## Weekly Seminar & Events Bulletin
October 30th, 2022 - November 5th, 2022

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<th>Monday, October 31, 2022</th>
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<tr>
<td>10:00am-11:00am <strong>Integrable Systems and Random Matrix Theory</strong> -- Marcelo Campos (IMPA) <em>The least singular value of a random symmetric matrix</em> -- ZOOM ID: 926 6491 9790 Virtual</td>
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<td>3:00pm-4:15pm <strong>RTG Seminar on Number Theory</strong> -- Kartik Prasanna (UM) <em>The Sakellaridis--Venkatesh conjectures</em> -- 4088 East Hall</td>
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<td>4:00pm-5:00pm <strong>Complex Analysis, Dynamics and Geometry</strong> -- Malavika Mukundan (U(M)) <em>Dynamical approximation of entire functions</em> -- 3096 East Hall</td>
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<td>4:00pm-5:00pm <strong>Integrable Systems and Random Matrix Theory</strong> -- Promit Ghosal (MIT) <em>Fractal Geometry of the KPZ equation</em> -- 4096 East Hall</td>
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<td>4:00pm-5:00pm <strong>Student Combinatorics</strong> -- Ryuichi Man (UM) <em>Schur Polynomials and Littlewood-Richardson Rule</em> -- 3866 East Hall</td>
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<td>5:00pm-6:00pm <strong>Student Analysis</strong> -- Katja Vassilev (University of Michigan) <em>Birkhoff Normal Form for Hamiltonian PDEs</em> -- 3096 East Hall</td>
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<td>4:00pm-5:30pm <strong>Logic</strong> -- Ronnie Chen (University of Michigan) <em>On the Joyal--Tierney descent theorem in countable model theory</em> -- 3088 East Hall</td>
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<tr>
<td>9:00am-10:00am</td>
<td>Variational Analysis and Optimization -- Henry Wolkowicz (University of Waterloo)[Strict Feasibility and Degeneracy in Linear Programming -- Virtual]</td>
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<tr>
<td>2:00pm-3:00pm</td>
<td>Group, Lie and Number Theory -- Carlo Pagano (Concordia University)[On the size and structure of images of Arboreal Galois representations (Note: special day) -- 4088 East Hall]</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics (AIM) -- Alexandre Watson (University of Minnesota)[Moiré-scale PDE models of twisted bilayer graphene -- 1084 East Hall]</td>
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<td>3:00pm-4:00pm</td>
<td>Combinatorics -- Yibo Gao (University of Michigan)[Symmetric structures in the strong Bruhat order -- 4088 East Hall]</td>
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<td>3:00pm-3:50pm</td>
<td>Student Algebraic Geometry -- James Hotchkiss (Michigan)[The exponential exact sequence -- 2866 East Hall]</td>
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<tr>
<td>4:00pm-5:00pm</td>
<td>MCAIM Graduate Seminar -- April Nellis (University of Michigan)[A neural network approach to high-dimensional optimal switching problems with jumps -- 2866 East Hall]</td>
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Integrable Systems and Random Matrix Theory  
Monday, October 31, 2022, 10:00am-11:00am  
ZOOM ID: 926 6491 9790 Virtual  
Marcelo Campos (IMPA)  

*The least singular value of a random symmetric matrix*

Let $A$ be an $n \times n$ symmetric matrix with $(A_{i,j})_{i \leq j}$ independent and identically distributed according to a subgaussian distribution. I will present a recent result in which we provide lower tail estimates for the least singular value of $A$ which are tight up to a constant factor. This is joint work with Matthew Jenssen, Marcus Michelen and Julian Sahasrabudhe.

*A recording of the talk can be found [here](https://youtu.be/uVvmjjMRc0g).*

RTG Seminar on Number Theory  
Monday, October 31, 2022, 3:00pm-4:15pm  
4088 East Hall  
Kartik Prasanna (UM)  

*The Sakellaridis--Venkatesh conjectures*

The goal of the S-V conjectures is to understand the relation between automorphic periods and L-values, as well as questions about distinction, both locally and globally. The motivating theorem is that of Tunnell-Saito-Waldspurger (T-S-W) for $GL_2$ and its inner forms, later generalized by the Gan-Gross-Prasad (G-G-P) and Ichino-Ikeda (I-I) conjectures. The SV conjectures are a further vast generalization of this circle of ideas to the setting of spherical varieties, though not yet formulated at the same level of precision. I will start by recalling the work of T-S-W, G-G-P and I-I to put things in context, then explain how the S-V conjectures generalize all of this.
Complex Analysis, Dynamics and Geometry  
*Monday, October 31, 2022, 4:00pm-5:00pm*  
3096 East Hall  
*Malavika Mukundan (U(M))*  
*Dynamical approximation of entire functions*

Post singularly finite holomorphic functions are entire functions for which the forward orbit of the set of critical and asymptotic values is finite. Motivated by the work of Bodelon-Devaney-Hayes-Roberts-Goldberg-Hubbard on approximating exponential functions dynamically by unicritical polynomials, we ask the following question:

Given a post singularly finite entire function $f$, can $f$ be realized as the locally uniform limit of a sequence of post critically finite polynomials?

