplacian Operator and Hyperbolic Geometry*<br>Xiaolong Han | *Minimal Generating Sets of the Symmetric Group*<br>Sadia Ansari |
| 12:20 - 12:45 | *Discrepancy Bounds for the Logarithmic Derivative of the Riemann Zeta Function*<br>Clayton Lungstrum | *Invariant metrics in complex geometry*<br>Gunhee Cho | *Exploring Connections Between Students' Representational Fluency and Functional Thinking*<br>Nigar Altindis | *Graded Modules in Topological Data Analysis*<br>René Corbet |
| 12:45 - 12:55 | Conference Photo (Carnegie Steps) | | | |
| 12:55 - 1:45 | Lunch (1st Floor Carnegie Hall) | | | |
| 2:00 - 3:00 | **Invited Address - Dr. Kathryn Mann (Shemin Aud, Shaffer)**<br>**Orderable groups in dynamics and topology** | | | |
| 3:15 - 3:40 | *Algebra Structures on Resolutions*<br>Rachel Diethorn | *Weighted Sobolev estimates for homotopy operators on strictly pseudo-convex domains with $C^2$ boundary*<br>Ziming Shi | *Derived differential geometry: from manifolds to derived $\infty$-stack*<br>Qingyun Zeng | |
| 3:40 - 3:55 | Coffee Break (1st Floor Carnegie Hall) | | | |
| 4:00 - 4:25 | *Quadratic Algebras and Their Duals*<br>Laura Ballard | *Fourier Series of Circle Embeddings*<br>Xuerui Yang | *Students' Conceptualization of Angle in a Realistic Real-Life Context*<br>*Grace Visher* | |
| 4:30 - 4:55 | *Progress in the Classification of Torsion Subgroups of Elliptic Curves*<br>Caleb McWhorter | *Anisotropic Interactions in Pedestrian Flow Modeling*<br>Elliot Cartee | *Examining the Relationship of Instruction in the Conceptual Understanding of Function in Precalculus Students*<br>Keshab Adhikari | |
| 6:00 - 10:00 | **Conference Dinner,**<br>**Inn Complete** | | | |

# About the Invited Speakers

**Dr. Kathryn Mann (Brown University)**

Professor Kathryn Mann received her Ph.D. at the University of Chicago under Professor Benson Farb. Dr. Mann then was a postdoctoral research fellow at MSRI, followed by being the Morrey Visiting Assistant Professor at UC Berkeley before finally arriving at Brown University as the Manning Assistant Professor of Mathematics. Broadly speaking, her research is in Topology, geometry, geometric group theory, dynamics, etc.. Specifically, she studies actions of infinite groups on manifolds and the moduli spaces of such actions: character varieties, spaces of flat bundles or foliations, and spaces of left-invariant orders on groups. Professor Mann has won numerous awards for her research, including the Mary Ellen Rudin young researcher award and the AWM Joan & Joseph Birman Research Price in Topology and Geometry. In addition to her commitment to excellent research, with over two dozen publications, she is committed to excellence in mathematics education for students at all levels. At the High School level, Dr. Mann has contributed to Mathcamp, a program for talented high schoolers. At the Undergraduate level, Dr. Mann is a co-developer and on the faculty oversight team for a national network for Directed Reading Program (DRP), and organizes the Topology Students Workshop. Finally at the Graduate level, Dr. Mann has given numerous excellent workshop and minicourse presentations in addition to running the Graduate Student Summer School: Diffeomorphism Groups: algebra, topolgy, homology at Berkley and co-organizing the Berkeley-Stanford Foliations seminar. Dr. Mann is also a referee for numerous journals, including Geometry & Topology, Journal of Topology, Algebraic & Geometric Topology, Annals of Mathematics, and others.

