### Monday, September 26, 2022

<table>
<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>3:00pm-4:15pm</td>
<td><strong>RTG Seminar on Number Theory</strong> -- Calvin Yost-Wolff (UM)</td>
<td>Luna--Vust theory: structure theory of spherical embeddings</td>
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<td>4:00pm-5:00pm</td>
<td><strong>Complex Analysis, Dynamics and Geometry</strong> -- Danny Stoll (U(M))</td>
<td>The Geometry of Marked Cycles</td>
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<td>4:00pm-5:00pm</td>
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### Tuesday, September 27, 2022

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### Wednesday, September 28, 2022

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<td>Derivation of wave kinetic equations for three wave models</td>
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<td>Quantization: The Possibles and Impossibles</td>
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<td>TBA</td>
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Friday, September 30, 2022

9:00am-10:00am  **Variational Analysis and Optimization** -- Shawn Wang (University of British Columbia - Canada)  
A Bregman inertial forward-reflected-backward method for nonconvex minimization -- Virtual

3:00pm-4:00pm  **Applied Interdisciplinary Mathematics (AIM)** -- Joaquim Martins (University of Michigan (Aerospace))  
*Engineering Design Optimization:*

3:00pm-3:50pm  **Student Algebraic Geometry** -- Brad Dirks (Michigan)  
*What is a singularity?* -- 2866 East Hall

3:00pm-4:00pm  **Combinatorics** -- Steven Karp (University of Notre Dame)  
*q-Whittaker functions, finite fields, and Jordan forms* -- 4088 East Hall

4:00pm-5:00pm  **Student AIM Seminar** -- Amaya Murguia (University of Michigan)  
*Representation Learning of Resting State Functional Magnetic Resonance Imaging Using Variational Autoencoder with Convolutional Neural Network and Transformer* -- 2866 East Hall
**RTG Seminar on Number Theory**  
*Monday, September 26, 2022, 3:00pm-4:15pm*  
4088 East Hall  
Calvin Yost-Wolff (UM)  
*Luna--Vust theory: structure theory of spherical embeddings*

**Complex Analysis, Dynamics and Geometry**  
*Monday, September 26, 2022, 4:00pm-5:00pm*  
3096 East Hall  
Danny Stoll (U(M))  
*The Geometry of Marked Cycles*

Discrete time dynamical systems can often be understood by studying their periodic orbits. By marking such a periodic orbit on an algebraic family of holomorphic functions, one obtains a branched cover whose geometry reflects the interactions between the various n-cycles arising in the family. We describe an algorithm to compute this branched cover for n-cycles under quadratic polynomials, along with partial results and generalizations to other families.

**Student Combinatorics**  
*Monday, September 26, 2022, 4:00pm-5:00pm*  
3866 East Hall  
Heitor Cotosky (UM)  
*Planar Network Graph and Total Positivity*

A matrix with real entries is total positive (TP) when all of its minors are positive. Although very useful at many different areas of mathematics and physics, they may seem rare at first. Lindstrom provided a straight-forward way of building TP matrices, as the path matrix of a planar network graph. In fact, all TP matrices are in this form. In this talk, we will prove this correspondence, and explore some of its consequences.
Student Analysis  
Tuesday, September 27, 2022, 5:00pm-6:00pm  
3096 East Hall  
Han Le (University of Michigan)  
*An Edge CLT for the Log Determinant of Laguerre Ensembles*  

In this talk, we consider \( \log|\det(M - s)| \) of random matrix \( M \) from the Laguerre \( \beta \) ensemble in the case \( s \) is near the upper edge of the Marchenko-Pastur law, and discuss its convergence to a Gaussian random variable as the size of the matrix grows. We first introduce the Laguerre ensemble for general \( \beta > 0 \), then examine the log determinant from the perspective of linear spectral statistics. Time permitting, we will discuss the starting point of the CLT analysis, and the connection to a spherical spin glass model.

The talk is based on joint work with Elizabeth Collins-Woodfin.

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Learning Seminar in Algebraic Combinatorics  
Wednesday, September 28, 2022, 2:30pm-4:00pm  
4088 East Hall  
Katie Waddle (University of Michigan)  
*Dimers and Spanning Trees*  

As we have seen, the set of dimer covers on a graph is in bijection with several other interesting objects. In this talk we will discuss a bijection between dimer covers on a graph and spanning trees on a related graph, a generalization of Temperley's classic bijection. The powerful tools developed for spanning trees, like Wilson's algorithm for selecting a uniformly random spanning tree can then be used on dimer covers as well.

