50th Annual New York State Regional Graduate Mathematics Conference

Syracuse University

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Contents

1. **Funding** 2
2. **Keynote Speakers** 3
3. **Friday Syracuse Alumni Special Session Talks** 6
3.1. 3:45-4:20 Carnegie 122 Tim Tribone 6
3.2. 4:25-5:00 Carnegie 122 Nathan Uricchio 6
3.3. 5:05-5:40 Carnegie 122 Nigar Altindis 6
3.4. 5:45-6:20 Carnegie 122 Erin Griffin 7
3.5. 6:25-7:00 Carnegie 122 Rachel Diethorn 7
4. **Saturday Talk Abstracts** 8
4.1. 9:40-10:10 Parallel Session 1 8
4.2. 10:15-10:45 Parallel Session 2 11
4.3. 11:00-11:30 Parallel Session 3 13
4.4. 11:35-12:05 Parallel Session 4 16
4.5. 2:40-3:10 Parallel Session 5 19
4.6. 3:10-3:45 Parallel Session 6 22
4.7. 4:00-4:30 Parallel Session 7 25
4.8. 4:35-5:05 Parallel Session 8 28

1. 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.

2. Keynote Speakers

Dr. Ruth Charney, Brandeis University

Ruth Charney received her PhD from Princeton University in 1977. She subsequently held positions at Yale University, and at Ohio State University. She is currently a professor at Brandeis University. Her research interest is in geometric group theory, the study of how topological metric spaces act on groups; topics of study include CAT(0) spaces, cube complexes, Artin groups, and Coxeter groups.

Title: Algebra Meets Geometry: From Braid Groups to Artin Groups

Abstract: In this talk I will discuss geometric approaches to a fascinating and challenging class of groups known as Artin groups. The most well-known Artin groups are the braid groups. Beginning with braid groups, I will discuss various algebraic and geometric characterizations of Artin groups. I will then survey what is known and not known about these groups and highlight a few of the new approaches that have been introduced to address some of the more challenging open questions.

Dr. Guohui Song, Old Dominion University

Guohui Song received his PhD from Syracuse University in 2009, advised by Yuesheng Xu. He subsequently held a position at Clarkson University. He is currently an associate professor at Old Dominion University. His research interests are in optimization and machine learning.

Title: Function Approximation from Non-uniform Fourier Data

Abstract: In many applications, including magnetic resonance imaging (MRI) and synthetic aperture radar (SAR), data are acquired in the Fourier domain. However, due to engineering constraints, the sampling may be non-uniform, introducing challenges in both analysis and computation. While uniform Fourier data processing is well understood, the non-uniform case requires specialized techniques. In this talk, we will explore these challenges and discuss approaches to address them using tools from frame theory, optimization, and statistics.

3. Friday Syracuse Alumni Special Session Talks

3.1. **3:45-4:20 Carnegie 122 Tim Tribone.**

Title: Factoring polynomials with matrices

Abstract: The fundamental theorem of algebra tells us that any single variable polynomial of degree $d \geq 1$ with complex coefficients can be factored completely into a product of d linear factors. In the world of multivariable polynomials, there is no such factorization theorem. Polynomials in more than one variable can simply be irreducible, regardless of the coefficient field. The good news is there's still a way to factor, as long as you are flexible with what exactly that means. If you allow for factorizations by matrices, then any (homogeneous) polynomial of degree $d \geq 1$, in any number of variables, can be factored into a product of d linear matrices (i.e., matrices with linear entries). We will build such a factorization from scratch using only matrix multiplication and some basic properties of roots of unity.

3.2. **4:25-5:00 Carnegie 122 Nathan Uricchio.**

Title: Matroidal Completions of Clutters

Abstract: his expository talk will explore some processes in which clutters (inclusion-minimal families of subsets) can be transformed into the set of circuits of a matroid.

3.3. **5:05-5:40 Carnegie 122 Nigar Altindis.**

Title: Exploring the role of disciplinary knowledge in students' covariational reasoning during graphical interpretation

Abstract: Understanding scientific graphs is essential for success in STEM disciplines, yet students often struggle with interpreting quantities and quantitative relationships in graphical representations. In this talk, I will talk about a study that examines how undergraduate STEM students interpret graphs in biology (population growth) and chemistry (titration) contexts, with a focus on covariational reasoning and the role of disciplinary knowledge in forming mental images. Through interviews with 15 students, we analyze how disciplinary knowledge enhances or constrains their ability to reason about changing quantities. Our findings suggest that students who integrate disciplinary knowledge into their mental imagery develop richer, more sophisticated interpretations of graphs, whereas those with weaker conceptual grounding struggle with covariational reasoning. In this talk, I present detailed case studies of four students with contrasting approaches, illustrating how mental imagery supports or limits graphical sense-making. These findings highlight the importance of fostering deep disciplinary understanding in STEM education to improve students' graph interpretation skills.

Implications for instructional strategies that support students' covariational reasoning through disciplinary knowledge integration will be discussed.

3.4. **5:45-6:20 Carnegie 122 Erin Griffin.**

Title: The Study of Ambient Obstruction Solitons

Abstract: Ambient obstruction solitons are fixed points of the ambient obstruction flow, a higher order geometric flow. In a recent paper, we define and investigate a generalization of solitons that we call extended ambient obstruction solitons. This talk will tell the story of the study of ambient obstruction solitons from homogeneous gradient Bach solitons to extended ambient obstruction solitons.