**Dr. John Voight (Dartmouth College)**

Dr. John Voight received his Ph.D. in 2005 from the University of California, Berkeley. He has held positions at the University of Sydney, the Institute for Mathematics and its Applications (IMA) at the University of Minnesota, and the University of Vermont. He is now an associate professor at Dartmouth College. Broadly speaking, Dr. Voight's research interests are number theory and arithmetic algebraic geometry, especially in their computational and algorithmic aspects. Dr. Voight has won numerous awards, including the Selfridge Prize, the Milt Silveira Award, and an NSF CAREER award. He is currently a principal investigator for the Simons Collaboration on Arithmetic Geometry, Number Theory, and Computation. Among his dozens of publications, Dr. Voight is currently writing a book on quaternion algebras, which has already reached 816 pages! Dr. Voight has given nearly 100 lectures and talks, including a TEDx talk, "Cryptography for Everyone."

# Invited Address – Dr. John Voight
# 9:15 – 10:15 : Shemin Aud, Shaffer

***Ranks of elliptic curves: the boundedness controversy***
Dr. John Voight (Dartmouth College)

Abstract: Elliptic curves lie at the intersection of many domains of mathematics: arising from the classical theory of elliptic integrals, they are complex tori of dimension 1 or algebraic curves of genus 1, and they are used extensively in modern cryptography. They have the special property that their set of points forms an abelian group; one would be hard-pressed to find a more beautiful structure in abstract mathematics than the secant/tangent law on an elliptic curve! Over the rational numbers, the group of points on an elliptic curve is finitely generated, and so it is natural to wonder: ranging over all elliptic curves over the rational numbers, is there a bound on the minimal number of generators? The answer is not known, and there is even a bit of friendly controversy about what the answer should be! In this talk, in joint work with Jennifer Park, Bjorn Poonen, and Melanie Matchett Wood, we will propose a heuristic that predicts boundedness.

# 10:35 – 11:00

## Carnegie 120

### Hermitian Maaß Lift for General Level

*An Hoa Vu*

Abstract: For an imaginary quadratic field $K$ of discriminant $-D$, let $\chi = \chi_K$ be the associated quadratic character. We will show that the space of special hermitian Jacobi forms of level $N$ is isomorphic to the space of plus forms of level $DN$ and nebentypus $\chi$ (the hermitian analogue of Kohnen's plus space) for any integer $N$ prime to $D$. This generalizes the results of Krieg from $N = 1$ to arbitrary level. Combining this isomorphism with the recent work of Berger and Klosin and a modification of Ikeda's construction we prove the existence of a lift from the space of elliptic modular forms to the space of hermitian modular forms of level $N$ which can be viewed as a generalization of the classical hermitian Maaß lift to arbitrary level.

## Carnegie 200

### Blaschke Expansions for Functions in Hardy Spaces

*Stephen Farnham*

Abstract: In this talk, we will discuss the concept of the Blaschke Expansion of a function that is analytic in the unit disc by drawing parallels to the well known Taylor Expansion. Once established, we will look into the benefits of using Blaschke expansions and present new theorems on their convergence.

## Carnegie 219

### A Brief Look at the Volume Comparison Theorem

*Erin Griffin*

Abstract: The Bishop-Gromov Theorem (Volume Comparison Theorem) looks at the consequences of bounding the Ricci curvature below by a constant on volume. This introductory level talk will begin by defining pertinent terms and continue to examine the Volume Comparison Theorem using methods that are largely dependent on calculus. Once the theorem has been established, we will proceed to examine the consequences of the theorem.

# 11:05 – 11:30

## Carnegie 120

### Equivariant cohomology: a topological and an algebraic approach

*Sergio Chaves*

Abstract: Let $X$ be a topological space with an action of a compact group $G$. It is known that the singular homology and cohomology groups of $X$ are invariants of the topology of the space. Is there an algebraic invariant that captures both the topology and the action? An answer was proposed by A. Borel in the 60's by introducing the notion of equivariant cohomology: An extension of the singular cohomology that also considers the action.

The purpose of this talk is twofold. First, we will introduce the Borel construction, discuss it main properties and present several illustrative examples. Second, restricting to finite group actions, there is an identification between the Borel's equivariant cohomology and group cohomology, which leads to advantages by using tools from homological algebra. This is an introductory-level talk, and only a basic course in algebraic topology is required.

