46th Annual New York State Regional Graduate Mathematics Conference

Syracuse University

Date: April 10, 2021

Contents

1. Welcome

Welcome and thank you for participating in the 46th 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.

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!

2. Conference Structure

We will be using Zoom to host this conference. The entire conference will be held in one Zoom session and all parallel sessions will make use of the zoom breakout room feature. Participants will be able to navigate between the breakout rooms at will.

Most talks will be recorded; those which will not be recorded are shaded in red on the schedule. After the conference, recordings will be posted at the following link and made available for a period of at least two weeks.

Recordings Link

There will be four rooms dedicated to our graduate student talks. There will be an additional 10 poster rooms, one for each undergraduate poster. Finally there will be five rooms that will serve as an informal gathering area to meet and talk with other participants: one main "coffee room" and 4 "coffee tables".

If you have not done so, please use the following link to register and be sent the zoom link for the day of the conference!

Link Registration

Posters can be found in the following Google Drive folder as they are received. The poster session will be held on Zoom, giving contributors a chance to present their posters and answer questions.

Posters Link

3. Acknowledgements

The organizers would like to thank the Graduate Student Organization, Syracuse University Mathematics Department, American Mathematical Society, and the National Science Foundation for generously supporting this conference. We would like to thank Julie O'Connor, Leah Quinones, Kelly Jarvi, and Jordan Correia for their help with all the conference details — both little and big. A special thanks to Hannah Kimbrell, Elana Israel, and Caleb McWhorter for all their help with the conference organization and event planning. The organizers would also like to give a special thanks to Professor Graham Leuschke and Amy Graves for their work with the NSF Grant; for their knowledge and endless patience, we are enormously indebted. We would like to thank our speakers, Dr. Linda Cummings and Dr. Dror Bar-Natan, 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.

4. 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.

5. Keynote Speakers

Dr. Dror Bar-Natan (University of Toronto)

Professor Bar-Natan received his B.Sc. in in mathematics at Tel Aviv University in 1984. After performing his military service as a teacher, he started his studies at Princeton University. He received his Ph.D. in 1987 under the direction of physicist Edward Witten. Dr. Bar-Natan then held the Benjamin Peirce Assistant Professorship at Harvard University from 1991 to 1995. After returning to Israel, he became an Associate Professor at the Hebrew University of Jerusalem. Professor Bar-Natan then moved to the University of Toronto as a professor starting in 2002. He has written dozens of papers and had 7 Ph.D. students. His research interests include knot theory, finite type invariants, and Khovanov homology.

Dr. Linda Cummings (New Jersey Institute of Technology)

Professor Cummings received her BA and Ph.D. from the University of Oxford under Professors Ockendon and Howison. She then held postdoctoral positions at the Technion and the Ecole Normale Superieure (Paris), before moving to the EPSRC and Dorothy Hodgkin Fellowships at the University of Nottingham. Professor Cummings then was a faculty member beginning in 2005 at the University of Nottingham before beginning her current residency as a faculty member at the New Jersey Institute of Technology in 2008. She has written dozens of papers and had 11 Ph.D. students. Her research interests are in Applied Mathematics, including fluid dynamics, liquid crystals, free boundary problems, asymptotics, complex variable methods, and mathematical modeling of industrial and biomedical systems.

6. Schedule

Time	Room 1	Room 2	Room 3	Room 4
8:30-8:45	Preconference			
8:45-9:00	Opening Remarks			
9:00-9:30	Feng Guo	Melea Roman	Erik Mainellis	Joshu Flynn
9:30-10:00	Michelle Bartolo	Caleb McWhorter	Andrew Hardt	Kaiyi Wu
10:00-10:30	Lubna Kadhim	Benjamin Jany	Lindsey Farris	Ethan Farber
10:30-11:00	Break			
11:00-12:00	Invited Address: Dr. Linda Cummings			
12:00-12:30	Sultanah Masmali	[redacted]	Sangsan Warakkagun	Danielle Witt
12:30-1:30	Lunch and Poster Session			
1:30-2:00	Cole Butler	Nishad Mandlik	Asiyeh Rafieipour	Hyogo Shibahara
2:00-2:30	Uddhaba Pandey	Joshua Siktar	Ethan Dlugie	Ahmed Al-Taweel
2:30-3:00	Break			
3:00-4:00	Invited Address: Dr. Dror Bar-Natan			
4:00-4:30	Mengxuan Yang	Alex Bongiovanni	Emily Hoopes-Boyd	Jasim Ismaeel
4:30-5:00	David Guinovart Sanjuan	Erika Pirnes	Puttipong Pongtanapaisan	Mohammad Khan

Talks highlighted in red will not be recorded.