In joint work (in progress) with Nikolai Prochorov and Bernhard Reinke, we show how we may answer this question in the affirmative.

Integrable Systems and Random Matrix Theory  
*Monday, October 31, 2022, 4:00pm-5:00pm*  
4096 East Hall  
*Promit Ghosal (MIT)*  
*Fractal Geometry of the KPZ equation*

The Kardar-Parisi-Zhang (KPZ) equation is a fundamental stochastic PDE related to many important models like random growth processes, Burgers turbulence, interacting particles system, random polymers etc. In this talk, we focus on how the tall peaks and deep valleys of the KPZ height function grow as time increases. In particular, we will ask what is the appropriate scaling of the peaks and valleys of the $(1+1)$-d KPZ equation and whether they converge to any limit under those scaling. These questions will be answered via the law of iterated logarithms and fractal dimensions of the level sets. The talk will be based on joint works with Sayan Das and Jaeyun Yi. If time permits, I will also mention an interesting story about the $(2+1)$-d and $(3+1)$-d case (work in progress with Jaeyun Yi).

Student Combinatorics  
*Monday, October 31, 2022, 4:00pm-5:00pm*  
3866 East Hall  
*Ryuichi Man (UM)*  
*Schur Polynomials and Littlewood-Richardson Rule*

The Schur polynomials are an important collection of symmetric polynomials indexed by partitions, and the Littlewood-Richardson rule provides a combinatorial method to express the product of two Schur polynomials as a linear combination of Schur polynomials. In this talk, I shall begin with an introduction to the notion of tableaux and use it to define Schur polynomials. Then, I will state and prove the Littlewood-Richardson rule, and discuss some of its implications in representation theory.
Group, Lie and Number Theory  
Monday, October 31, 2022, 4:30pm-5:30pm  
4088 East Hall  
Congling Qiu (Yale University)  
*Arithmetic mixed Siegel-Weil formulas and modular forms of arithmetic divisors*

The classical Siegelâ€“Weil formula relates theta series to Eisenstein series and its arithmetic version is central in Kudla's program. I will discuss arithmetic mixed Siegel-Weil formulas. I will focus on the one in the work of Gross and Zagier, and the one in my recent work. As an application, I obtained modular generating series of arithmetic extensions of Kudla's special divisors for unitary Shimura varieties over CM fields with arbitrary split level. This provides a partial solution to a problem of Kudla.

Student Commutative Algebra  
Tuesday, November 01, 2022, 3:00pm-4:00pm  
3866 East Hall  
Hyunsuk Kim (UM)  
*Syzgies, Minimal resolution and Castelnuovo-Mumford regularity*

Parallel to the story of syzygies for modules over local rings, we can implant the situation to graded modules over graded rings and study graded minimal free resolutions. I will talk about how we can use them in the context of algebraic geometry to obtain effective results.

Colloquium Series  
Tuesday, November 01, 2022, 4:00pm-5:00pm  
on Zoom Virtual  
Jed Buchwald (California Institute of Technology)  
*Isaac Newton and the Origin of Civilization*

Isaac Newton, who renovated the foundations of mathematics, optics, and mechanics in the 17th century, aimed also to overturn the entire history of civilization. By the late 1690s Newton had become convinced that the natural rate of population growth implied that elaborately organized social life had not arisen until near the time of Solomon’s kingdom. He canvassed ancient texts for words that could be pruned and transformed into supporting evidence deploying in the process the earliest known procedures for handling discrepant data, and reconstructing the very plan of Solomon’s temple. Here we will find Newton's unorthodox religious convictions interacting in complex ways with the new methods that he had introduced into experimental science. And we will also see how the most sophisticated of techniques can produce error when data is massaged to fit a strongly-held conviction.