## Carnegie 200

### On certain canonical Jordan bases of H-selfadjoint matrices and its stability under small perturbations

*Anastasiia Minenkova*

Abstract: In this talk we will discuss a special canonical Jordan basis for real H-selfadjoint matrices. This basis has simultaneously flipped orthogonality property and it is $\gamma$-conjugate symmetric. Moreover, its Lipschitz stability under small perturbation, preserving Jordan structure, will be presented.

## Carnegie 219

### Creative Mathematical Reasoning among Undergraduate Students

*Joash Geteregechi*

Abstract: Ability to reason critically and creatively is one of the most important components of doing mathematics. These skills contribute immensely to the growth of the field of mathematics. Studies in the field of mathematics education suggest that if students are to learn mathematics meaningfully, the environment in which

they learn should provide opportunities for engaging in high order forms of reasoning (e.g., creative mathematical reasoning). In this talk, I present a framework (Lithner, 2008) that mathematics instructors can use to characterize the kinds of reasoning that their students engage in while working on certain mathematical tasks. This knowledge can be of great importance for instructors in making decisions about teaching as well as assessment of learning in mathematics.

# 11:50 – 12:15

## Carnegie 100

### Minimal Generating Sets of the Symmetric Group

*Sadia Ansari*

Abstract: After discussing a few group theory and representation theory concepts, we will question whether the minimal generating set with adjacent transpositions exhibits better qualities than other minimal generating sets for the symmetric group on $n$ elements. A few of the qualities we will consider are the representation order, the representation stability, and the rooted tree corresponding to each minimal generating set, as well as the ability to make a poset, and compute length of an element.

A rooted tree is built for each distinct minimal generating set $X$. This tree records a shortest expression for each element $w$ in $S_n$ using the elements of $X$ (i.e. generators).

## Carnegie 120

### Cohomology of group theoretic Dehn fillings

*Bin Sun*

Abstract: The notion of a group theoretic Dehn filling generalizes that of a geometric Dehn filling of 3-manifolds. By refining the Lyndon-Hochschild-Serre spectral sequence, we obtain a spectral sequence to compute the cohomology of the quotient arising from a Dehn filling of a hyperbolically embedded subgroup. As an application, we estimate the cohomology dimension of the corresponding Dehn filling quotients. Moreover, we construct, for any two given finitely generated acylindrically hyperbolic groups, a finitely generated, acylindrically hyperbolic quotient with a nice bound on its cohomological dimension.

## Carnegie 200

### Another Thing Erdős Did

*Daniel Zackon*

Abstract: Most of the major ideas and results of infinite graph theory—one of Erdős's favourite topics—can be traced back to him and his collaborators. A number of these results concern a graph's chromatic number, i.e., the least cardinal $\kappa$ for which a proper colouring of the graph exists. This talk will introduce a graph-theoretic construction of Erdős and Hajnal, and provide an overview of its remarkable compactness properties and the mathematical wizardry involved in proving them.

## Carnegie 219

### Laplacian Operator and Hyperbolic Geometry

*Xiaolong Han*

Abstract: The Laplacian operator acting on functions on a Riemannian manifold is an analytic operator invariant under isometry of the manifold. Its spectrum encodes much geometric information of the manifold. In this talk, I will start with some basic properties of Laplacian operator and hyperbolic geometry. Then I will talk about how they interact with each other beautifully. Time permitting, I will talk about some of my recent works. No background on Laplacian operator or hyperbolic geometry is assumed.

# 12:20 – 12:45

## Carnegie 100

### Graded Modules in Topological Data Analysis

*René Corbet*

Abstract: Topological data analysis is an active area in data science. Its main tool, persistent homology, has lead to successes in a wide variety of applications. Furthermore, persistent homology gives rise to a rich mathematical theory including several fields of mathematics. In this talk, I explain how we can understand the algebraic structure of persistent homology by studying graded modules.