7. Talk Abstracts

7.1. 9:00-9:30 Parallel Session 1.

Room 1: Feng Guo, Bowling Green State University

Title: Regularizations in Machine learning: intuition and practice

Abstract: Ridge and lasso are popular regularization techniques in Machine learning nowadays. But, what are the intuitions behind? What are the differences between ridge & lasso regression when using them in practice? I aim to demonstrate the differences of the regularization techniques in the context of NLP/text mining application.

Room 2: Melea Roman, Kansas State University

Title: k-fold super totient numbers

Abstract: Let n be a positive integer and let $R(n)$ be the set of positive integers less than and relatively prime to n. If $R(n)$ can be partitioned into two subsets of equal sum then we say n is super totient. This definition was introduced in 2017 by Mahmood and Ali and then completely classified in 2019 by Harrington and Wong. The generalization of this concept into k subsets of equal sum we call k-fold super totient numbers. We give complete classifications for 3-fold, 5-fold and show that for any prime k, the classification of all k-fold super totient numbers can be found computationally. Further, a connection to a conjecture of Erdős and Selfridge is made.

Room 3: Erik Mainellis, North Carolina State University

Title: Factor Systems and the Second Cohomology Group of Leibniz Algebras

Abstract: Factor systems are a tool for working on the extension problem for algebraic structures such as groups, Lie algebras, and Leibniz algebras. We construct the Leibniz-analogue to a series of group-theoretic results from W. R. Scott's Group Theory. Fixing a pair of Leibniz algebras A and B, we develop a correspondence between factor systems and extensions of A by B. This correspondence is strengthened by the fact that equivalence classes of factor systems correspond to those of extensions. Under this correspondence, central extensions give rise to 2-cocycles while split extensions give rise to 2-coboundaries. We thus have a notion of the second cohomology group of A with coefficients in B.

Room 4: Joshua Flynn, University of Connecticut

Title: Sharp Caffarelli-Kohn-Nirenberg Inequalities for the Grushin operator and Iwasawa Groups

Abstract: Sharp Caffarelli-Kohn-Nirenberg inequalities are established for the Grushin vector fields and for Iwasawa groups (i.e.,the boundary group of a real rank one noncompact symmetric space). For all but one parameter case, this is done by introducing a generalized Kelvin transform which is shown to be an isometry of certain weighted Sobolev spaces. For the exceptional parameter case, the best constant is found for the Grushin vector fields by introducing Grushin cylindrical coordinates and solving the transformed Euler-Lagrange equation.

7.2. **9:30-10:00 Parallel Session 2.**

Room 1: Michelle Bartolo, North Carolina State University

Title: Multiscale Model Predictions of Mechanical Forces in the Pulmonary Vasculature in the United States

Abstract: Pulmonary hypertension due to LHF (PH-LHF) is a progressive disease that occurs in 60-80% of these patients. PH-LHF begins as a passive process termed isolated post-capillary PH (Ipc-PH), diagnosed by elevated mean pulmonary artery pressure (mPAP) with normal pulmonary vascular resistance (PVR), but significantly increases mortality once Ipc-PH transitions to combined pre-/post-capillary PH (Cpc-PH). Clinical and experimental hypotheses suggest that pathological shear stress and cyclic stretch are key regulators of pulmonary vasoconstriction and remodeling, yet the exact mechanical stimuli of PH-LHF are unknown. We propose an in-silico computational fluid dynamics of the large and small pulmonary arteries and veins as well as capillaries to predict shear stress and cyclic stretch. Large vessel hemodynamics are predicted in a reconstructed geometry from computed tomography imaging, while small vessel predictions occur in an empirically driven, bifurcating fractal tree. The arterial and venous trees are connected by pulmonary capillaries, whose network geometry is characterized by a sheet of fluid flowing between two membranes. This multiscale model provides predictions of dynamic blood pressure, blood flow, and area deformation throughout the pulmonary circulation. In large vessels, numerical simulations show that shear stress increases coincide with larger flow and pressure. In the microvasculature, we find that as vessel radius decreases, shear stress increases and flow decreases. In arterioles, this corresponds with lower pressures; however, in venules, smaller vessels have higher pressure. Our model is novel tool that can be used to analyze and investigate hypotheses related to understanding the physiological mechanisms underlying the progression of pulmonary diseases.