Zoom link:
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https://umich.zoom.us/j/95169432750
Passcode  123456

Student Analysis
Tuesday, November 01, 2022, 5:00pm-6:00pm
3096 East Hall
Katja Vassilev (University of Michigan)
Birkhoff Normal Form for Hamiltonian PDEs

In this talk, we will use Birkhoff Normal Form to prove stability for specific (strongly-nonresonant) PDEs. We will begin with an overview of Hamiltonian Formalism for PDEs. Then, we will discuss the non-resonance conditions that we need and why we need them. The brunt of the talk will focus on the statement of Birkhoff Normal Form and how it can be used to prove long-time stability of a Hamiltonian PDE. We will also discuss the algorithm for Birkhoff Normal Form. Time permitting, we will discuss more recent work that has proved Nekhoroshev time stability for the NLS with a specific convolution potential.

Learning Seminar in Algebraic Combinatorics
Wednesday, November 02, 2022, 2:30pm-4:00pm
4088 East Hall
Amanda Schwartz (University of Michigan)
Tilings with Convex Polygons

I will discuss tilings with convex polygons and their relationship to the dimer model. I will introduce certain types of tilings called T-graphs and discuss connections to Dehn's theorem about tiling a rectangle with squares and Menelaus' theorem from Euclidean geometry.

Student Arithmetic
Wednesday, November 02, 2022, 3:00am-4:00am
1866 East Hall
Paul Mammen ()
Bhargava Cubes approach to quadratic forms

The foundations of binary quadratic forms were laid in the 19th century by Gauss. We shall look at a novel approach to this classical theory due to Manjul Bhargava centered around the Bhargava Cube, a cube with numbers at the vertices which encode the information about related quadratic forms.
Algebraic Geometry
Wednesday, November 02, 2022, 4:00pm-5:30pm
4096 East Hall
Stephen Pietromonaco (University of Michigan)
A Theory of Gopakumar-Vafa Invariants for Orbifold Calabi-Yau Threefolds

The first part of the talk will be an expository survey of the Gopakumar-Vafa (GV) invariants of a Calabi-Yau threefold. The GV invariants are "virtual counts" of genus \( g \) curves in a fixed curve class. They are the best such invariants in that they conjecturally: (1) most accurately reflect the content of genus \( g \) curves in the class; (2) are zero for all but finitely many \( g \) in a fixed class; and (3) they underlie all other curve-counting theories people may have heard of (Gromov-Witten, Donaldson-Thomas, Pandharipande-Thomas). My main example will be a local K3 surface. In the second part of the talk, I will describe work in progress with Jim Bryan where we develop the theory of GV invariants for certain orbifold Calabi-Yau threefolds. I'll give formulas for the invariants in terms of modular forms and theta functions for the case of local orbifold K3 surfaces.

Financial/Actuarial Mathematics
Wednesday, November 02, 2022, 4:00pm-5:00pm
1360 East Hall
Zhenhua Wang (UM)
Stability of Equilibria in Time-inconsistent Stopping Problems

We investigate the stability of equilibrium-induced optimal values with respect to reward functions (which is denoted by \( f \)) and transition kernels (which is denoted by \( Q \)) for time-inconsistent stopping problems under non-exponential discounting in discrete time. First, with locally uniform convergence of \( f \) and \( Q \) equipped with total variation distance, we show that the optimal value is semi-continuous w.r.t. \((f,Q)\). We provide examples showing that exact continuity may fail. Next we show that, with the uniform convergence of \( f \) and \( Q \), the optimal value is continuous w.r.t. \((f,Q)\) under a relaxed limit over epsilon-equilibria. This is a joint work with Erhan Bayraktar and Zhou Zhou.

Logic
Wednesday, November 02, 2022, 4:00pm-5:30pm
3088 East Hall
Ronnie Chen (University of Michigan)
On the Joyal--Tierney descent theorem in countable model theory

The Joyal--Tierney descent theorem in topos theory, when stated in model-theoretic terms, says that given an infinitary interpretation inducing a "continuous open quotient" between spaces of models, the "quotient" theory may be recovered as the "equivariant" part of the theory into which it's interpreted. I will give an exposition of the Joyal--Tierney theorem from this perspective. No knowledge of toposes or category theory will be needed.
Differential Equations  
**Thursday, November 03, 2022, 4:00pm-5:00pm**  
4088 East Hall  
**Konstantin Matetski (MSU)**  
*Polynuclear growth and the Toda lattice*  

Polynuclear growth is one of the basic models in the Kardar-Parisi-Zhang universality class, which describes a one-dimensional crystal growth. For a particular initial state, its one-point value equals the length of the longest increasing subsequence for uniformly random permutations (whose asymptotic behavior was first studied by S. Ulam). In my joint work with J. Quastel and D. Remenik, we computed the distribution function of the polynuclear growth with arbitrary initial conditions. These formulas allowed us to express the distribution function in terms of the solutions of the Toda lattice, one of the classical integrable systems. A suitable rescaling of the model yields a non-trivial continuous limit of the polynuclear growth (the KPZ fixed point) and the respective equations (Kadomtsev-Petviashvili).