## Carnegie 120

### Discrepancy Bounds for the Logarithmic Derivative of the Riemann Zeta Function

*Clayton Lungstrum*

Abstract: The problem of the distribution of the logarithmic derivative of the zeta function dates as far back as Kershner and Wintner's original paper from 1937, where they prove that $\zeta'/\zeta(\sigma + it)$ has an asymptotic distribution for any fixed $\sigma > \frac{1}{2}$. Nearly 60 years later, C. R. Guo improved this result by providing an explicit error term for the distribution. Lester improved Guo's result further and determined that the distribution is, in fact, a Gaussian distribution. In the literature, this error term has become known as the discrepancy as it quantifies how much is lost when approximating a function by its appropriate random model.

In this paper, we investigate the discrepancy of the logarithmic derivative of Riemann's zeta function on the line $\Re(s) = \sigma > \frac{1}{2}$ when compared to its random model $\zeta'/\zeta(\sigma, X)$. We then look at extending the result to a subset of $L$-functions in the Selberg class, improving upon Masahiro Mine's recent results.

## Carnegie 200

### Invariant metrics in complex geometry

*Gunhee Cho*

Abstract: This talk is a gentle introduction to complex geometry for a general audience that has taken at least one course in complex analysis. Crucial theorems in complex analysis like Schwarz lemma, Riemann mapping theorem, and Uniformization theorem lead us to the natural question: How can we understand complex manifolds based on the observation of the Poincare-disk in the complex Euclidean plane? We will introduce the intrinsic metrics; Caratheodory, Kobayashi, Bergman, and the Kahler-Einstein metrics, and we will see how these metrics help us to understand a large class of complex manifolds. If time allows, I will introduce my papers (https://arxiv.org/abs/1806.06311, https://arxiv.org/abs/1812.05398) related to the talk.

## Carnegie 219

### Exploring Connections Between Students' Representational Fluency and Functional Thinking

*Nigar Altindis*

Abstract: This study explores the relationship between preservice teachers (PTs) representational fluency and functional thinking. We conducted task-based interviews with five preservice teachers within a growing rectangle context. Although PT create, interpret, and connect representations with covariational and corresponding approach, they identified relationship between area and height an exponential rather than a quadratic. These findings illustrate a challenge of building rich conceptions of functions from emerging representational fluency and functional reasoning.

# Invited Address
# 2:00 – 3:00 : Shemin Aud, Shaffer

***Orderable groups in dynamics and topology***
Dr. Kathryn Mann (Brown University)

Abstract: A left-order on a group is a left-multiplication invariant linear order (think: the usual $<$ on the integers). While this is a purely algebraic construction, orders have deep connections to problems in low-dimensional dynamics and geometric topology. Many fascinating examples of left-orders come from topological constructions like codimension-1 foliations, and there is a close relationship between orders on a group and actions of the group by homeomorphisms on the line. Thus, techniques from one area (algebra, topology, or dynamics) can often be used in this framework to answer a question in another. In this talk, I'll paint a picture of a current research program to establish a "three-way dictionary" between the algebraic structure of a group, the dynamics of its actions on 1-manifolds, and the topology of its space of left-orders. This is a new and fairly accessible research area, and I'll aim to give lots of open problems and concrete examples.

# 3:15 – 3:40

## Carnegie 120

### Algebra Structures on Resolutions

*Rachel Diethorn*

Abstract: In this talk, I will discuss differential graded (DG) algebra structures and the more general notion of $A_\infty$-algebra structures on resolutions. I will discuss some classical results on DG-algebra resolutions due to Avramov and Buchsbaum-Eisenbud and a recent result of Burke on $A_\infty$-algebra resolutions. I will also highlight a useful consequence when such algebra structures exist due to Iyengar.

## Carnegie 200

### Weighed Sobolev estimates for homotopy operators on strictly pseudo-convex domains with $C^2$ boundary

*Ziming Shi*

Abstract: In this talk I will present a homotopy operator for the d-bar equation on strictly pseudo-convex domains with $C^2$ boundary, and show that it gains "almost" 1/2 derivative with respect to a weighted Sobolev norm.