3.5. **6:25-7:00 Carnegie 122 Rachel Diethorn.**

Title: Powers of edge ideals with linear quotients

Abstract: The linear quotients property is known to reveal a wealth of information about the free resolutions of edge ideals and their powers. Indeed it follows from a well-known result of Herzog, Hibi, and Zheng that the edge ideals that admit linear quotients are precisely the ones whose powers have linear resolutions. In this talk we explore resolutions of edge ideals and their powers via the linear quotients property and present results from joint work with undergraduate students Basser, Miranda, and Stinson-Maas. In particular, we construct an explicit linear quotient ordering for any power of an edge ideal that admits linear quotients, and as an application, describe the minimal free resolution of any power of the edge ideal of a whisker graph. We also prove a surprising property of the edge ideal of the anti-cycle graph and its powers. This talk is intended to be accessible to graduate students who have taken a course in ring theory.

4. Saturday Talk Abstracts

4.1. 9:40-10:10 Parallel Session 1.

Carnegie 100: Maryam Haneef

Title: Numerical study on heat and mass transfer in Maxwell fluid with tri and hybrid nanoparticles.

Abstract: "This article is a study of heat and mass transport in Maxwell fluid mixed with tri, hybrid and mono nanoparticles. Using conservation laws and correlations among thermophysical characteristics of the base fluid, tri, hybrid and mono nanoparticles, the flow situation is converted into mathematical problems. Boundary layer (BL) approximations are used to approximate these mathematical models. The finite element approach is used to solve the non-dimensional problems numerically. The behavior of viscoelastic materials on momentum and temperature is investigated. Al2O3, TiO2 and SiO2 are simultaneous dispersed and case of tri (Al2O3, TiO2 and SiO2), hybrid (Al2O3 and TiO2) and mono (Al2O3) are considered. It is possibly achieved the convergent and mesh-free solutions. Present results are validated. Momentum relaxation time determines the characteristics of fluid to restore momentum changes. Therefore, fluids with more viscoelastic property (with high Deborah number) have smaller viscous region relative to the fluid with smaller Deborah. There is a remarkable decrease in momentum transport versus an increase in Deborah number is noted. It is noted that Deborah number for tri-nanofluid has the smaller effects on flow relative to its impact on the flow of hybrid and mono nanofluids. "

Carnegie 114: Qiyao Yu

Title: On counting totally imaginary number fields (in collaboration with A. Raghuram)

Abstract: A number field is said to be a CM-number field if it is a totally imaginary quadratic extension of a totally real number field. We define a totally imaginary number field to be of CM-type if it contains a CM-subfield, and of TR-type if it does not contain a CM-subfield. For quartic totally imaginary number fields when ordered by discriminant, we show that about 69.95% are of TR-type and about 33.05% are of CM-type. For a sextic totally imaginary number field we classify its type in terms of its Galois group and possibly some additional information about the location of complex conjugation in the Galois group.

Carnegie 115: Anthony Graves-McCleary

Title: Heat Kernels of Schrödinger Operators on Manifolds

Abstract: The heat kernel is the fundamental solution to the heat equation. We discuss joint work with Laurent Saloff-Coste on a generalized version of the heat equation in which the Laplacian term is replaced by a Schrödinger operator term. Our main topic is the resulting heat kernel, on the setting of a Riemannian manifold. We give conditions on the manifold and on the Schrödinger operator that yield matching upper and lower bounds for the heat kernel.

Carnegie 119: Ali Çataltepe

Title: Categorifications of formal language complexity

Abstract: "In the paper "Topological Theories and Automata" (2022), Im and Khovanov present a categorification of the syntactic monoid–an algebraic structure associated to a given formal language over a finite alphabet–via a semiring-valued analogue of the universal construction of topological theories. The evaluation for this universal construction takes values in the Boolean semiring and evaluates diffeomorphism classes of 1-dimensional cobordisms with 0-dimensional defects labelled with letters for belonging to a formal language, with orientation determining the order the resultant word (or cyclic equivalence class of words) is read in. The authors additionally introduce analogues of regular language complexity that operate on the state spaces in this topological theory and prove the existence of a unique evaluation, given a regular language, that makes the resulting topological theory a TQFT.
This talk will provide a brief exposition of the machinery involved in the results of the paper: 1-dimensional topological theories, Boolean semimodules, and regular (circular) languages. Additional focus will be on the particular constructions used to define a notion of "mutual information" between the theories associated with two different regular languages. The possibility of and obstructions towards generalizing these constructions to non-regular languages will also be discussed."

Carnegie 200: Elana Israel

Title: Maximal Simple Regular Matroids

Abstract: Matroids are mathematical objects that broaden the concept of independence in both graph theory and linear algebra. In this talk, we will explore matroids from each of these fields, and discuss how new matroids are constructed from these fundamental examples through k-sums. We will talk about properties of these constructions as well as conditions for these new matroids to be regular, simple, and maximal.

Carnegie 219: Trang Quach

Title: Category and Measure

Abstract: In Real Analysis, we have encountered different notions of a ”small” versus a ”big” set. Cardinality-wise, a set is small when it is countable and big while it is uncountable. Measure-wise, a set with measure zero is considered small while a set with positive measure is considered big. In terms of category, a set is small if it’s in the ”first category” and big when it’s in the ”second category”. In this talk, we explore Baire’s theorem concerning category and discuss the set of Liouville numbers which gives an example of a set that is big in some sense but small in others.