Arithmetic Geometry Learning  
**Thursday, November 03, 2022, 4:00pm-12:00am**  
4096 East Hall  
**Lena Ji (UM)**  
*The fibration method*

Student Dynamics/Geometry Topology  
**Thursday, November 03, 2022, 4:00pm-5:00pm**  
3096 East Hall  
**Urshita Pal (University of Michigan)**  
*A Gentle Introduction to Representation Stability*  

Representation Stability is a phenomenon observed in many families of spaces - such as the pure braid groups, flag varieties, etc. - where the (co)homologies of a growing family of spaces stabilize as representations of a group.  
In this talk I will explain this phenomenon by focusing on (pure) braid groups as an example, with lots of pictures and minimal prerequisites.
Arboreal Galois groups are constructed upon iterating a rational function. A general expectation about them is that over arithmetic fields these Galois groups should be as complicated as possible, unless the dynamics of the rational map is of an extremely special kind. What the word "special" exactly means, depends on the property at hand. We will discuss three instances, the Galois groups being topologically big (special is conjectured to be "post-critically finite maps" in analogy of Serre's open image theorem), the Galois group being non-abelian (special is conjectured to be "conjugate to a Chebichev or a power polynomial"), the sequence of Galois groups of the iterates are big in size (special here is conjecture to be given by "exceptional maps"). Namely I will discuss past and ongoing joint work in progress with Andrea Ferraguti on each of these conjectures and how they relate to each other.

2D materials are materials consisting of a single sheet of atoms. The first 2D material, graphene, a single sheet of carbon atoms, was isolated in 2005. In recent years, attention has shifted to materials created by stacking 2D materials with a relative twist. Such materials are known as moire materials because of the approximate periodicity of their atomic structures over long distances, known as the moire pattern. In 2018, experiments showed that, when twisted to the first so-called ``magic angle" (approximately 1 degree), twisted bilayer graphene exhibits exotic quantum phenomena such as superconductivity. I will present the first rigorous justification of the Bistritzer-MacDonald moire-scale PDE model of twisted bilayer graphene, which played a critical role in identifying twisted bilayer graphene's magic angles, from a microscopic tight-binding model. If time permits, I will discuss the chiral model, a simplification of the Bistritzer-MacDonald model with remarkable spectral properties.

The Bruhat order encodes algebraic and topological information of Schubert varieties in the flag manifold and possesses rich combinatorial properties. In this talk, we discuss three interrelated stories regarding the Bruhat order: self-dual Bruhat intervals, Billey-Postnikov decompositions and automorphisms of the Bruhat graph. This is joint work with Christian Gaetz.
The exponential exact sequence is a short exact sequence of sheaves on a smooth complex manifold, e.g., a smooth complex projective variety. The goal of the talk is to describe the corresponding long exact sequence of cohomology groups. We will see that, far from being mundane, the long exact sequence connects a number of interesting invariants of the variety, including the Picard group, the Chern character, Hodge structures, the Brauer group, and the topological Brauer group. No prior background on these topics is necessary.

We develop a backward-in-time machine learning algorithm that uses a sequence of neural networks to solve optimal switching problems in energy production, where electricity and fossil fuel prices are subject to stochastic jumps. We then apply this algorithm to a variety of energy scheduling problems, including novel high-dimensional energy production problems. Our experimental results demonstrate that the algorithm performs with accuracy and experiences linear to sub-linear slowdowns as dimension increases, demonstrating the value of the algorithm for solving high-dimensional switching problems.

Currently, the simplex method and the interior point method are indisputably the most popular algorithms for solving linear programs. Unlike general conic programs, linear programs with a finite optimal value do not require strict feasibility in order to establish strong duality. Hence strict feasibility is often less emphasized. In this note we discuss that the lack of strict feasibility necessarily causes difficulties in both simplex and interior point methods. In particular, the lack of strict feasibility implies that every basic feasible solution is degenerate. We achieve this using facial reduction and simple means of linear algebra. Furthermore, we emphasize that facial reduction involves two steps where the first guarantees strict feasibility, and the second recovers full-row rankness of the constraint matrix.

(joint work with: Jiyoung (Haesol) Im)