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Student Arithmetic  
Wednesday, September 28, 2022, 3:00pm-4:00pm  
1866 East Hall  
Sandra Nair (UM)  
*Abelian Varieties and some interesting arithmetic*  

Abelian varieties are generalizations of elliptic curves into higher dimensions, carrying rich algebro-geometric as well as arithmetic information. We shall define what they are and give a couple important examples, along with some properties. The study of \( p \)-torsion of abelian varieties over a field of characteristic \( p \) is of particular interest, much less well understood than their elliptic curve counterparts. We will use this to motivate the study of the moduli spaces of certain classes of abelian varieties, which are known as Shimura varieties.
Algebraic Geometry  
**Wednesday, September 28, 2022, 4:00pm-5:30pm**  
4096 East Hall  
**Jenia Tevelev (UMass, Amherst)**  
*Semi-orthogonal decompositions (SOD) of moduli spaces*  

I will discuss strategies for combining categorical and geometric techniques to decompose derived categories of coherent sheaves into semi-orthogonal indecomposable blocks focusing on two classical moduli spaces. For the moduli space of stable rank 2 vector bundles on a smooth projective curve, jointly with Sebastian Torres, we construct an SOD with blocks given by symmetric powers of the curve, confirming a conjecture of Narasimhan and Belmans-Galkin-Mukhopadhyay. For the moduli space of stable pointed curves of genus 0, jointly with Ana-Maria Castravet, we construct an exceptional collection invariant under the symmetric group of permutations of marked points, proving a conjecture of Manin and Orlov.

Financial/Actuarial Mathematics  
**Wednesday, September 28, 2022, 4:00pm-5:00pm**  
1360 East Hall  
**Dominykas Norgilas (UM)**  
*Supermartingale shadow couplings: the decreasing case*  

A classical result of Strassen asserts that given probabilities $\mu, \nu$ on the real line which are in convex-decreasing order, there exists a **supermartingale coupling** with these marginals, i.e. a random vector $(X_1, X_2)$ such that $X_1 \sim \mu$, $X_2 \sim \nu$, and $\mathbb{E}[X_2 \mid X_1] = X_1$. However, it is a non-trivial problem to construct particular solutions to this problem. In this talk we introduce a family of such supermartingale couplings, each of which admits canonical characterization in terms of stochastic dominance. As particular elements of this family we recover the increasing and decreasing supermartingale couplings that solve the supermartingale optimal transport problem for particular cost functions. This is a joint work with Erhan Bayraktar and Shuoqing Deng.

RTG Seminar on Geometry, Dynamics and Topology  
**Wednesday, September 28, 2022, 4:00pm-5:30pm**  
3866 East Hall  
**Teddy Weisman (U Michigan)**  
*Ping-Pong, Automata and Stability for Hyperbolic Group Actions*  

The ping-pong lemma is a well-known and ubiquitous tool in group theory. In this talk, I will discuss applications of some variations of the ping-pong lemma, involving the machinery of finite-state automata. These variations provide a technique for proving stability results about actions of arbitrary hyperbolic and relatively hyperbolic groups - even those which do not split as free products.
Logic  
**Wednesday, September 28, 2022, 4:00pm-5:30pm**  
3088 East Hall  
**Ronnie Chen (University of Michigan)**  
*Topology versus Borel structure for actions*

It is a classical result that any Borel set in a "nice" topological space can be made open in a finer "nice" topology. The Becker-Kechris theorem can be seen as characterizing the extent to which this remains true in the presence of a group action. We give a new proof of the Becker-Kechris theorem, and use it to extend the theorem in several directions: to n-ary relations; to groupoids; to non-Hausdorff spaces; and even to point-free "spaces".

Commutative Algebra  
**Thursday, September 29, 2022, 3:00pm-4:00pm**  
https://umich.zoom.us/j/96274532499 (password: algebra) Virtual East Hall  
**Anna Brosowsky (University of Michigan)**  
*The Cartier core map for Cartier algebras*

For a local $F$-finite ring, the splitting prime is an "obstruction" to strong $F$-regularity. In this talk, we will define the self-map on the Frobenius split locus of a ring $R$ which sends a point $P$ to the splitting prime of $R_P$, and discuss the generalization of this map to the setting of Cartier algebras. We will go over some properties of this map and, as an application, will show how it behaves for Stanley-Reisner rings.

Differential Equations  
**Thursday, September 29, 2022, 4:00pm-5:00pm**  
4088 East Hall  
**Xiao Ma (Princeton)**  
*Derivation of wave kinetic equations for three wave models*

Wave kinetic equations (WKE) describe the statistical behavior of turbulence in wave equations. In this presentation, I will first give a brief introduction to the physics of wave turbulence and discuss papers of Deng and Hani about the derivation of WKE for four wave models. Then I present my recent paper about the derivation of wave kinetic equations for a three wave model, the KZ equation. The proof is based on a detailed graphical analysis of degeneracy manifold of the resonant surface.

Arithmetic Geometry Learning  
**Thursday, September 29, 2022, 4:00pm-6:00pm**  
4096 East Hall  
**Alexander Bauman (UM)**  
*Local obstructions to rational points, local-to-global principle, weak approximation*
Student Dynamics/Geometry Topology
Thursday, September 29, 2022, 4:00pm-5:00pm
3096 East Hall
Reebhu Bhattacharyya (University of Michigan)
Quantization: The Possibles and Impossibles

Going from classical to quantum mechanics involves promoting observables (like position and momentum) to the status of operators acting on a Hilbert space. This process is called quantization. We will describe a basic quantization scheme for Euclidean space and some theorems related to it, namely the Stone-von Neumann theorem and the Groenewold-Van Hove theorem.