4.2. **10:15-10:45 Parallel Session 2.**

Carnegie 100: Aaron Agulnick

Title: Higher-Order Autocorrelations

Abstract: From a signal on a locally compact abelian group, one can extract a family of statistics called (higher-order) autocorrelations. For applications such as the phase problem of X-ray crystallography, it would be useful to understand when finitely many orders of autocorrelation data suffice to reconstruct a function, and even more useful to be able to perform this reconstruction algorithmically. In this talk, I will describe some classical challenges, some new positive results, some emerging constructive techniques, and a surprising number-theoretic approach.

Carnegie 114: Joseph Beckmann

Title: Bounding Intersections Using Intersection Theory

Abstract: Fulton and MacPhearson's intersection theory was an achievement in setting the field on sound foundations. One key component is the idea of "proper" intersections, where two schemes meet with the correct dimension relative to their ambient space. In this talk, I will outline how to get around this issue, and how to set bounds on the number of times that two curves can intersect in ^{r} for $r \geq 3$.

Carnegie 115: Anthony Christiana

Title: Third Homology of the Yang Baxter Operator

Abstract: In an effort to compute the third homology of the Yang Baxter operator leading to the Jones polynomial, we find a more general result: a direct sum decomposition of the n-th Yang Baxter homology group depending on the (significantly simpler) computation of a finite set of initial conditions. In this talk, we recall the homology theory for Yang Baxter operators based on a theory for precubic modules; then, we describe the technique used to produce the direct sum decomposition and conclude with explicit computations for the third and fourth homology groups.

Carnegie 119: Sophia Marx

Title: 2-Segal Simplicial Sets and Pseudomonoids in Span

Abstract: This (mostly expository) talk is designed as an accessible introduction to the correspondence between 2-Segal simplicial sets, which can be thought of as encoding a kind of weak categorical associativity, and pseudomonoids in the bicategory Span. If time permits, I will also allude to several natural extensions of this correspondence, adding further structure to our simplicial sets and discovering the kinds of algebraic structures they produce. These structures may in many cases then be "decategorified", yielding familiar associative algebras such as the group ring C(G). While this topic may appear somewhat linguistically heavy, a convenient graphical calculus will be provided, and no knowledge of infinity-categories is required to understand this talk! Content is based on current work-in-progress (joint with R. Mehta), as well as previous results by Ivan Contreras, Rajan Mehta, and Walker Stern.

Carnegie 200: Ryan Gelnett

Title: Configuration Spaces of Circles in the Plane

Abstract: We consider the space of all configurations of finitely many (potentially nested) circles in the plane and compute the fundamental group of each of its connected components. These groups can be viewed as "braided" versions of the automorphism groups of finite rooted trees. This is joint work with Justin Curry and Matthew Zaremsky.

Carnegie 219: Malak Lafi

Title: Measure comparison problems for dilations of convex bodies

Abstract: " In this talk, we will explore a variant of the Busemann-Petty problem for log-concave measures, incorporating additional information about dilates. Our primary tool for addressing this question is a new analog of the classical large deviation principle for log-concave measures, which depends on the norm of a convex body, which we hope will be of independent interest."

4.3. **11:00-11:30 Parallel Session 3.**

Carnegie 100: Dmitrii Gudin

Title: Modeling Spatial Technology Diffusion with Reaction-Diffusion Equations

Abstract: The market of renewable technologies is known to be directly tied to geographical factors such as proximity to the grid lines, climate conditions, or local governmental regulations. However, the most commonly used models of technology adoption estimate only the total adoption over time, and the research on equipping them with the spatial component has been scarce. We draw inspiration from the population dynamics models of mathematical biology, and combine the reaction-diffusion equations with the innovator-imitator framework of the Bass model. The resulting flexible model allows for inclusion of all relevant geographical variables, while remaining both analytically and numerically tractable. We apply the model to the market of Large-Scale Photovoltaic plants, producing a powerful forecasting tool that can inform both governmental policies, and company decision-making.

Carnegie 114: Brody Lynch

Title: Equidistribution of Realizable Steinitz Classes in Kummer Extensions

Abstract: Let L/K be an extension of number fields. Artin showed that the ring of integers O_L has an integral O_K-basis if and only if the Steinitz class of L/K is principal. We study how frequently this occurs. More specifically, let p be prime and K be a number field containing the p-th roots of unity. We use techniques from classical algebraic number theory to prove that the Steinitz classes of Z/pZ extensions of K are equidistributed among realizable classes in the ideal class group of K. For p=2, this was proved by Kable and Wright using the deep theory of prehomogeneous vector spaces. Foster proved this result for any p for tamely ramified extensions using the theory of Galois modules; but our approach eliminates this tameness hypothesis. We also discuss the extension of our methods to elementary p-extensions of K and give preliminary results suggesting failure of equidistribution in this general case.

Carnegie 115: Nathaneael Grand

Title: Sequences of Minimal Surfaces and Compactness

Abstract: "I will discuss the paper ""The space of minimal embeddings of a surface into a three-dimensional manifold of positive Ricci curvature"" By Hyeong In Choi and Richard Schoen. They discovered that for an ambient space of three dimensions with positive Ricci curvature, there is compactness in C^k for the space of embedded minimal surfaces. An outline of the proof will be presented, with some connections to subsequent research."

