48th Annual New York State Regional Graduate Mathematics Conference

Syracuse University

Date: April 1st, 2023

MORNING

Time	Carnegie 100	Carnegie 115	Carnegie 120	Carnegie 200	Carnegie 219
7:15-8:30	Registration and Breakfast (Carnegie 111)				
8:45-9:00	Welcome and Opening Remarks (Life Sciences Building, Room 001)				
9:00-10:00	Dr. Eloísa Grifo (Life Sciences Building, Room 001) Cohomological support varieties				
10:15-10:40	Albert Madinya Topologizing the Space of Minimal Primes of an M-frame	Arya Vadnere Shirts	Ali Balooch A New Formalization of Dirichlet Type Spaces	Ben Adenbaum Rowmotion on 321-avoiding permutations	Chanon Thongprayoon Offline and online embedding of temporal networks
10:45-11:10	NO TALK	Daniel Havens Closures, Completions, and Topological Takeaways	Joon Do Chang Local Well-Posedness for the BBM Equation	Daniel Hwang Chip-firing, served three ways	Ewan Gray Applications of Machine Learning Models - Horse Racing in United Kingdom
11:10-11:25	Coffee Break (Carnegie 111)				
11:30-11:55	Bailey Heath Representation Dimensions of Algebraic Tori	Deepisha Solanki Plat Representations of the unknot	Kate Howell The Characteristic Polynomial of Projections	Firdavs Rakhmonov Distribution of similar configurations in subsets of $\mathbb{F}_q^d$	Madison Russell Community detection in multilayer gene co-expression networks using correlation matrix input
12:05-12:30	Hari Asokan Geometric Invariant Theory	Yukun Du Geometry of Selberg's bisectors in the symmetric space $SL(n,\mathbb{R})/SO(n,\mathbb{R})$	Rahul Rajkumar Elements and Applications of p-Adic Analysis	Hillary Bermudez Investigating Tasks that Support Undergraduate Students Proof Comprehension	Md Mostak Ahammed Constrained inference in a scaled linear mixed model for multiple outcomes
12:30-1:45	Conference Photo (Steps of Carnegie) then Lunch				

AFTERNOON

Time	Carnegie 100	Carnegie 115	Carnegie 120	Carnegie 200	Carnegie 219
12:30-1:45	Conference Photo (Steps of Carnegie) then Lunch				
2:00-3:00	Dr. Vera Mikyoung Hur (Life Sciences Building, Room 001) Stable undular bores: rigorous analysis and validated numerics				
3:10-3:35	Mahyar Shafighi Introduction to Homological Mirror Symmetry	Waleed Raja Supporting Students Learning in Social Justice Mathematics Classrooms	Trevor Lax Generating models of Jasmonic Acid Biosynthesis using Sparse Identification of Nonlinear Dynamics	Jason Howell Generalized Pascal's Triangles	Narshini Gunputh Mathematical Modeling of Contact Lens Drug Delivery
3:40-4:05	Thang Vo Dual codes of cyclic code of length $5p^s$ over $\mathbb{F}_{p^m} + u\mathbb{F}_{p^m}$	Ruodan Liu Fixation probability in evolutionary dynamics on hypergraphs	Fatemah Fogh Special Extend of The Classes of Contractive Non-Self Mapping Theorems	Kaitian Jin Analytical Combinatorics in Several Variables	Nathaniel Smith Spectral Information in the Dirichlet-to-Kirchoff Map
4:10-4:25	Coffee Break (Carnegie 111)				
4:30-4:55	Melanie Ferreri A proof of a nonderangement identity	Ian Gossett Orientations and Additive Colorings of Graphs	Charles Kulick Scalable Multi-Species Agent-Based Modeling with Sparse GP	Preston Kelley The Height Gap in in Abelian Extensions of the Rationals	Sahil Chindal Predicting Dengue Incidence In Central Argentina Using Google Trends Data
5:00-5:25	Ray Maresca A 4-fold Categorical Equivalence	NO TALK	NO TALK	Yixin (Kathy) Lin Penney's game for permutations	Samuel Paul Gyamfi Herding Behavior on the cryptocurrency Market
6:00-10:00	Conference Dinner (Schine Student Center, 304 ABC)				

Contents

1. A Letter from the President and Vice-President of the MGO

Welcome and thank you for participating in the 48th Annual 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.

We 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, Kimberly Canino, Kelly Jarvi, and M'Tia Williams for their help with all the conference details — both little and big. A special thanks to Chelsea Sato, Ben Kaufman, Sabrina Traver for all their help with the conference organization and event planning. We would also like to give a special thanks to Professor Graham Leuschke, Professor Will Wylie, and Amy Graves for their work with the NSF Grant, in addition to their knowledge and endless patience. We would like to thank our speakers, Dr. Eloísa Grifo and Dr. Vera Mikyoung Hur, for graciously accepting the invitation to speak at our conference. Finally, we would like to thank all the conference attendees for participating and giving such wonderful talks. This conference would truly be impossible without all of you.