Room 2: Caleb McWhorter, Syracuse University

Title: Torsion Subgroups of Rational Elliptic Curves over Odd Degree Galois Fields

Abstract: The Mordell-Weil Theorem states that if K is a number field and E/K is an elliptic curve that the group of K-rational point $E(K)$ is a finitely generated abelian group, i.e. $E(K) \cong^{r_K} \oplus E(K)_{\text{tors}}$ where r_K is the rank and $E(K)_{\text{tors}}$ is the subgroup of torsion points on E. Unfortunately, very little is known about the rank r_K. Even in the case of $K = \mathbb{Q}$, it is not known which ranks are possible or even if the ranks are unbounded. On the other hand, there has been great strides in determining the sets $E(K)_{\text{tors}}$.

Progress began in 1977 with Mazur's classification of the possible torsion subgroups for rational elliptic curves $E(\mathbb{Q})_{\text{tors}}$, and there has seen been an explosion of classifications. The possible structures for $E(K)_{\text{tors}}$ is known for elliptic curves over number fields of degree $d = 2, 3$ and which ones occur infinitely often for $d = 4, 5, 6$. When restricting to rational elliptic curves or elliptic curves with CM, there is even greater progress. For instance, the torsion structures for $E(K)_{\text{tors}}$ are known for number fields of degree $d = 1, 2, \ldots, 12$.

Inspired by work of Chou, Gonzalez-Jimenez, Lozano-Robledo, and Najman, the purpose of this talk is to discuss the classification of the sets $\Phi_{\mathbb{Q}}^{\text{Gal}}(9)$, the set of possible torsion subgroups for rational elliptic curves over nonic Galois fields - there are 22 possible isomorphism classes. Finally, extending these techniques, we will discuss the classification of the sets $\Phi_{\mathbb{Q}}^{\text{Gal}}(d)$ for any odd integer d.

Room 3: Andrew Hardt, University of Minnesota

Title: Solvable Lattice Models and Special Functions

Abstract: Solvable lattice models originate in statistical mechanics, but have surprising applications throughout mathematics. They can represent special functions throughout combinatorics, geometry, and probability. Most importantly, they satisfy Yang-Baxter equations, which allow us to prove identities and symmetry properties. Strikingly, Yang-Baxter equations come from modules of quantum groups, whose similarities to Lie groups are miraculous from the statistical mechanics perspective.

I will briefly introduce these objects, and summarize recent research.

Room 4: Kaiyi Wu, Tufts University

Title: A Posteriori Error Estimates for Solving Graph Laplacians

Abstract: In this project, we study a posteriori error estimators which aid multilevel iterative solvers for linear systems with graph Laplacians. In earlier works such estimates were computed by solving global optimization problems, which could be computationally expensive. We propose a novel strategy to compute these estimates by constructing a Helmholtz decomposition on the graph based on a spanning tree and the corresponding cycle space. To compute the error estimator, we solve efficiently the linear system on the spanning tree, and then we solve approximately a least-squares problem on the cycle space. As we show, such an estimator has a nearly-linear computational complexity for sparse graphs under certain assumptions. Numerical experiments are presented to demonstrate the efficacy of the proposed method.

7.3. **10:00-10:30 Parallel Session 3.**

Room 1: Lubna Kadhim, Morgan State University

Title: Analysis of a Couple of Dynamical System Associated with Cancer Treatment

Abstract: In this paper we have considered two dynamical systems associated with cancer treatment. The two dynamical systems are derived from two free boundary problems modeling tumor growth and cancer treatment by combination therapy. By analyzing the fixed points and their linear stability, we study the asymptotic property of the solution and its dependence on the dose levels of the drug.

Room 2: Benjamin Jany, University of Kentucky

Title: Rank metric codes and their associated q-matroids

Abstract: In 2018, R.Jurrius and R.Pellikaan defined the notion of q-matroid, the q-analogue of a matroid. They defined q-matroids via a monotonic, non-negative, bounded and submodular integer-valued function on the collection of subspaces of F_q^n. However, it was shown that q-matroids have several cryptomorphic definitions based on q-independent spaces, q-bases or q-flats, which are, respectively, the q-analogues of the independent sets, basis and flats of a matroid. The motivation behind studying q-matroids comes from its application to rank-metric codes. An F_{q^m}-linear rank-metric code induces a q-matroid, and several code invariants such as the code's dimension, rank distance and generalized weights can be determined from the q-matroid. My talk will focus on introducing the notion of q-matroid and showing how to derive invariants of rank-metric codes from their associated q-matroid.