Carnegie 119: Ume Hania

Title: Finiteness Conditions on Large Subsemigroup and Small Extension

Abstract: "The algebraic theory of semigroups is relatively new in modern pure mathematics and was introduced by De-Seguier, in 1904. A semigroup is defined as an algebra having associative binary operation. A subsemigroup is the subset of a semigroup that holds closure law, w.r.t binary operation. In a same manner, we define a large subsemigroup T of a semigroup S, if S T is finite, and S will be known as Small Extension of T. In particular, T is said to have a finite Rees Index in S. The concept of Rees index was introduced by Andrzej Jura to study the relation of semigroup and large subsemigroup with help of ideals and finite presentation. In group theory, the Todd-Coxeter algorithm is a systematic procedure for enumerating the cosets of a subgroup H of finite index in a group G, given a set defining relation for G and words generating H. While, B.H.Neumann modified Todd-Coxeter's algorithm to enumerate cosets in a semigroup. In the last decade of 20th century, N.RUSKUC worked on the different finiteness conditions to find a relation between large subsemigroups and their small extensions. The study of algebras via their finiteness conditions has been of significant importance in understanding the structure and behaviour of various kinds of algebraic structures. The aim of this project is to review the work of N.RUSKUC, and to compile all the results in updated form. I have studied most of the finite conditions on large subsemigroup that have the most impact on semigroups, and vice versa. In semigroups, ideals play an important role to generate the equivalence relations and to deal with finiteness conditions. The main result related to ideals is about, whether the Green's relation J and D will coincide in large subsemigroup if and only if this relation holds in small extension or not. Apart from ideals the presentation of semigroups have the cruical impact in the field of computer science. We prefer to have a presentation that describe a semigroup with some defining relations. The main result is based on finite presentation finding out a presentation for semigroup is easy to handle, while the procedure for finding out the presentation of a subgroup was described by Reidemeister and Schreier that was further generalized to subsemigroups, and is explicitly described in this project. Due to the presentations of semigroups, one can transfer the humans language in digital/computing form and vice versa. Some of the open problems, i.e. Hopficity, finite complete rewriting system, finite derivation type, and the other finiteness conditions that are important to relate large and small extensions are also mentioned in this project and have figure out the table of updated results, where + sign defines the preserveness of conditions and - sign define the contradiction. In the table of results, the ? sign denotes the symbol of open problems that are still under consideration, i.e. finite derivation type and cohomological conditions. The study of finiteness conditions helps to analyze the properties of semigroups with respect to finite Rees index, and vice versa."

Carnegie 200: Johnny Rivera, Jr.

Title: Counting Pattern Avoiding Permutations by Big Descents

Abstract: One can define various statistics on permutations and study the distribution of these statistics over the symmetric group. Moreover, one may seek to describe the distribution of a permutation statistic over a set of restricted permutations which avoid predetermined patterns. In this talk, I will provide an introduction both to permutation patterns and permutations statistics. Further, I will highlight new enumerative results regarding the big descent statistic on pattern avoiding permutations.

Carnegie 219: Sabrina Traver

Title: Global invertibility of Sobolev mappings with prescribed homeomorphic boundary values

Abstract: The classical inverse function theorem guarantees local invertibility for continuously differentiable maps with a positive Jacobian determinant. In Nonlinear Elasticity, variational problems often lead to the question of whether a Sobolev mapping is invertible in an appropriate sense. This talk addresses this question and presents an analogue of the inverse function theorem for Sobolev mappings with an almost everywhere positive Jacobian that coincide with a homeomorphism (in the Sobolev sense) on the boundary. A key notion in our result is monotonicity for vector-valued functions, which we will introduce and discuss.

4.4. **11:35-12:05 Parallel Session 4.**

Carnegie 100: Patrick Addona

Title: Laser Speckle Contrast Synthetic Wavelength Holography

Abstract: Imaging blood vessels is crucial for healthcare practitioners. Optical imaging techniques like interferometry and holography offer non-invasive and non-ionizing approaches, but are limited in depth by light scattering in tissue. To mitigate this, we propose using synthetic wavelength holography, which operates at two closely spaced wavelengths whose photons exhibit similar scattering profiles and thus similar speckle patterns. By combining these images, we generate a hologram at a longer synthetic wavelength that is more robust to scattering, albeit at the expense of spatial resolution. Furthermore, laser speckle contrast imaging identifies regions of increased flow by exploiting the fact that speckle patterns in these areas decorrelate more quickly. As such, the blood vessels exhibit greater contrast than the surrounding tissue, enabling improved vessel visualization in scattering media.

Carnegie 114: Bhargavi Parthasarathy

Title: Homomorphisms of maximal Cohen-Macaulay modules over the cone of an elliptic curve

Abstract: Consider the ring $R = k[[x, y, z]]/(f)$ where $f = x^3 + y^3 + z^3$ with an algebraically closed field k and $\text{char}(k) \neq 3$. In a 2002 paper, Laza, Popescu and Pfister used Atiyah's classification of vector bundles over elliptic curves to obtain a description of the maximal Cohen-Macaulay modules (MCM) over R. In particular, the matrix factorizations corresponding to rank one MCMs can be described using points in V(f). If M, N are rank one MCMs over R, then so is Hom(M,N). In this talk, I will discuss how the elliptic group law on f can be used to obtain the point in V(f) that describes the matrix factorization corresponding to Hom(M,N).

Carnegie 115: Hezekiah Seun Adewinbi

Title: On the rate of approximation of finite topological annuli by rational lemniscates

Abstract: For any finite collection of pairwise disjoint topological annuli K in the complex plane. We study the rate of approximation of K by rational lemniscates in terms of level lines of a conformal mapping.