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 across the country an opportunity to come together and explore a wide variety of mathematical topics. Students have a unique opportunity to explore their interests, gain new insights across fields, network with their peers, and explore possible cross-disciplinary collaborative efforts. Early graduate students and advanced undergraduate students are able to present undergraduate research, experience a broad range of current mathematical research, and learn from older graduate students. Overall, it is our hope and our goal to develop careers, broaden horizons, and engage the mathematics community at large. We hope you enjoy the conference!

Elana Israel and Henry Potts-Rubin, President and Vice-President

2. 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.

3. Keynote Speakers

Dr. Eloísa Grifo (University of Nebraska-Lincoln)

Professor Eloísa Grifo received her B.S. and M.S. in Mathematics at Instituto Superior Técnico in Portugal in 2011 and 2013, respectively. She then went on to receive her Ph.D. from the University of Virginia, working under Craig Huneke. Professor Grifo later held positions at University of Michigan and University of California, Riverside, before landing at the University of Nebraska-Lincoln, where she is currently an Assistant Professor. Her research interests lie in homological and commutative algebra, focusing on topics such as symbolic powers, local cohomology, and the homological algebra of local rings.

Title: Cohomological support varieties

Abstract: In commutative algebra, there is a long and beautiful history of applying homological methods to study singularities. Cohomological support varieties, defined by Avramov in the 1980s, assign to each finitely generated module a projective variety encoding homological information. In this talk, we will introduce some of that history, and discuss the following realizability problem: given an appropriately chosen variety, when can it be realized as the variety associated to some module? This is joint work with Ben Briggs and Josh Pollitz.

Dr. Vera Mikyoung Hur (University of Illinois Urbana-Champaign)

Professor Vera Mikyoung Hur completed her Ph.D. at Brown University in 2006, advised by Walter Strauss. Afterwards, Professor Mikyoung-Hur was a CLE Moore Instructor at MIT for three years before becoming a Professor at the University of Illinois Urbana-Champaign, where she is currently the chair of the Mathematics Department. Her research focuses on analysis, numerical computation, and modelling, including physical oceanography and geophysical fluid dynamics.

Title: Stable undular bores: rigorous analysis and validated numerics

Abstract: I will discuss the 'global' nonlinear asymptotic stability of the traveling front solutions to the Korteweg-de Vries–Burgers equation, and other dispersive-dissipative perturbations of the Burgers equation. Earlier works made strong use of the monotonicity of the profile, for relatively weak dispersion effects. We exploit the modulation of the translation parameter, establishing a new stability criterion that does not require monotonicity. Instead, a certain Schrodinger operator in one dimension must have exactly one negative eigenvalue, so that a rank-one perturbation of the operator can be made positive definite. Counting the number of bound states of the Schrodinger equation, we find a sufficient condition in terms of the 'width' of a front. We analytically verify that our stability criterion is met for an open set in the parameter regime including all monotone fronts. Our numerical experiments, revealing more stable fronts, suggest a computer-assisted proof. Joint with Blake Barker, Jared Bronski, and Zhao Yang.

4. Talk Abstracts

4.1. **10:15-10:40 Parallel Session 1.**

Carnegie 100: Albert Madinya, Florida Atlantic University

Title: Topologizing the Space of Minimal Primes of an M-frame

Abstract: An M-frame is an algebraic frame possessing a unit and satisfying the Finite Intersection Property. Given an M-frame, call it L, we can topologize the set of minimal prime elements of L, which we will denote by Min(L). One such way we could topologize Min(L) is with the Zariski topology as is done with the prime ideals of a commutative ring. The other is the inverse topology which has a similar construction to that of the Zariski topology. Our aim in this talk to is to study these topological spaces and the interplay that exists between the topological properties of Min(L) and the frame-theoretic properties of L.

Carnegie 115: Arya Vadnere, University at Buffalo

Title: Shirts

Abstract: Teichmüller theory is a rich branch of geometric topology which relates several objects associated to a surface, such as hyperbolic structures, the mapping class group and the curve graph. In this talk, we shall work with the sphere with 4 punctures (shirts!) to demonstrate this interplay. Expect several pretty pictures!

Carnegie 120: Ali Balooch, University of Nevada, Las Vegas

Title: A New Formalization of Dirichlet Type Spaces

Abstract: Applications and findings involving the norm of the weighted Dirichlet space Dα are steadily being discovered. One particular paper from 1993 presents a notable characterization of D_α through an estimation of its norm. Applications include determining the conditions for boundedness of a Bergman type operator, and characterizing functions in the Drury–Arveson space that induce bounded Hankel operators. This paper improves the norm estimation by extending the domain of relevant parameters, and establishing the asymptotic formula with precise constants.