Room 3: Lindsey Farris, North Carolina State University

Title: Coclass of Leibniz Algebras

Abstract: This talk discusses nilpotent Leibniz algebras, and their corresponding upper central series. The upper central series consists of the center, second center, third center, and so forth. The dimensions of the different centers must always increase by at least one, but may increase by more than one. How the dimensions change not only determines the coclass of the Leibniz algebra, but also uniquely defines the Leibniz algebra itself.

Room 4: Ethan Farber, Boston College

Title: Constructing pseudo-Anosovs from interval maps

Abstract: Pseudo-Anosovs are locally linear models of dynamically complicated surface homeomorphisms. As it turns out, these can each be encoded by a transformation of a branched 1-manifold, and in nice cases this 1-manifold is essentially an interval. In this talk, I will partially classify which interval maps give rise to pseudo-Anosovs. This classification is in terms of the combinatorics of the interval maps, and recovers relevant dynamical information about the interval maps, such as the entropy.

7.4. **11:00-12:00 Invited Address: Dr. Linda Cummings.**

Dewetting and dielectrowetting in thin films of nematic liquid crystals

Thin films of nematic liquid crystal (NLC) find widespread industrial use, in applications ranging from liquid crystal display devices to liquid lenses and optical shutters. Understanding how such films spread and flow is therefore important from an industrial perspective as well as being of fundamental scientific interest. We will describe how asymptotic methods (lubrication theory) can be applied to derive a simplified model for the free surface evolution of NLC films in a number of different settings. Of particular importance for film behavior is the orientation of the NLC molecules, both within the bulk film and at interfaces. The former is dictated by elastic effects and by the presence of applied external fields such as an electric field; while the latter depends primarily on interactions of the NLC with the adjacent material (a phenomenon known as anchoring). We will present simulations of our model that illustrate film behavior both without (dewetting) and with (dielectrowetting) an applied electric field, showing good qualitative agreement with available experimental data.

7.5. **12:00-12:30 Parallel Session 4.**

Room 1: Sultanah Masmali, Kansas State University

Title: Stability and bifurcations of a discrete predator prey system

Abstract: We study the dynamics behavior in first closed quadrant of a host-parasite model with four positive parameters, as a type of Nicholson-Bailey model. By a re-scaling, the model can be reduced to a two parameter model carries over the dynamics of the original model. This model always possesses two axial equilibrium points and we show that the third and unique interior equilibrium exists under a certain condition on one of the parameters. We analyze the stability of each of the equilibrium points for different range of parameters by linearization of the model about each of the equilibrium points. For the parameters values which equilibrium point is non-hyperbolic, stability of equilibrium point is studied by application of center manifold. Moreover, by application of Jury's test, we find thresholds for which the system is stable or unstable. A period-doubling bifurcation occurs once we cross one of this thresholds which leads to a chaos. The results are supported by some simulations.

Room 3: Sangsan Warakkagun, Boston College

Title: Connectivity of the space of pointed hyperbolic surfaces
Abstract: In this talk, I will give a meaningful way to topologize the space of all (pointed) hyperbolic surfaces including both compact and non-compact, both finite- and infinite-type surfaces. I will quickly review surface decompositions and the Fenchel-Nielsen coordinates on the Teichmüller space before sketching a proof of the connectedness and local connectedness of this space. No prior familiarity with hyperbolic geometry is assumed.

Room 4: Danielle Witt, Bowling Green State University

Title: Generalizing the Spectral Radius Formula to Joint Spectra

Abstract: The classical spectral radius formula gives a way to calculate the radius of the smallest disc in the complex plane centered at the origin containing the spectrum of a given element in a Banach algebra, based on the norms of powers of the element. This is equivalent to determining the smallest polynomially convex circled subset of the complex plane containing a spectrum. This talk will demonstrate a way to determine the smallest polynomially convex circled subset of $\mathbb{C}^n$ containing the joint spectrum of n elements in a commutative Banach algebra, based on the norms of products of the elements.