Carnegie 119: Manh Thang Vo

Title: Multi-constacyclic Codes Over a Finite Chain Ring

Abstract: " Given a nonzero element λ of the finite field F, λ-constacyclic codes of length n are classified as ideals as the ideals $\langle f(x)\rangle$ of the quotient ring $\frac{F[x]}{\langle x^n-\lambda\rangle}$, where $f(x)$ is a divisor of $x^n-\lambda$. Historically, research on error-correcting codes focused primarily on the case where the code length n is relatively prime to the characteristic of the field F. This condition ensures that $x^n-\lambda$, and hence the generator polynomial of any λ-constacyclic code, will have no multiple factors, and hence no repeated roots in an extension field.
In this talk, we study situations when linear codes are both α- and β-constacyclic codes over a finite chain ring R, for different units α, β, which we call multi-constacyclic codes. As an application, it will be shown that if λ is a unit of the chain ring R with maximal ideal $\langle\gamma\rangle \neq \langle 0\rangle$, such that $\lambda-\lambda^{-1}$ is a unit, then there is a self-dual λ-constacyclic code C of length n over R if and only if the nilpotency index N_γ is even. In such case, $\left\langle\gamma^{N_\gamma/2}\right\rangle^n$ is the unique self-dual λ-constacyclic code of length n over R."

Carnegie 200: Michaela Polley

Title: Patterns in Rectangulations: Top-avoiding rectangulations, Catalan structures, inversion sequences, and Dyck paths

Abstract: In this talk we give a formal definition of pattern avoidance in rectangulations and analyze rectangulations that avoid $\top$-like patterns. For every $L \subseteq \{\top, \bot, \vdash, \dashv\}$ we enumerate L-avoiding rectangulations, both weak and strong. In particular, we show $\top$-avoiding weak rectangulations are enumerated by Catalan numbers and $\top$-avoiding strong rectangulations are in bijection with several classes of inversion sequences, among them those that avoid $\{010, 101, 120, 201\}$ and those that avoid $\{011, 201\}$ — which leads to a solution of the conjecture that these classes are Wilf-equivalent.

Carnegie 219: Jonathan Lindbloom

Title: Preconditioning techniques for large-scale sparsity-promoting inverse problems

Abstract: Hybrid projection methods have proven to be a powerful technique for the solution of large-scale linear inverse problems with $\ell 2$ regularization, enabling efficient regularization parameter selection via a reduced basis while also mitigating the number of matrix-vector products with the forward model. However, a major obstacle arises when applying these methods to solving sparsity-promoting inverse problems: the prescribed reduced basis must be very large to appropriately represent the sparsity in the solution, which greatly hinders the computational efficacy of the hybrid projection method. To remedy this, here we introduce a new preconditioning technique that seeks a reduced basis in a transformed space which drastically reduces the number of basis vectors required to appropriately capture the sparsity. We illustrate the efficacy of our technique using several numerical tests and compare our approach to alternatives such as recycling methods based on iterative basis expansion and flexible methods.

4.5. **2:40-3:10 Parallel Session 5.**

Carnegie 100: Nasir Yasin

Title: Analysis of Flow Patterns Around Bluff Bodies Using the SRT-Lattice Boltzmann Method and Physics-Informed Graph Neural Networks

Abstract: The investigation of fluid flow around stationary and moving bluff bodies is of significant importance in engineering applications. However, the intricate wake interactions and aerodynamic characteristics associated with staggered configurations remain inadequately characterized and require further analysis. The study investigates flow dynamics around stationary and moving bluff bodies using the single relaxation time lattice Boltzmann method (SRT-LBM), focusing on Reynolds numbers and gap spacing ratios. Results indicate distinct flow regimes, where larger gaps exhibit regular vortex shedding, whereas smaller gaps induce complex interactions. Introducing a rod upstream mitigates chaotic behavior, offering a control strategy for flow stabilization. Additionally, a Physics-Informed Graph Neural Network (PI-GNN) is explored as a surrogate model, integrating physical constraints to enhance predictive accuracy, stability, and scalability. Comparative analysis with traditional models evaluates computational efficiency across training and inference phases, highlighting PI-GNN's potential for large-scale fluid dynamics simulations. Furthermore, we assessed the computational cost associated with deploying PI-GNN models in practical applications, considering both training and inference phases.

Carnegie 114: Almachius Rwejuna

Title: On Divided and Locally Divided Rings

Abstract: "This study investigates the divided and locally divided rings. It investigates the results in divided and locally divided rings and collects them into a coherent study. In particular, motivated by the recent study of amenable and locally amenable algebraic frames by Dube in 2019, this investigation tries to extend some of the results of divided and locally divided rings to amenable and locally amenable algebraic frames. The study generalizes some characterizations on the divided property of rings to the amenability behavior of algebraic frames. It then sets the comparability conditions for a ring to acquire the almost-amenable-like behavior of algebraic frames and for the amenable algebraic frames to acquire the divided-like property of rings. This study finally observes that there is a coherent symbiosis between the divided property of rings and the amenable property of algebraic frames.
Furthermore, in this work, we investigate several standard results and notions of straight rings. Then we establish the transfer of these results to

straight domains and characterize that all straight domains are possibly locally divided.
Lastly, this study establishes a new class of domains for which the CPI-closedness would be detectable locally. This new class of CPI-closed domains with the local detectability requires that the CPI-extensions be both R-flat and straight domains. The study also characterizes that not all the Prufer domains are friendly to be incorporated into any new class of domains for which the CPI-closedness would be detectable locally despite the fact that the Prufer domains can be characterized as the integrally closed coherent locally divided domains (in the sense of Dobbs and Shapiro, 2006). This is because it has been known that there exists a Prufer domain which is not locally divided."