Carnegie 200: Ben Adenbaum, Dartmouth College

Title: Rowmotion on 321-avoiding permutations

Abstract: We give a natural definition of rowmotion for 321-avoiding permutations, by translating, through bijections involving Dyck paths and the Lalanne–Kreweras involution, the analogous notion for antichains of the positive root poset of type A. We prove that some permutation statistics, such as the number of fixed points, are homomesic under rowmotion, meaning that they have a constant average over its orbits.

Carnegie 219: Chanon Thongprayoon, University at Buffalo

Title: Offline and online embedding of temporal networks

Abstract: Author: Chanon Thongprayoon (1), Naoki Masuda (1,2)
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A useful method for visualizing networks and assisting analysis of network data is network embedding, with which one maps the given network into a low dimensional vector space or manifold. In network embedding, we generally preserve the dissimilarity between pairs of the original data points in the embedding space. For temporal (i.e., time-dependent) networks, network embedding may mean embedding of either individual nodes or the entire network that are mobile in a latent space. In the present work, we focus on embedding of the entire network that moves in the embedding space as the network varies over time.
We represent the network evolution over time with a time-dependent adjacency matrix. Particularly, we use a tie-decay network model in which the weight of each edge exponentially decays at a fixed rate in the absence of contact events. If there is a contact event between two nodes, then the weight of the edge between them instantly increases by 1.
We aim to embed the given tie-decay temporal network to obtain a continuous-time trajectory in a low-dimensional Euclidean space. To this end, firstly, we propose to construct a matrix encoding the distance between pairs of tie-decay networks at different discrete times. Next, we apply the landmark multidimensional scaling (LMDS) algorithm to the distance matrix. The LMDS, an extension of multidimensional scaling (MDS), uses a selected subset of the data points as reference points (i.e., landmarks) to compute the embedding coordinates of any other data points. In this manner, we produce trajectories of temporal networks in continuous time. We also prove mathematical properties of our embedding algorithm.
The aforementioned algorithm embeds the entire temporal network at once. Now we assume a stream of networks as input and consider the question of keeping to update the embedding as new networks arrive. We call the resulting embedding scheme the online embedding. Technically, we may keep the same set of landmarks and continue the embedding procedure as new networks come in. However, it may yield less distortion in the embedding if we replace some of the current landmarks by some of the new data points. In the presentation, we also discuss algorithms and mathematics of landmark replacement.

4.2. **10:45-11:10 Parallel Session 2.**

Carnegie 100: NO TALK

Carnegie 115: Daniel Havens, University of New Mexico

Title: Closures, Completions, and Topological Takeaways

Abstract: Closures and completions, while initially developed in the field of topology, have long been a topic of interest in algebra and its sub-disciplines. We discuss closures first in a topological setting, giving background on the subject, before we move on to how these results can be generalized to a category theoretic setting. We present existence theorems, as well as several concrete topological examples which are of notable significance. We conclude with several new conjectures in the field, and some hopeful directions for future research.

Carnegie 120: Joon Do Chang, University of Memphis

Title: Local Well-Posedness for the BBM Equation

Abstract: The BBM Equation (aka Benjamin Mahony Equation) is a nonlinear dispersive equation (alternative model for the well known kdV equaation) derived to study and model long wavelength water waves with small amplitude. This equation was first introduced by T.B. Benjamin, Jerry L. Bona, and J. Mahony in 1972 whom showed the global well-posedness of his equation in H^k for $k > 0$. In this presentation, we shall study the BBM equation with the initial conditions $u(0, x) = u_0(x)$ in H^s for $0 \leq s \leq 1$. In particular, I will talk about the local well-posedness result of J. L. Bona and N. Tzetkov published in 2008. If time permits, I will also briefly talk about Mahendra Panthee's local ill-posedness result of the BBM equation for $s < 0$ and discuss about some open problems.

Carnegie 200: Daniel Hwang, Georgia Institute of Technology

Title: Chip-firing, served three ways

Abstract: Chip-firing asks a simple question: Given a group of people and an initial integer distribution of dollars among the people including people in debt, can we redistribute the money so that no one ends up in debt? This simple question with its origins in combinatorics can be reformulated using concepts from linear algebra, graph theory, and even divisors in Riemann surfaces. In this expository presentation, we will cover the original chip-firing problem, along with three different approaches to solving this problem: utilizing the Laplacian, Dhar's algorithm, and a graph-theoretic version of the Riemann-Roch theorem by Baker and Norine.

Carnegie 219: Ewan Gray, Dominican University New York

Title: Applications of Machine Learning Models - Horse Racing in United Kingdom

Abstract: Horse racing has been an area of interest to many mathematicians and researchers. There are an abundance of papers comparing complex mathematical and statistical models to predict race outcomes. Many researchers have built models which exploit inefficiencies in betting markets, to generate consistently profitable systems. We are the first to compare machine learning methods in UK Horse Racing markets. We have also taken steps to advance prior research by combining predictive models with the well known betting strategy - The Kelly Criterion. We compared GLM-Net with SMOTE, OverSampling, UnderSampling, Logistic Regression, and SVM models, to find our optimal betting strategy.