7.6. **1:30-2:00 Parallel Session 5.**

Room 1: Cole Butler, North Carolina State University

Title: Density-dependence and the effectiveness of gene drives in controlling prevalence of mosquito-borne infections

Abstract: A gene drive is a genetic mechanism that can spread a gene through a population. Gene drives have the potential to significantly change the way we control vector-borne diseases, most notably dengue and malaria, with mathematical models having demonstrated their potential effectiveness. A key consideration absent from the mathematical modeling literature is the influence of density-dependence on target populations. Density-dependence is a natural ecological process that can counteract population suppression by a gene drive. The purpose here is then to study gene drive performance in a population of mosquitoes with density-dependent characteristics and determine how this affects infectious disease control. We use a mathematical framework in which a model for mosquito population genetics and dynamics is coupled to an epidemiological model. We explore a variety of different scenarios relating to the type of transgene released (e.g. whether it kills both male and female mosquitoes, and whether male and/or female transgenic mosquitoes are released). We undertake a sensitivity analysis to explore performance over a wide range of scenarios and to identify key parameters that influence the effectiveness of the approach. In each situation, results of system analysis with and without density-dependence is compared, and to what extent such factors influence certain quantities of interest such as disease prevalence in a human population.

Room 2: Nishad Mandlik, Oklahoma State University

Title: P-shifted Matroids

Abstract: We give a condition for a matroid to be transversal. This condition depends on P-shiftedness, which is a generalization of the classical notion of shiftedness in simplicial complexes and matroids. Our result both generalizes and recovers a result that characterized shifted matroids as transversal.

Room 3: Asiyeh Rafieipour, Ohio University

Title: A Monoid Structure on the Set of all Binary Operations over a Fixed Set and some of its properties

Abstract: Given a set S, we consider an operation $\triangleleft$ on the set $\mathcal{M}(S)$ where $\mathcal{M}(S) = \{* \mid * \text{ is a binary operation on } S\}$ such that $(\mathcal{M}(S), \triangleleft)$ is a monoid.

We consider several properties of this monoid including the fact that it has all subsets of the form $out(*) = \{\circ \in \mathcal{M}(S) \mid * \text{ distributes over } \circ\}$ as submonoids, a complete characterization of its group of units and of a subgroup of its group of automorphisms, induced by permutations. In addition we introduce for the case when $|S| < \infty$, a user-friendly representation of the elements of $\mathcal{M}(S)$.

This talk reports some results from a paper with S.R. López-Permouth and Isaac Owusu Mensah that is currently under consideration for publication.

Room 4: Hyogo Shibahara, University of Cincinnati

Title: Gromov-Hausdorff distance with boundary and its application to Analysis on metric spaces

Abstract: We will introduce a notion of Gromov-Hausdorff distance with boundary to discuss convergence of noncomplete metric spaces. We present some fundamental results for Gromov-Hausdorff distance with boundary and its application to Analysis on metric spaces.

7.7. **2:00-2:30 Parallel Session 6.**

Room 1: Uddhaba Pandey, Oklahoma State University

Title: The stabilizing effect of temperature in the buoyancy driven fluids

Abstract: The Boussinesq system for buoyancy driven fluids couples the momentum equation forced by the buoyancy with the convection-diffusion equation for the temperature. One fundamental issue on the Boussinesq system is the stability problem on perturbations near the hydrostatic balance. This problem can be extremely difficult when the system lacks full dissipation. This paper solves the stability problem for a two-dimensional Boussinesq system with only vertical dissipation and horizontal thermal diffusion. We establish the stability for the nonlinear system and derive precise large-time behavior for the linearized system. The results presented in this paper reveal a remarkable phenomenon for buoyancy driven fluids. That is, the temperature actually smooths and stabilizes the fluids. If the temperature were not present, the fluid is governed by the 2D Navier-Stokes with only vertical dissipation and its stability remains open. It is the coupling and interaction between the temperature and the velocity in the Boussinesq system that makes the stability problem studied here possible. Mathematically the system can be reduced to degenerate and damped wave equations that fuel the stabilization.

Room 2: Joshua Siktar,University of Tennessee-Knoxville

Title: On the Combinatorics of Placing Balls into Ordered Bins

Abstract: We consider a particular configuration of the classic Balls in Bins counting problem: we count the number of ways to split n balls into nonempty, ordered bins so that the most crowded bin has exactly k balls. We establish closed forms for three of the different cases that can arise: $k > \frac{n}{2}$, $k = \frac{n}{2}$, and where $\exists\ j < k$ such that $n = 2k + j$. As an immediate result of our proofs, we find a closed form for the number of positive integer solutions to $x_1 + x_2 + \cdots + x_\ell = n$ with the attained maximum of the integers equalling k, and ℓ represents the number of bins in an arbitrary configuration. The problem is generalized to find a formula that enumerates the total number of ways without specific conditions on n, ℓ, and k, using only direct enumeration instead of generating functions. Subsequently, we prove various identities and properties associated with such sums and find lower and upper bounds on the generalized problem using the modified version of Stirling's approximation.