Carnegie 115: Jordan Barrett

Title: a Zariski-Nagata Theorem for Smooth, Complete Toric Surfaces

Abstract: The Zariski-Nagata theorem is a classical result which gives an expression for the nth symbolic power of a radical ideal I in a polynomial ring over a perfect field in terms of the nth regular powers of the maximal ideals in mSpec(I). In this talk I will discuss the generalization of a well-known projective analog of Zariski-Nagata to smooth, complete toric surfaces.

Carnegie 119: Clement Ampong

Title: Forecasting Influenza Dynamics in The USA

Abstract: "This study explored advanced forecasting techniques for influenza outbreaks across the United States using the n-sub epidemic model and the STAT MOD PREDICT toolbox. Weekly influenza case data from May to October 2024, collected through CDC surveillance and wastewater monitoring, were modeled to assess outbreak dynamics. Predictive models, including ARIMA, GLM, GAM, Prophet, and ensemble approaches, were employed to generate region-specific forecasts.
The analysis identified ARIMA as the most effective model for forecasting influenza dynamics across all regions, achieving the lowest error metrics (MAE and MSE) and reliable 95% prediction intervals. Weighted ensemble models also demonstrated strong performance in areas with complex epidemic patterns. By leveraging advanced statistical methods, the study provided accurate short-term forecasts to support early intervention and resource allocation strategies.
This work underscores the critical role of robust predictive modeling and surveillance data integration in guiding public health responses. The findings emphasize the potential of these methodologies to mitigate the societal impact of influenza outbreaks by enabling timely and informed decision-making."

Carnegie 200: Beth Anne Castellano

Title: Kohnert posets and polynomials of northeast diagrams

Abstract: Kohnert polynomials and their associated posets are combinatorial objects with deep geometric and representation theoretic connections, generalizing both Schubert polynomials and type A Demazure characters. We explore the properties of Kohnert polynomials and their posets indexed by northeast diagrams. We give separate classifications of the bounded, ranked, and multiplicity-free Kohnert posets for northeast diagrams. We also specialize these classifications to simple criteria in the case of lock diagrams.

Carnegie 219: Elena Shevchenko

Title: Automatic Density-based Clustering using Prim's Minimum Spanning Tree (MST) algorithm and Chebyshev's Inequality.

Abstract: While numerous clustering algorithms are available, a substantial portion exhibits limitations in effectively handling clusters with diverse shapes and densities or recommends hyperparameter tuning prior to algorithm utilization. A primary drawback lies in the algorithm's incapacity to autonomously determine the number of clusters, as clustering, in contrast to classification, does not inherently provide information regarding this quantity. Using graph-based approach for clustering produces additional insights for cluster interpretation, which is a common challenge in cluster analysis. Viewing points as vertices and distances between vertices as edges, it is possible to construct a graph and to build Euclidean minimum spanning forest on this graph, where each minimum spanning tree (MST) spans data points from a particular cluster. Algorithm starts with building MST on the whole set of points using Prim's algorithm and stops when no more edges can be added to the current tree. A stopping rule is based on a sample version of one-sided Chebyshev's inequality. The described algorithm executes clustering in a single stage and does not require users to predefine the number of clusters or to tune hyperparameters. As a result, no prior knowledge of the data or additional steps are necessary to perform clustering.

4.6. **3:10-3:45 Parallel Session 6.**

Carnegie 100: Darrion Thornburg

Title: On generalizing cryptographic results to Sidon sets in F_2^n

Abstract: A Sidon set S in $\mathbb{F}_2^n$ is a set such that $x + y = z + w$ has no solutions $x, y, z, w \in S$ with x, y, z, w all distinct. In this talk, we discuss how we can generalize and use known cryptographic results to study Sidon sets in $\mathbb{F}_2^n$. In particular, we generalize known results on the Walsh transform of almost perfect nonlinear (APN) functions to Sidon sets. For example, it is a well-known result in the theory of cryptographic functions that almost bent (AB) functions are those with minimal linearity. We generalize this result by classifying k-covers (an important subclass of Sidon sets) as those with minimal linearity. Moreover, we extend this further by classifying k-covers in terms of strongly regular graphs. We conclude our talk by using our result to construct the unique rank 3 strongly regular graph with parameters $(2048, 276, 44, 36)$ from a multiplicative subgroup of $\mathbb{F}_{2^n} \setminus \{0\}$.

Carnegie 114: Des Martin

Title: DG Algebras through Morse Matchings

Abstract: Let G be a tree and I_G the edge ideal of G. In this talk we explore the relationship between the Taylor resolution of an edge ideal and its minimal free resolution using Morse theory. We then ask when the minimal free resolution inherits the differential graded (dg) algebra structure form the Taylor resolution. In joint work iwth Hugh Geller and Henry Potts-Rubin.

Carnegie 115: Sreedev Manikoth

Title: Existence of minimal surface in a homotopy class

Abstract: Given a Riemannian manifold, one can measure the areas of all its submanifolds. A submanifold is said to be minimal if it is a critical point of the above area functional. Simplest examples are geodesics, which are the one-dimensional minimal submanifolds. Given a submanifold one can ask whether it is possible to modify it (I.e, homotope) to a minimal submanifold. In this talk we will show it is possible to convert it into an area minimizer given the induced map is injective on the fundamental groups and we'll describe some applications of this result in studying the topology of three manifolds with positve scalar curvature . This is an expository talk based on the work of R. Schoen and S.T Yau.