4.3. **11:30-11:55 Parallel Session 3.**

Carnegie 100: Bailey Heath, University of South Carolina

Title: Representation Dimensions of Algebraic Tori

Abstract: Algebraic tori over a field k are special examples of affine group schemes over k, such as the multiplicative group of the field or the unit circle. Any algebraic torus can be embedded into the group of $n \times n$ invertible matrices with entries in k for some n, and the smallest such n is called the representation dimension of that torus. In this work, I am interested in finding the smallest possible upper bound on the representation dimension of all algebraic tori of a given dimension d. After providing some background, I will discuss how we can rephrase this question in terms of finite groups of invertible integral matrices. Then, I will share some progress that I have made on this question, including general lower bounds for all d and exact answers for certain values of d.

Carnegie 115: Deepisha Solanki, University at Buffalo

Title: Plat Representations of the unknot

Abstract: The main result is a version of Birman's theorem about equivalence of plats, which does not involve stabilisation, for the unlink. We introduce the 'flip move', which modifies a plat without changing its link type or bridge index. Theorem 1 shows that the flip move is the only obstruction to reducing a closed n-plat representative of the unknot to the standard 0-crossing diagram of the unknot, through a sequence of plats of non-increasing bridge index. The theorem readily generalises to the case of the unlink.

Carnegie 120: Kate Howell, SUNY Albany

Title: The Characteristic Polynomial of Projections

Abstract: Given matrices $A_1, \ldots, A_n$, the characteristic polynomial is defined as $\det(z_0 I + z_1 A_1 + \ldots + z_n A_n)$. In this talk, we will prove that the characteristic polynomial is a complete unitary invariant for pairs of projection matrices. Some special cases involving three or more projections will also be considered.

Carnegie 200: Firdavs Rakhmonov, University of Rochester

Title: Distribution of similar configurations in subsets of $\mathbb{F}_q^d$

Abstract: Let $\mathbb{F}_q$ be a finite field of order q and E be a set in $\mathbb{F}_q^d$. The *distance set* of E is defined by $\Delta(E) := \{\|x-y\| : x, y \in E\}$, where $\|\alpha\| = \alpha_1^2 + \cdots + \alpha_d^2$. Iosevich, Koh and Parshall (2018) proved that if $d \geq 2$ is even and $|E| \gg q^{d/2}$, then

$$\mathbb{F}_q = \frac{\Delta(E)}{\Delta(E)} = \left\{ \frac{a}{b} : a \in \Delta(E),\ b \in \Delta(E) \setminus \{0\} \right\}.$$

In other words, for each $r \in \mathbb{F}_q^*$ there exist $(x, y) \in E^2$ and $(x', y') \in E^2$ such that $\|x-y\| \neq 0$ and $\|x'-y'\| = r\|x-y\|$.
Geometrically, this means that if the size of E is sufficiently large, then for any given $r \in \mathbb{F}_q^*$ we can find a pair of edges in the complete graph $K_{|E|}$ with vertex set E such that one of them is dilated by $r \in \mathbb{F}_q^*$ with respect to the other. A natural question arises whether it is possible to generalize this result to arbitrary subgraphs of $K_{|E|}$ with vertex set E and this is the main goal of this talk.
In this talk, we'll explain the proof of this problem for k-paths ($k \geq 2$), simplexes and 4-cycles. The proof is based on the ideas from different areas such as enumerative combinatorics, group actions and Turán type theorems.

Carnegie 219: Madison Russell, University at Buffalo

Title: Community detection in multilayer gene co-expression networks using correlation matrix input

Abstract: In network science, a community is a group of nodes that are densely connected to each other, and therefore likely share common properties. Communities in gene co-expression networks reveal sets of genes similarly expressed across individuals, potentially involved in related biological processes. Gene expression and co-expression depend on regulatory elements in the genome, often specific to different cell types (such as organs). A challenge for deciphering gene expression data is integrating and distinguishing between communities found in various cell types, determining their biological relevance, and identifying regulatory elements maintaining these communities.
Here, we compare gene co-expression communities across four organs using multilayer network analysis techniques. We developed a multilayer community detection method that takes correlation matrices as the input and uses an appropriate null model of the correlation matrices. The Pearson correlation between the expression of two different genes in the same organ across samples dictates the strength of the intralayer edges, and the Pearson correlation between the expression of the same gene in two different organs across all shared samples dictates the strength of the interlayer edges. We also construct a statistical method to assess the statistical significance of communities detected in multilayer correlation matrices and multilayer networks. The results indicate that our correlation matrix input multilayer community detection method extracts statistically significant and biologically interesting communities of genes.

4.4. **12:05-12:30 Parallel Session 4.**

Carnegie 100: Hari Asokan, SUNY Binghamton

Title: Geometric Invariant Theory

Abstract: Developed by David Mumford in 1965, GIT studies the action of algebraic group, G on a scheme, X and construct a quotient of the action of G on X. GIT quotients often appears in the study of the moduli space of various algebraic objects, including abelian varieties . We will discuss some basic definitions and results in GIT.