## Carnegie 219

### Derived differential geometry: from manifolds to derived $\infty$-stack

*Qingyun Zeng*

Abstract: There has been a fast development of derived algebraic geometry in the past few years. On the other hand, traditional method in differential geometry and topology do not play well with singularities. Also, manifolds are ill behaved under many operations in homotopy theory, for example, pullback does not always exists. Hence there exists demand to develop derived geometry in the differential-geometric context. I will introduce basics ideas about derived differential geometry in the sense of Nuiten and Lurie, and then talk about some applications.

# 4:00 – 4:25

## Carnegie 120

### Quadratic Algebras and Their Duals

*Laura Ballard*

Abstract: Some of the algebras we are most familiar with, such as a polynomial ring over a field, are quadratic algebras. In this talk, we will explore the notions of quadratic algebras and quadratic dual algebras, and will look at a small example to illustrate. If time permits, we will construct an associated complex of modules with some special properties. This talk will be somewhat computational and will have parts that should be accessible to all attendees.

## Carnegie 200

### Fourier Series of Circle Embeddings

*Xuerui Yang*

Abstract: We study the Fourier series of circle homeomorphisms and circle embeddings, with the emphasis on Blaschke product approximation and the vanishing of Fourier coefficients. The analytic properties of the Fourier series are related to the geometry of the circle embeddings, and have implications for the curvature of minimal surfaces.

## Carnegie 219

### Students' Conceptualization of Angle in a Realistic Real-Life Context

*Grace Visher*

Abstract: This talk will report dissertation findings on how sixth grade students conceptualized the angle concept, before, during, and after a geometry instructional unit, set up in a miniature golf context. Students' understanding of the angle concept is pertinent for both in-school and out-of-school contexts. For instance, angle knowledge is important in understanding of trigonometry and construction. However, students struggle to understand the angle concept. Thus, we need to understand how students conceptualize the angle concept in various contexts in order to offer the necessary support.

# 4:30 – 4:55

## Carnegie 120

### Progress in the Classification of Torsion Subgroups of Elliptic Curves

*Caleb McWhorter*

Abstract: The Mordell-Weil Theorem states that the rational points on an elliptic curve defined over a number field are a finitely generated abelian group, i.e. of the form $\mathbb{Z}^{r_K} \oplus E(K)_{\text{tors}}$, where $r_K$ is the rank of the curve and $E(K)_{\text{tors}}$ is the set of torsion points. While the rank is still quite mysterious (it is not even known to be bounded/unbounded), the torsion subgroup is much better understood. In 1978, Mazur classified the possible torsion subgroups for elliptic curves $E/\mathbb{Q}$. However, much of the progress in understanding and classifying torsion subgroups of elliptic curves has occurred in the last 20 years. This talk will outline some of the most recent results and techniques as well as discuss future questions in this area.

## Carnegie 200

### Anisotropic Interactions in Pedestrian Flow Modeling

*Elliot Cartee*

Abstract: How do choices made by individual pedestrians influence large-scale crowd dynamics? What factors slow them down and motivate them to seek detours? What happens when multiple crowds pursuing different targets interact with each other? We will consider how answers to these questions shape a class of popular PDE-based models, in which a conservation law models the evolution of pedestrian density while a Hamilton-Jacobi PDE is used to determine the directions of pedestrian flux. This presentation will emphasize the role of anisotropy in pedestrian interactions, the geometric intuition behind our choice of optimal directions, and connections to non-zero-sum game theory.

## Carnegie 219

### Examining the Relationship of Instruction in the Conceptual Understanding of Functions in Pre-Calculus Students

*Keshab Adhikari*

Abstract: A solid Understanding of the function concept is essential for students' success in calculus and in STEM-oriented careers. This brief report shares a small part of findings examining relationships between the teaching of inverse functions and representations of functions in a classroom and students' learning of the concept as displayed in their response to O'Shea et al.'s (2016) Function Concept Inventory.


Mathematics Graduate Organization