This work is joint with Vedant Bonde.

Room 3: Ethan Dlugie, UC Berkeley

Title: Geometry, Topology, and a Wall Near You

Abstract: Imagine you're shopping online for wallpaper to decorate your new apartment. The styles are endless, how do they manage to come up with so many thousands of patterns? We'll see how to understand this situation by connecting ideas from Riemannian geometry, algebraic topology, and geometric group theory. In the end, we'll understand that there are not thousands of wallpaper patterns but only really 17. The rest is just advertising.

Room 4: Ahmed Al-Taweel, University of Arkansas at Little Rock

Title: A stabilizer free weak Galerkin finite element method with supercloseness of order two

Abstract: The weak Galerkin (WG) finite element method is an effective and flexible general numerical technique for solving partial differential equations. A simple WG finite element method is introduced for second-order elliptic problems. First we have proved that stabilizers are no longer needed for this WG element. Then we have proved the supercloseness of order two for the WG finite element solution. The numerical results confirm the theory.

7.8. **3:00-4:00 Invited Address: Dr. Dror Bar-Natan.**

Knots in Three and Four Dimensions

Much as we can understand 3-dimensional objects by staring at their pictures and x-ray images and slices in 2-dimensions, so can we understand 4-dimensional objects by staring at their pictures and x-ray images and slices in 3-dimensions, capitalizing on the fact that we understand 3-dimensions pretty well. So we will spend some time staring at and understanding various 2-dimensional views of a 3-dimensional elephant, and then even more simply, various 2-dimensional views of some 3-dimensional knots. This achieved, we'll take the leap and visualize some 4-dimensional knots by their various traces in 3-dimensional space, and if we'll still have time, we'll prove that these knots are really knotted.

Talk Webpage Link

7.9. **4:00-4:30 Parallel Session 7.**

Room 1: Mengxuan Yang, Northwestern University

Title: Diffraction and Wave Trace of the Aharonov-Bohm Hamiltonian

Abstract: Hörmander's classic theorem shows the singularities of solutions to the wave equation propagate along the geodesic flow. Duistermaat-Guillemin trace formula gives the singularities of the wave trace on closed compact manifolds. In this talk, we will discuss the analogous results for the wave equation with singular magnetic vector potentials, which corresponds to the so-called Aharonov-Bohm effect. A result on lower bound of resonances is also given.

Room 2: Alex Bongiovanni, Kent State University

Title: A divisor sum with Piatetski-Shapiro sequences

Abstract: For any fixed $c > 1$ we prove an asymptotic formula for the sum over the number of divisors where one divisor has the form $[n^c]$.

Room 3: Emily Hoopes-Boyd, Kent State University

Title: Writing Nilpotent Matrices as Commutators

Abstract: The relationship between nilpotent elements and commutators in rings has been studied over the years. We will show that every nilpotent N in $M_n(D)$, the ring of square matrices over a division ring, can be presented as a single commutator, that is, $N = AB - BA$ for some matrices A, B in $M_n(D)$. We will also construct an example illustrating that there exists a prime ring with unity over which some nilpotent matrices cannot be presented as commutators.

Room 4: Jasim Ismaeel, University of Missouri-Columbia

Title: Paulsen's Problem for Matrix Frames

Abstract: The Paulsen Problem in frame theory asks for an upper bound on the squared distance between an ϵ-nearly equal-norm Parseval frame and an equal-norm Parseval frame. Such an upper bound that does not depend on the number of vectors in the frames was first found by Kwok, Lau, Lee, and Ramachandran. Later, Hamilton and Moitra gave a significantly shorter proof using the notion of radial isotropy. In this talk, we present a generalized version of the Paulsen Problem for frames of matrices instead of vectors. The proof uses tools from quiver invariant theory. This is based on a joint work with Calin Chindris.

7.10. **4:30-5:00 Parallel Session 8.**

Room 1: David Guinovart Sanjuan, University of Central Florida

Title: Analysis of the effective properties for multilayered piezocomposite with non-uniform imperfect contact at the interface

Abstract: This work offers a methodology to compute the effective properties of multilayered laminated composite with different crack failure at the interface. In order to achieve the objective, the equilibrium problem for a curvilinear three dimensional composite structure with generalized periodicity is considered. The problem is subjected to different conditions for the components like elasticity and piezoelectricity with perfect and imperfect contact at the interfaces. The two-scales asymptotic homogenization method (AHM) is used to derive the expressions of the local problems and the effective coeffcients. In order to study the influence of the crack in the effective properties, different cases of geometry for the crack are considered and compared. The general expressions of the homogenized problem are derived for all the aforementioned cases. To validate the model, some numerical examples are studied, and the results are compared with the values obtained by nite elements method (FEM).