Carnegie 115: Yukun Du, UC Davis

Title: Geometry of Selberg's bisectors in the symmetric space $SL(n,\mathbb{R})/SO(n,\mathbb{R})$

Abstract: We discussed some properties of a family of symmetric spaces, namely $SL(n,\mathbb{R})/SO(n,\mathbb{R}) =: \mathcal{P}(n)$, where we replace the Riemannian metric on $\mathcal{P}(n)$ with a premetric suggested by Selberg. These include intersecting criteria of Selberg's bisectors, the shape of Dirichlet-Selberg domains, and angle-like functions between Selberg's bisectors. These properties are generalizations of properties on the hyperbolic spaces $\mathbf{H}^n$ related to Poincaré's fundamental polyhedron theorem.

Carnegie 120: Rahul Rajkumar, UC Riverside

Title: Elements and Applications of p-Adic Analysis

Abstract: Completing the rational numbers with respect to the Euclidean absolute value yields the real numbers, the setting of classical analysis. With respect to the p-adic absolute value, the completion of the rationals is known as the p-adics. Kurt Hensel introduced the p-adics in order to bring certain analytic techniques to bear on problems in number theory. We will introduce the p-adic field and provide motivation for its study through recent work on diffusion in multiple p-adic dimensions.

Carnegie 200: Hillary Bermudez, Syracuse University

Title: Investigating Tasks that Support Undergraduate Students Proof Comprehension

Abstract: For many students, reading and understanding mathematical proofs can be challenging, especially for those students who have inequitably been placed at a disadvantage in their mathematics classrooms, such as historically marginalized students. This can create a barrier to understanding mathematical proofs and may result in many students feeling frustrated and disengaged from mathematics as a whole. Consequently, I argue that if undergraduate mathematics classrooms want their students to successfully read and comprehend proofs, through learning experiences that are accessible for all, we should pay more attention to the instructional practices used in these classrooms.
In this talk, I present a study designed to investigate the impact that having students actively engage in a series of tasks in an introductory proof course has on their learning and comprehension of proofs. Specifically, this study aims to investigate the impact that implementing self-explanation training tasks influenced by Variation Theory has on undergraduates' comprehension of mathematical proofs. The study aims to answer two questions: How does an undergraduate who is inexperienced at reading mathematical proofs learn mathematical proof reading strategies? How do patterns of variation in self-explanation training tasks help undergraduate students' development of mathematical proof reading strategies?

Carnegie 219: Md Mostak Ahammed, Southern Illinois University at Carbondale

Title: Constrained inference in a scaled linear mixed model for multiple outcomes

Abstract: The problem of analyzing multiple outcomes arises frequently in many fields of bio-medical research. A global measure of the exposure effects on the original scales of the outcomes could be misleading. Situation in which the parameters of a model are subject to some restrictions or constraints arise naturally in applied statistical research. In many practical settings, the fixed effects may be subject to constraints. So, in case of scaled linear mixed model(SLMM), we propose an estimation procedure which accounts for constraints on the fixed effect parameter. In this talk, we discuss ECME (Expectation-Conditional Maximization Either) Algorithm in the presence of constraints to find MLE. Simulation results show that the proposed methods improve in terms of MSE on the unconstrained estimators. Due to the presence of constraints, hypothesis testing is a bit challenging.

4.5. **3:10-3:35 Parallel Session 5.**

Carnegie 100: Mahyar Shafighi, The University of New Mexico

Title: Introduction to Homological Mirror Symmetry

Abstract: The Homological Mirror Symmetry and SYZ conjecture are two of the major approaches to the so-called mirror symmetry in the field of string theory. Recently, there have been significant advances toward solving the Homological Mirror Symmetry proposed by Maxim Kontsevich in 1996 during his talk at ICM in Zurich. Precisely speaking, it states that the derived category of coherent sheaves of a Calabi-Yau manifold is equivalent to the Fukaya category of its mirror symplectic manifold. In the language of string theory, a string may be open or closed. When an open string propagates through spacetime, based on the equations of the quantum field theory, which describes the physics of the strings, its endpoints should lie on a D-brane, meaning the Dirichlet boundary condition. Now interestingly enough, D-branes can be formalized as the objects of certain types of categories, namely as the submanifolds of Calabi-Yau manifolds, when we are dealing with the type A-string theory, and the Lagrangian submanifolds of Calabi-Yau manifolds, when we are dealing with the type B-string theory. The latter one is, from a category theoretical point of view, the Fukaya category of a symplectic manifold defined by Kenji Fukaya. We will examine some of the mathematical aspects of the HMS based on Kontsevich's talk.