Carnegie 119: Benjamin Krewson

Title: Patterns in the Wake of a Parameter Ramp

Abstract: We study the formation of patterns in the light-sensitive CDIMA system in the presence of a slowly-varying opaque mask which induces a Turing instability as it moves through both 1 and 2 spatial dimensions. Previous work used a sharp mask to control the formation of patterns, whereas we study the behavior under a slowly-varying mask. Here the slowly varying parameter induces an asymptotically constant front from which Turing patterns can form in the wake of the ramp. We find through numerical simulation that the wave number selection curves under a slow-ramp significantly differ from those under a sharp parameter ramp. This is further confirmed using pseudo-arc-length continuation. We then study the relationship between the slowly-ramped CDIMA and an analogous complex Ginzburg-Landau equation. For the cGL equation, we use geometric singular perturbation theory and invariant manifold theory to construct pattern forming fronts and determine wave number selection curves. We observe a change in the shape of the manifold at a critical parameter value, determined by the absolute instability threshold of the trivial state.

Carnegie 200: Alizera Salahshoori

Title: Circle Gains in Gain Graphs

Abstract: A gain graph is a graph in which each oriented edge is assigned a gain, represented by a group element, with the gain inverted when the edge orientation is reversed. The gain of a circle in a gain graph is defined as the product of the gains of its edges, with the result depending on the orientation and the chosen "root" (starting edge) of the circle. A "circle gain system" refers to the collection of all oriented and rooted circle gains. In this talk I establish the necessary and sufficient conditions for a circle gain system to originate from a gain graph, specifically when the underlying group is abelian.

Carnegie 219: Pedro Takemura

Title: A New Class of Herz Spaces and Singular Integral Operators

Abstract: The theory of Herz spaces has seen numerous developments in the past two decades, resulting in a diverse family of function spaces. The common nature of these spaces invites the question of whether there is a functional analytic template that unifies the existing body of work. In this talk, we introduce a new class of Herz-type spaces, called Composite Herz spaces, which addresses this question. We present various examples to illustrate how many Herz-type spaces fit within our framework. As an application, we establish boundedness results for singular integral operators of Calderón-Zygmund type on uniformly rectifiable sets. This is joint work with Marius Mitrea.

4.7. **4:00-4:30 Parallel Session 7.**

Carnegie 100: Karie Schmitz

Title: Causal analysis with multidimensional treatments and an application

Abstract: In this project, we aim to establish a causal link between multidimensional religious profiles and substance use among young people transitioning to adulthood. To achieve these goals, we propose a fusion approach that integrates state-of-the-art techniques to analyze the multi-waves National Longitudinal Survey of Youth (NLSY97) data. We review three major threads of methods in causal inference with multidimensional treatments. Finally, we estimate the causal effects of multidimensional religious profiles on substance abuse through regression adjustment, inverse probability weighting, and nonparametric Bayesian modeling technique. This research is in collaboration with Jianxuan Liu, Siying Guo, and Yixuan Liu.

Carnegie 114: Jordan Martino

Title: A Variety of Varietes: Quiver, Hessenberg, and Slodowy, Oh My!

Abstract: In this talk, I will describe the work done during my Undergraduate Senior Thesis on Quiver Varieties. We will begin by defining Nakajima quiver varieties and talk about their connection to Slodowy varieties using Andrea Maffei's isomorphism (in type A). Then we will talk about Hessenberg varieties and the possibility of an isomorphism from Hessenberg varieties to families of quiver varieties. This would bring together concepts from algebra, representation theory, and geometry, allowing us to apply the techniques for quiver varieties to the setting of Hessenberg varieties (and vice versa) and producing new questions we can ask about both of these objects.

Carnegie 115: Courtney Hauf

Title: Equivariant Fundamental Groupoid

Abstract: The fundamental groupoid is a functor from Top to Grpds, consisting of homotopy classes of paths between any two points in our topological space (not just the loops!). We will discuss the equivariant fundamental groupoid and how the captured information changes when our space has a G-action. This will be done in part by looking at comparative examples.

Carnegie 119: Vaibhava Srivastava

Title: The "Fear" Effect in Competition Systems: Theory and Applications to Avian Invasions

Abstract: Non-consumptive effects, such as fear of depredation, can strongly influence predator-prey dynamics. There are several ecological and social motivations for these effects in competitive systems as well. In this work, we consider the classic two species ODE and PDE Lotka-Volterra competition models, where one of the competitors is "fearful" of the other. We find that the presence of fear can have several interesting dynamical effects on the classical competitive scenarios. Notably, for fear levels in certain regimes, we show novel bi-stability dynamics. Furthermore, in the spatially explicit setting, the effects of several spatially heterogeneous fear functions are investigated. In particular, we show that under certain integral restrictions on the fear function, a weak competition-type situation can change to competitive exclusion. Applications of these results to ecological as well as sociopolitical settings are discussed, which connect to the "landscape of fear" (LOF) concept in ecology. Using the test case of northern spotted and barred owl populations in the Pacific Northwest region of the United States, we evaluate if this fear (co-occurrence) model can generate more robust population estimates than previous models. We then evaluate if potential co-occurrence effects among barred and northern spotted owls are uni- or bi-directional. Lastly, we leverage the best-performing model to evaluate the degree to which a recently proposed barred owl culling program may help recover northern spotted owl populations.

Carnegie 200: Emma Naguit

Title: A New Computational Algebraic Proof for the Height of Toric Ideals of Graphs

Abstract: A graph is a pair of sets, a set of vertices and a set of edges, where each edge is defined by the two vertices to which it is incident. We can find ideals that correspond to graphs, called toric ideals of graphs. Two unrelated algebraic concepts are that of geometric vertex decomposition and height. Geometric vertex decomposition was first introduced by Knutson, Miller and Yong, and we can compute geometric vertex decompositions of toric ideals of graphs. By a result from Villarreal, we have a formula for the height of a toric ideal of a graph. In this talk, we explore how we can relate the notions of geometric vertex decomposition and height to provide a new, computational algebraic proof for Villarreal's height formula. In the process, we develop tools for working with edge deletions of graphs. No background is required.