Mathematics Communications
Thursday, September 29, 2022, 4:00pm-5:00pm
1866 East Hall
Sam Hansen (University of Michigan, Ann Arbor)
TBA

This week in the Mathematics Communication seminar we will be discussing the podcast episode Chinook from Relatively Prime (http://relprime.com/chinook) and analyzing its story for things like narrative structure, events, characters, and more. Do not worry if that does not sound like a familiar thing to do, we will be doing it as a group (and I just happen to be the producer who put the episode together so I will even be able to discuss the authorial intent and decisions that went into its structure). I will also put a copy of the audio file in the Google Drive Directory for the Seminar https://tinyurl.com/mathCommSemF22
Optimization is a human instinct. People constantly seek to improve their lives and the systems that surround them. Engineers seek to minimize the energy consumption and cost of vehicles. Although some optimization problems can be solved analytically, most practical problems of interest must be solved numerically. Despite the progress in high-fidelity numerical simulations enabled by high-performance computing, challenges have remained in using these simulations for design optimization. This talk focuses on the developments that enabled high-fidelity design optimization of aircraft and other engineering systems. The challenges addressed include handling a large number of design variables, robust and efficient large-scale simulations, effective geometry and mesh handling, and efficient discipline coupling. To tackle these issues, we combine gradient-based optimization algorithms with adjoint gradient computation and develop an adaptive coupled Newton-Krylov approach to solve the coupled numerical simulations efficiently and robustly. The methods we developed to tackle this problem are generalized in an open-source framework for multidisciplinary analysis and optimization. This and other open-source tools developed in this work open the door to further advances in algorithms and their application to aircraft design and beyond.

In algebraic geometry, even if one is only interested in smooth spaces, it is inevitable that some singular spaces will arise, even from the most basic operations like intersecting smooth varieties or looking at fibers of morphisms. In this talk, I will describe several classes of singularities and some tools which are used in the study of singularities.
Combinatorics
Friday, September 30, 2022, 3:00pm-4:00pm
4088 East Hall
Steven Karp (University of Notre Dame)
q-Whittaker functions, finite fields, and Jordan forms

The q-Whittaker symmetric function associated to an integer partition is a q-analogue of the Schur symmetric function. Its coefficients in the monomial basis enumerate partial flags compatible with a nilpotent endomorphism over the finite field of size 1/q. We show that considering pairs of partial flags and taking Jordan forms leads to a probabilistic bijection between nonnegative-integer matrices and pairs of semistandard tableaux of the same shape, which we call the q-Burge correspondence. In the q -> 0 limit, we recover a known description of the classical Burge correspondence (also called column RSK). We use the q-Burge correspondence to prove enumerative formulas for certain modules over the preprojective algebra of a path quiver. This is joint work with Hugh Thomas.
Student AIM Seminar
Friday, September 30, 2022, 4:00pm-5:00pm
2866 East Hall
Amaya Murguia (University of Michigan)

Representation Learning of Resting State Functional Magnetic Resonance Imaging Using Variational Autoencoder with Convolutional Neural Network and Transformer

A variational autoencoder (VAE) based on a convolutional neural network (CNN) architecture has been applied to resting state functional magnetic resonance imaging (rsfMRI) data to learn compressed latent representations. The VAE method can reconstruct and generate rsfMRI images using the latent representations as the input, and the latent representations can be used to discover brain networks and characterize individual variation. However, a CNN architecture fails to account for long-range connectivity and interactions among different brain regions. To overcome this limitation, we have further refined the VAE model by adding a spatial transformer module to the CNN. The transformer module uses a self-attention mechanism to learn dynamic and long-range interactions between brain regions. After training the model with data from the Human Connectome Project, we present tests comparing the performance of compressing and reconstructing the patterns of rsfMRI activity for various levels of compression. We also compare this method to principal component analysis (PCA). Analysis of the self-attention matrices from the transformer may provide insight into the dynamic functional connectivity of different brain regions of interest (ROI). This model is also expected to open new ways for using rsfMRI data to classify and characterize patients with different conditions of neurological disorders.

Variational Analysis and Optimization
Friday, September 30, 2022, 9:00am-10:00am
Virtual

Shawn Wang (University of British Columbia - Canada)

A Bregman inertial forward-reflected-backward method for nonconvex minimization

We propose a Bregman inertial forward-reflected-backward method for nonconvex composite problems. Our analysis relies on a novel approach that imposes general conditions on implicit merit function parameters, which yields a stepsize condition that is independent of inertial parameters. In turn, a question of Malitsky and Tam regarding whether FRB can be equipped with a Nesterov-type acceleration is resolved. Assuming the generalized concave Kurdyka-Lojasiewicz property of a quadratic regularization of the objective, we obtain sequential convergence as well as convergence rates on both the function value and actual sequence. Joint work with Ziyuan Wang