Carnegie 115: Waleed Raja, Syracuse University

Title: Supporting Students Learning in Social Justice Mathematics Classrooms

Abstract: This research is part of an ongoing research project. Our research is focused on social justice mathematics classrooms. This talk will share findings from a literature review we conducted to identify factors that support student learning in social justice mathematics classrooms. In our review of empirical peer-reviewed journal articles on the implementation of social justice in mathematics classrooms, we found five factors that supported student learning: co-creating classrooms, problem-solving, group work, and investigative research, social justice mathematics curriculum, attending to students' emotions, and support from the school. In this talk, we will focus on the first four factors and share examples of how mathematics teachers can incorporate these factors in their teaching to better facilitate student learning. We believe these factors can support student learning in not just social justice mathematics classrooms but any mathematics classroom at any grade level. We intend to spread awareness amongst the mathematics community to better teach mathematical content to our students.

Carnegie 120: Trevor Lax, Rochester Institute of Technology

Title: Generating models of Jasmonic Acid Biosynthesis using Sparse Identification of Nonlinear Dynamics

Abstract: Jasmonic Acid Biosynthesis is an important mediator in a plant's response to abiotic stresses and pathogens, which is crucial for survival; however, the mechanisms of this response are still under investigation. While preliminary attempts have been made to model the phenomenon and first-principles driven models have been able to suggest some important mechanisms, they have been unable to fully capture the complex dynamics, which has led to an increased interest in data-driven approaches. In this work we are attempting to use data-driven methods to not only create a more accurate system of governing equations, but to suggest possibilities for the underlying mechanisms of Jasmonic Acid Biosynthesis, which can be verified via future lab experiments. Using Sparse Identification of Nonlinear Dynamics (SINDy) and clustering analysis on a set of experimental data we have been able to obtain potential systems of governing equations that closely fit the data. If data-driven methods are able to provide insights into Jasmonic Acid Biosynthesis, an area of sparse, highly noisy data, either through generated systems of equations or suggested future experiments, then this methodology can likely provide insights into many other application problems.

Carnegie 200: Jason Howell, SUNY Albany

Title: Generalized Pascal's Triangles

Abstract: We generalize Pascal's triangle by allowing the entries to be in groups other than the integers. The triangle is then constructed in the same manner as the standard Pascal's triangle, i.e. an entry is given by combining the two entries above it using the group operation. Here however, we add the rule that the identity element is always omitted from the triangle. Thus, it is possible for the row lengths to decrease from one row to the next. And so, it is possible for a row to be the same as a previous row which means the triangle will then repeat. This gives rise to the notion of the period of such a triangle. We show some examples and analyze their periods.

Carnegie 219: Narshini Gunputh, Rochester Institute of Technology

Title: Mathematical Modeling of Contact Lens Drug Delivery

Abstract: Ninety percent of ophthalmic medications are delivered via eye drops, however, eye drops are inefficient as less than five percent of the drug reaches the target tissue. Other ocular drug delivery methods, such as ocular injection, gene therapy, and insertion of a medical vial, are more effective at drug delivery to the eye, but are often invasive and associated with ocular inflammation. Over the last few years, new ocular drug delivery technologies aim at increasing the bioavailability of ophthalmic drugs, while minimizing the need for invasive procedures. One such novel drug delivery system is a contact lens. We use mathematical modeling to study drug-release mechanisms from contact lenses. In this work, we test the hypothesis that the dominant drug release mechanism is diffusion. To do so, we estimate the diffusion coefficient of different drugs from different contact lenses using three different experimental datasets. Our results show that drugs released from contact lenses immersed in a vial of a saline solution follow the law of diffusion for some, but not all of the lenses considered. In the future, we plan to extend the mathematical model to study the release of the drug via contact lenses into the eye.

4.6. **3:40-4:05 Parallel Session 6.**

Carnegie 100: Thang Vo, Ohio University

Title: Dual codes of cyclic codes of length $5p^s$ over $\mathbb{F}_{p^m} + u\mathbb{F}_{p^m}$

Abstract: The class of constacyclic codes plays a significant role in the theory of error-correcting codes as they are a direct generalization of the important family of cyclic codes, which are the most studied of all codes. Many well-known codes, such as BCH, Kerdock, Golay, Reed-Muller, Preparata, Justesen, and binary Hamming codes, are either cyclic codes or constructed from cyclic codes.
We investigated all cyclic codes of length $5p^s$ over $\mathcal{R} = \mathbb{F}_{p^m} + u\mathbb{F}_{p^m}$ for an odd prime $p \neq 5$. The algebraic structures of all cyclic codes of length $5p^s$ over $\mathcal{R}$ determined in all cases $p \equiv 1 \pmod 5$, $p^m \equiv 4 \pmod 5$, $p \equiv 2 \pmod 5$ or $p \equiv 3 \pmod 5$.
In this talk, we provide the structures of all dual of all cyclic codes of length $5p^s$ over $\mathcal{R}$. All the results of the work hold true for negacyclic codes via that isomorphism.