Room 2: Erika Pirnes, University of Wisconsin-Madison

Title: Reconstruction conjecture in graph theory

Abstract: The deck of a graph with n vertices is a multiset of n unlabeled graphs, each obtained from the original graph by deleting a vertex (and the edges incident to it). The reconstruction conjecture says that if two finite simple graphs with at least three vertices have the same deck, then they are isomorphic.

Room 3: Puttipong Pongtanapaisan, University of Iowa

Title: Meridional rank and bridge number for nonclassical knotted objects

Abstract: The meridional rank conjecture posits that the minimum number of meridional generators needed to generate the fundamental group of the link exterior equals the smallest possible number of local maxima for a representative of the link. This conjecture remains unsolved both in dimension three and dimension four settings. In this talk, I will discuss properties and calculations of a numerical invariant called the welded bridge number and explain how one may use this quantity to study the meridional rank conjecture. This is joint work with Jason Joseph.

Room 4: Mohammad Khan, University of Tennessee - Chattanooga

Title: Minimum and Maximum Eigenvalues for a Sturm-Liouville Problem Describing Waves in the Ice-Covered Ocean

Abstract: In this talk, I will present the impact of acoustic waves in an ocean covered by pack ice. The problem of acoustic wave propagation in a layered ocean waveguide is formulated as a boundary value problem for the Helmholtz equation subject to the boundary conditions on the rigid bottom and the ice sheet on the top. With the help of the separation of variables method, we obtained the Sturm-Liouville problem. We used Sturm-Liouville theory, L^2 convergence, and eigenfunction properties to find the two leading modes that are the separated solutions for two maximal eigenvalues. Using some optimization techniques, we found the minimum and maximum of the wavenumbers for these leading modes. Besides evaluating the frequency dependence of the leading wavenumbers analytically, we developed an algorithm to obtain the numerical results for the wavenumbers with different speed profiles over a range of frequencies. We noticed that the numerical results match with the analytical results and the wavenumbers are almost independent of the speed profile. With the help of asymptotic analysis, we found the approximate formulas for the extreme values of the first two eigenvalues. These results could be extended to the model of thick ice, and this new model could provide us new results such as the impact of global warming on thick ice plates. This project was partially funded by the SimCenter at the University of Tennessee at Chattanooga.

8. Undergraduate Posters

We have scheduled in a sequence of breaks so that our undergraduates presenting posters can take a look at their peers work.

Poster Break Schedule

Presenter	Time
Zetty Cho	**12:35-12:45**
Andrew Cirincione	**12:40-12:50**
Erin Cronce	**12:45-1:55**
Ayush Garg	**12:50-1:00**
Tavianne Kemp	**1:00-1:10**
Isaac Moorman	**1:05-1:15**
Micah Phillips-Gary	**1:10-1:20**
Parul Rai	**1:15-1:25**
Matthew Won	**1:20-1:30**

Presenter: Zetty Cho

Title: Artifacts in Reconstructions Based on Numerical Limitations in an Incomplete Data Set

Abstract: In two-dimensional sonar imaging, we can identify the position of a target object by producing a sound wave from a given source and measuring the total reflectivity of the region surrounding the object. For this study, we considered when both transmitter and receiver devices were located at the same position in a plane, where the horizontal axis represented device position and the vertical axes represented the depth of the transmission. Given a finite number of device positions and depths, which resulted in a limited data set for the object, we explored the accuracy of the reconstructions and potential artifact creation. We created an algorithm to generate multiple two-dimensional data sets of an object and then visually identified the differences between the reconstruction and the original object. We specifically studied how the limits on the measured depth of transmission of the data set affected our reconstructions and found that these limits were a direct cause for additional artifacts in our reconstructions. We studied specific artifacts caused by rough data boundaries (probably caused by numerical limitations), and we showed that, as the boundaries became smoother, the artifacts turned into smooth curves that can be explained analytically.