Carnegie 219: Bryan Ducasse

Title: Tiling Properties of Unions of Intervals Via Unitary Matrices of Boundary Conditions

Abstract: In 2023, Dutkay and Jorgensen explored connections between Fuglede's conjecture and self-adjoint extensions of the momentum operator on domains that are disjoint unions of open intervals. Each self-adjoint extension of the momentum operator corresponds simultaneously to a unique unitary matrix of boundary conditions and a unique strongly continuous one-parameter unitary group. This unitary group acts as a translation operator when translation is restricted to a single interval and acts as a general translation operator on the domain under the additional constraint of spectrality of the domain and a specific choice of boundary condition matrix. In this talk, we describe a more explicit formula for the unitary group. This formula is used to associate structural properties of the matrix of boundary conditions to tiling properties of the domain. We then use these connections to demonstrate some necessary tiling conditions that arise under the additional constraint of spectrality of the domain. Finally, if time permits, we explore the relationship between the assumption of multiplicativity of the unitary group and permutation-type boundary conditions.

4.8. **4:35-5:05 Parallel Session 8.**

Carnegie 100: Mahdi Mazloum

Title: Mamba Meets Financial Markets: A Graph-Mamba Approach for Stock Price Prediction

Abstract: Stock markets play an important role in the global economy, where accurate stock price predictions can lead to significant financial returns. While existing transformer-based models have outperformed long short-term memory networks and convolutional neural networks in financial time series prediction, their high computational complexity and memory requirements limit their practicality for real-time trading and long-sequence data processing. To address these challenges, we propose SAMBA, an innovative framework for stock return prediction that builds on the Mamba architecture and integrates graph neural networks. SAMBA achieves near-linear computational complexity by utilizing a bidirectional Mamba block to capture long-term dependencies in historical price data and employing adaptive graph convolution to model dependencies between daily stock features. Our experimental results demonstrate that SAMBA significantly outperforms state-of-the-art baseline models in prediction accuracy, maintaining low computational complexity.

Carnegie 114: Julian Michele

Title: Eisenstein polynomials with a small number of terms for extensions of local fields

Abstract: Given a totally ramified extension L/K of local fields and a uniformizer $\pi$of L, L=K(π) and the minimal polynomial of πover K is Eisenstein. If this polynomial has few nonzero terms, it gives us a relatively simple description of L/K. I will introduce local fields and some terminology regarding ramification. I will discuss some prior results about when we can get a polynomial with only two or three nonzero terms for a totally ramified extension of local fields, as well as defining a set of invariants called "indices of inseparability." Finally, I will discuss some of my research about how certain assumptions on the indices of inseparability allow us to get a small number of terms.

Carnegie 115: Giang Vu Thanh Nguyen

Title: On the steady state solutions to a 2D Smoluchowski equation

Abstract: "We revisit a 2D Smoluchowski equation that is used to model nematic liquid crystalline polymers. In particular, we give a new proof to the study of steady state solutions to the 2D Smoluchowski equation: if the intensity constant is less or equal than 4, then there exists a unique (trivial) solution; if the intensity constant is greater than 4, then there are exactly two solutions that correspond to the isotropic and nematic phases, respectively. The proof depends purely on calculus and looks more transparent."

Carnegie 119: Narenda Pant

Title: A discrete-time predator-prey model with seasonal breeding and prey evolution

Abstract: "We build upon the predator-prey model introduced by Ackleh et al. (2019) to examine the effects of periodic reproduction driven by seasonality. By assuming that prey reproduction follows a periodic function with a period of two, we analyze the local stability of periodic solutions, establish the system's persistence, and compare our findings to those of Ackleh et al. (2019), which assumed continuous reproduction. Additionally, we extend this model to incorporate evolutionary dynamics, coupling population dynamics with the evolution of a phenotypic trait representing the mean toxicant resistance within the prey population, and present preliminary results from this evolutionary model."

Carnegie 200: Chi Nyugen

Title: Minimal hamiltonian-connected graphs

Abstract: A graph is hamiltonian-connected if every pair of vertices can be connected by a hamiltonian path, and it is hamiltonian if it contains a hamiltonian cycle. It is known that there are families of non-hamiltonian graphs for which the ratio of pairs of vertices connected by hamiltonian paths to all pairs of vertices approaches 1; this means that the graphs pack as many hamiltonian paths as possible while remaining non-hamiltonian. Considering the other extreme (graphs that have as few edges as possible while being hamiltonian-connected), I will use the result established by Moon (1965) to construct an infinite family of graphs that are minimal and hamiltonian-connected.

Carnegie 219: Jianqing Jia

Title: Computing Proximity Operators for Scale and Signed Permutation Invariant Functions

Abstract: "This presentation delves into the computation of proximity operators for scale and signed permutation invariant functions. A scale-invariant function demonstrates resilience to uniform scaling, while a signed permutation invariant function maintains its form despite permutations and sign changes applied to its input variables. Notable examples include the ℓ_0 function and the ratios of ℓ_1/ℓ_2 and its square. The computation of proximity operators for these functions holds significant importance in sparse signal recovery. This talk will detail a method for explicitly computing the proximity operator of $(\ell_1/\ell_2)^2$ and introduce an efficient algorithm for the proximity operator of ℓ_1/ℓ_2. "