Carnegie 115: Ruodan Liu, University at Buffalo

Title: Fixation probability in evolutionary dynamics on hypergraphs

Abstract: Hypergraphs have been a powerful tool for analyzing population dynamics because hypergraphs are a natural extension of conventional networks to the case of many empirical data of social and ecological interactions. We study constant-selection evolutionary dynamics (equivalent to the biased voter model) on hypergraphs by extending the birth-death process on conventional networks. The birth-death process is a standard model in evolutionary graph theory. We assume that there are two types of individuals, referred to as A and B, and that A and B have fitness r and 1, respectively. We refer to A as the mutant type and B as the resident type. In each time step, we select one node for reproduction with the probability proportional to its fitness. We call this node the parent. Then, the parent node selects one of the hyperedges to which it belongs, denoted by e, with the equal probability. In model 1, the parent converts the type (i.e., A or B) of all other nodes belonging to e into the parent's type. In model 2, the parent node converts all the other nodes belonging to e into the parent's type if and only if the parent's type is the majority in e. We repeat this process until fixation of either type, i.e., until all nodes have the same type. For each model, we semi-analytically derived the fixation probability for the mutant type for three synthetic hypergraphs with high symmetry, which generalize the complete graph, cycle graph, and star graph. We have found that model 1 is appropriate for discussing the strength of natural selection, and we have shown that these synthetic hypergraphs are suppressors of natural

selection (i.e., hypergraph that suppresses the effect of r larger/smaller than 1 on the fixation probability relative to the Moran process, which is a standard baseline and corresponds to the complete graph) with few exceptions. We then numerically examined model 1 on four empirical hypergraphs. We have found that all the four hypergraphs are suppressors. We also simulate the birth-death process on the weighted one-mode projection of each empirical hypergraph, finding that the fixation probability for the obtained weighted network is close to that for the Moran process, which indicates that our result that the four empirical hypergraphs are suppressors is not expected from the one-mode projection of the hypergraph. To further examine the result that the empirical hypergraphs are suppressors, we also simulate the same evolutionary dynamics on randomized hypergraphs (i.e., an equivalent of the configuration model for hypergraphs), finding that the randomized hypergraphs are also suppressors for all the four hypergraphs. Our results are surprising because various research since 2005 has revealed that most conventional networks are amplifiers of natural selection, which are opposite of the suppressors, under the birth-death process. Our results indicate that amplifiers may not be as common as they have been considered once we incorporate some realistic features of networks such as higher-order interactions. Inspired by these results, we are currently studying the constant-selection evolutionary dynamics on multilayer networks.

Carnegie 120: Fatemah Fogh, Florida Atlantic University

Title: Special Extend of The Classes of Contractive Non-Self Mapping Theorems

Abstract: In this paper, we present two main theorems. The first is extended proximal contraction. We begin by defining S-proximal contraction and considering the conditions in which the best proximity point for S-proximal contraction on complete metric space exists and is unique. Then, we give some relevant examples.

Carnegie 200: Kaitian Jin, University of Pennsylvania

Title: Analytical Combinatorics in Several Variables

Abstract: How does one count things? For example, how many ways are there for one to go from $(0, 0)$ to (n, n) by only going right or up one unit at a time and not crossing the main diagonal? The answer is the Catalan number C_n, which is encoded by the Catalan generating function $(1-\sqrt{1-4z})/(2z)$. In general, a generating function encodes an infinite sequence of numbers (a_n) as coefficients of z^n of a formal power series. Methods for extracting coefficients from univariate generating functions are well developed. A natural extension of the theory is from the univariate version to the multivariate version. Analytic Combinatorics in Several Variables (ACSV) is still developing its theory and a substantial amount has been known for multivariate rational generating functions. This talk will be expository and only assumes basic knowledge on complex analysis and differential geometry. I will give a concrete example in ACSV to guide through all important components in the theory, including Morse theory and Fourier-Laplace integrals. If time permitted, I will also talk about a recent development on multivariate algebraic generating functions based on works collaborated with Yuliy Baryshnikov and Robin Pemantle.

Carnegie 219: Nathaniel Smith, Miami University

Title: Spectral Information in the Dirichlet-to-Kirchoff Map

Abstract: Eigenvalue problems on quantum graphs arise often when modeling phenomena with a network structure (population dynamics in a branching stream, electricity in city power grids, etc). Different solutions arise when different boundary conditions are specified. One can construct maps which convert between different types of boundary data of some solution. This map may contain poles at certain parameter values. By utilizing the resolvent of our differential operator we can determine exactly how such singularities end up in the map, and what they tell us about the eigenvalue problems we are mapping between.

4.7. **4:30-4:55 Parallel Session 7.**

Carnegie 100: Melanie Ferreri, Dartmouth College

Title: A proof of a nonderangement identity

Abstract: A derangement is a permutation with no fixed point, and a nonderangement is a permutation with at least one fixed point. There is a one-term recurrence for derangements, and we describe a bijective proof of this recurrence which can be found recursively. Nonderangements satisfy a similar recurrence. We can convert the bijective proof of the one-term identity for derangements into a bijective proof of the one-term identity for nonderangements using two alternative routes that result in the same bijection.