Presenter: Andrew Cirincione

Title: A Numerical Investigation of the Wilson-Cowan Model

Abstract: The Wilson-Cowan model describes the dynamics between excitatory and inhibitory subpopulations of neurons from a macroscopic perspective. We investigate the stability of this model under the ReLU and shifted logistic sigmoid activation functions, obtain parametric regimes that guarantee certain stability behaviors (including stable and oscillatory steady states), and explore possible biological implications of our results. Lastly, we use the BCM rule to vary the synaptic weights (with time) between the subpopulations in the Wilson-Cowan model.

Presenter: Erin Cronce

Title: Using Topology to Analyze Antarctic Firn Samples

Abstract: Firn refers to partially compacted snow whose micro-CT scans researchers can use to determine past climate patterns and atmospheric activity. However, one of the main challenges in the field is to distinguish the ice from the interconnected pore space in the scan. We implemented tools from Topological Data Analysis, a novel area in applied mathematics, in our study of several hundred cross-sectional two-dimensional scans of an Antarctic firn column. We discuss the use of topological methods such as thresholding and persistent homology in interpreting firn scans of different resolutions. These topological methods have proven effective in studying scans and extracting distinct components to represent the complete firn sample, focusing on preserving the image's most persistent features. Climate scientists can in turn apply these topological techniques in order to obtain a clearer representation of firn samples and thus more accurately interpret climate records.

This is a joint work with Yu-Min Chung (UNCG), Sarah Day (W&M), and Kaitlin Keegan (UNR).

Presenter: Ayush Garg

Title: Convex Geometries and their representations by circles on the plane

Abstract: A convex geometry is a closure system satisfying the anti-exchange property. We document all convex geometries on 4- and 5-element base sets with respect to their representation by circles on the plane, with respect to the closure operator of convex hull. All 34 non-isomorphic geometries on a 4-element set can be represented by circles, and of 672 known geometries on a 5-element set, we made representations of 623. Of the 49 remaining geometries on a 5-element set, one was already shown not to be representable due to the Weak Carousel property, as articulated by Adaricheva and Bolat (Discrete Mathematics, 2019). We discovered novel geometrical properties, namely the Triangle Property and the Opposite Property using which we show that 14 more of these convex geometries cannot be represented by circles on the plane. We also expand closure systems to systems with a number of unary predicates (colors), and apply this approach to representation of convex geometries by colored circles.

Presenter: Tavianne Kemp

Title: Computer Simulation of Random Walks in Different Dimensions

Abstract: Properties of random walks in arbitrary dimension are investigated. In particular, the probability distribution function of the magnitude of the vector pointing between the end points of a random walk, the mean squared end-to-end distance, and its first few moments are derived for random walks on lattices in D dimensions. The theoretical predictions are tested with Monte Carlo computer simulations in dimensions $D = 1 \ldots 7$. All values agree within a small error. The behavior of these quantities as D approaches infinity is explored.

Presenter: Isaac Moorman

Title: Spanning tree congestion, stretch and other parameters of the graph

Abstract: In this poster we introduce a new characteristic of connected simple finite graphs which we term support number. We present relations with the previously defined notions of congestion and stretch. We also give an approximation algorithm for support number, and thus a polynomially computable lower bound for stretch.

Presenter: Micah Phillips-Gary

Title: The Five Lemma for Abelian Categories and the Phenomenology of Mathematical Abstraction

Abstract: (This poster is based on interdisciplinary research in mathematics and philosophy.) We will give the Five Lemma as a theorem for groups and give definitions for the analogue category theory concepts necessary to state the Five Lemma as it applies to any abelian category. In particular, we will define "isomorphism," "kernel," "image" and "exact sequence" as applicable to any abelian category. We will then briefly discuss the philosophical implications of this abstraction. Namely, it shows the difference between generalization and abstraction as conceptual procedures and suggests a relativization of the notion of material conceptual content so as to make multiple levels of abstraction possible.

Presenter: Parul Rai

Title: Investigating the Activity of Coupled Neurons

Abstract: In the present project, we explore synchronous and asynchronous spiking patterns of coupled integrate-and-fire neurons with synaptic conductance. We investigate the interaction between two coupled neurons with chemically exciting or inhibiting synapses. Our results suggest excitatory coupled neurons produce asynchronous spiking patterns, inhibitory coupled neurons produce synchronous spiking patterns, and mixed synapse types exhibit characteristics of both spiking patterns.

Presenter: Matthew Won

Title: A Note on Probability Calculations in Bitcoin's Blocks Chasing

Abstract: To prove bitcoin's security system works, we have to make sure that the honest chain will never lose in the blocks chasing with the attacker chain. To solve this problem, we propose the Binomial Distribution as a solution that show the probability of the attacker chain catch up the honest chain.