Carnegie 115: Ian Gossett, Wesleyan University

Title: Orientations and Additive Colorings of Graphs

Abstract: An additive coloring of a graph is a labeling of it's vertices with positive integers so that the sum of the neighbors of any two adjacent vertices differs. Given an orientation D of a graph G, we introduce a new digraph W(D) that allows us to prove an additive coloring analog of the well-known Alon-Tarsi list coloring theorem. As a consequence of this theorem, we extend a list additive coloring result that was previously known only for bipartite graphs to a special class of tripartite graphs.

Carnegie 120: Charles Kulick, University of California, Santa Barbara

Title: Scalable Multi-Species Agent-Based Modeling with Sparse GP

Abstract: We approach the data-driven learning problem for a general second order ODE agent-based system with multiple species. By modeling with interaction kernels, we can use a Gaussian Process approach to learn a nonparametric model for the dynamical system with built-in uncertainty quantification. In this talk, we develop the modeling system, present theoretical analysis on the learning methodology, and present empirical investigations into scalability and practicality using a biological predator-prey model.

Carnegie 200: Preston Kelley, Oklahoma State University

Title: The Height Gap in Abelian Extensions of the Rationals

Abstract: The (absolute logarithmic) Weil height is a measurement of arithmetic complexity for algebraic numbers, which has a codomain in the nonnegative real numbers. The Weil height, and more general height functions, have played essential roles in proving finiteness and equidistribution theorems in number theory and dynamics. A key property of the Weil height is the Northcott property, which states that the set of algebraic numbers with bounded height and bounded degree is finite. This property is one of main motivations to study algebraic numbers which have relatively small height. Another property of Weil height is Kronecker's theorem, which states that the points with height 0 are precisely the roots of unity. In this talk, we review a result of Amoroso and Dvornicich, which gives a lower bound for the heights of algebraic numbers that are not roots of unity in abelian extensions of the rational numbers.

Carnegie 219: Sahil Chindal, Virginia Commonwealth University

Title: Predicting Dengue Incidence In Central Argentina Using Google Trends Data

Abstract: Dengue is a mosquito-borne disease prominent in tropical and subtropical regions of the world but has recently been emerging in temperate areas. In Cordoba, a city in temperate central Argentina, there have been several dengue outbreaks in the last decade. Prior to 2009, dengue cases had not been reported in Cordoba. However, major outbreaks occurred in 2009, 2013, 2015, 2016, and 2020. Internet data, such as social media and search engine data, have proven to be useful for predicting the spread of infectious diseases. With the rapid growth of and increased accessibility to the internet, its relevance for epidemiological research has increased in recent years. We have developed a predictive model of dengue incidence in Cordoba using Google Trends data. Specifically, using relevant search terms as predictors and dengue case data as the response, our training model determines which search terms are significant for predicting dengue cases. We employ several methods to test the significance of search terms. We discuss the development of a model utilizing these search terms and how this model will be useful to provide warning of outbreaks to local public health and mosquito control agencies.

4.8. **5:00-5:25 Parallel Session 8.**

Carnegie 100: Ray Maresca, Brandeis University

Title: A 4-fold Categorical Equivalence

Abstract: In this talk, we will construct an isomorphism between the category of smooth projective curves with a category of quiver grassmannians. We will use this to provide a 4-fold categorical equivalence between a category of quiver grassmannians, smooth projective curves, compact Riemann surfaces and fields of transcendence degree 1 over C. We finish with noting that the category of elliptic curves is isomorphic to a category of quiver grassmannians.

Carnegie 115: NO TALK

Carnegie 120: NO TALK

Carnegie 200: Yixin (Kathy) Lin, Dartmouth College

Title: Penney's game for permutations

Abstract: We consider the permutation analogue of Penney's game for words. Two players, in order, each choose a permutation of length k¿=3; then a sequence of independent random values from a continuous distribution is generated, until the relative order of the last k numbers coincides with one of the chosen permutations, making that player the winner. We compute the winning probabilities for all pairs of permutations of length 3, showing that, as in the original version for words, the game is non-transitive. We give some formulas to compute the winning probabilities more generally, and we conjecture a winning strategy for the second player when k is arbitrary.

Carnegie 219: Samuel Paul Gyamfi, Ohio University

Title: Herding Behavior on the cryptocurrency Market

Abstract: This study tests evidence of herding behaviour in the cryptocurrency market. Using the Cross-Sectional Absolute Deviation (CSAD) technique, fourteen digital currencies sourced from the Bloomberg Database from January 2016 to December 2018 were used testing evidence of herding in the cryptocurrency market. The results show that investors mimic the investment decisions of others and follow the consensus during periods of market stress in the cryptocurrency market.