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<th>Day</th>
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<td>Wednesday, November 16, 2022</td>
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<td><strong>Learning Seminar in Algebraic Combinatorics</strong> -- George Seelinger (University of Michigan) Producing a Poisson cluster variety using dimer models II</td>
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<td>2:30pm-4:00pm</td>
<td><strong>Student Arithmetic</strong> -- Oscar Gonzalez () Cubic Reciprocity</td>
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<td><strong>Algebraic Geometry</strong> -- Louis Esser (UCLA) Quotient singularities in the Grothendieck ring of varieties</td>
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<td>9:00am-10:00am</td>
<td><strong>Commutative Algebra</strong> -- Sasha Pevzner (University of Minnesota) Symmetric group fixed quotients of polynomial rings</td>
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<td><strong>Topology</strong> -- Nicholas Wawrykow (U Michigan) Representation Stability and Disk configuration spaces</td>
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<td>3:00pm-4:00pm</td>
<td><strong>Differential Equations</strong> -- Dallas Albritton (Princeton University) Non-uniqueness of Leray solutions to the forced Navier-Stokes equations</td>
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<td>4:00pm-5:00pm</td>
<td><strong>Arithmetic Geometry Learning</strong> -- Alison Miller (UM) Insufficiency of the Brauer--Manin obstruction</td>
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<td>4:00pm-5:00pm</td>
<td><strong>Student Dynamics/Geometry Topology</strong> -- Christopher Stith (University of Michigan) Hodge systems and the uniformization theorem</td>
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<td>9:00am-10:00am</td>
<td>Variational Analysis and Optimization -- Harbir Antil (George Mason University)</td>
<td>Optimization Problems Constrained by PDEs and Augmented Lagrangian Methods -- Virtual</td>
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<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics (AIM)</strong> -- Maria Han Veiga (University of Michigan)</td>
<td>Towards high fidelity numerical simulations: using machine learning models</td>
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<td>Combinatorics -- Yurii Burman (Higher School of Economics, Moscow)</td>
<td>Matrix-tree theorems, higher determinants, and the Tutte-Bernardi polynomial</td>
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<td>4:00pm-5:00pm</td>
<td>MCAIM Graduate Seminar -- Reebhu Bhattacharyya (University of Michigan)</td>
<td>Complex-valued Hamiltonians in Classical and Quantum Mechanics</td>
<td>2866 East Hall</td>
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<td>4:00pm-5:30pm</td>
<td>Preprint Algebraic Geometry -- Riku Kurama</td>
<td>Integral Fourier transforms and the integral Hodge conjecture for one-cycles on abelian varieties</td>
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Abstracts for the week of November 13th, 2022 - November 19th, 2022

RTG Seminar on Number Theory
Monday, November 14, 2022, 3:00pm-4:15pm
4088 East Hall
Chen Wan (Rutgers University - Newark)
Local relative character for some strongly tempered spherical varieties

In this talk, I will explain how to compute the local relative character for strongly tempered spherical varieties in the unramified case. I will first explain the general strategy of the computation, then I will give some specific examples. This is a joint work with Lei Zhang.

Algebraic Topology
Monday, November 14, 2022, 3:00pm-4:00pm
1866 East Hall
Hana Jia Kong (Institute for Advanced Study)
Toward a $C_p$ analog of the real motivic category

The real motivic stable homotopy category has a close connection to the $C_2$-equivariant stable homotopy category. From a computational perspective, the real motivic computation can be viewed as a simpler version which "removes the negative cone" in the $C_2$-equivariant stable homotopy groups. On the other hand, the work of Burklund--Hahn--Senger shows that one can deform the completed $C_2$-equivariant category to get the completed Artin--Tate real motivic category. The $C_2$-effective spectral sequence plays an important role in the deformation point of view; it calculates the Artin--Tate homotopy groups.

In the ongoing project with Gabriel Angelini-Knoll, Mark Behrens, and Eva Belmont, we try to build a $C_p$ analog of this story for an odd prime $p$. We give a new interpretation of the $C_2$-effective spectral sequence, and we show that this interpretation generalizes to the odd prime case. This gives a deformation of the Borel equivariant stable homotopy category for more general groups.
Complex Analysis, Dynamics and Geometry  
Monday, November 14, 2022, 4:00pm-5:00pm  
3096 East Hall  
Caroline Davis (Indiana)  
*Carpets, Matings and Carpet Matings*

We begin by introducing Sierpinski carpets and matings and why they are interesting in complex dynamics. Then, we describe work in progress (joint with Insung Park) to give a combinatorial criterion for a mating to be a carpet and, as an application, to quantify the expected topology of a random mating. This problem has parallels in group theory and in knot theory.

Lastly, we will take a step back to parameter space and illustrate how the potential failures for matings to be carpets can be witnessed by the behavior of hyperbolic components. In particular, we will contextualize this work within a special dynamical subvariety of the moduli space of quadratic rational maps.

Integrable Systems and Random Matrix Theory  
Monday, November 14, 2022, 4:00pm-5:00pm  
ZOOM ID: 926 6491 9790 Virtual  
Klara Courteaut (KTH)  
*Rate of convergence of linear statistics for the compact classical groups - from Berry-Esseen to super-exponential*

The Berry-Esseen theorem gives the rate of convergence of a normalized sum of $n$ i.i.d. random variables to its limiting Gaussian. Assuming finite third absolute moment, the difference between the cumulative distributions decays uniformly like $n^{-1/2}$. We consider the rate of convergence of the moments of the spectral distribution of random matrices from the compact classical groups. Equivalently, we study the trace of the powers of the matrices. We show that the (stronger) total variation norm has a bound which interpolates between the Berry-Esseen bound - when the power $m$ is close to the size of the matrix $n$ - and a bound which decays faster than $1/n!$ when $m$ is equal to one.

A recording of the talk can be found [here](https://youtu.be/WZn7g4z_zx0).

Student Combinatorics  
Monday, November 14, 2022, 4:00pm-5:00pm  
3866 East Hall  
Katie Waddle (UM)  
*An Introduction to Coxeter Groups*

Coxeter groups formalize and abstract reflection groups, and combine combinatorics, algebra, and geometry in surprising ways. The matrices define groups, the groups have orders, the graphs determine placement of mirrors, it's madness! We will try our hand at working with some basic definitions and get a taste of Bruhat order.
Group, Lie and Number Theory  
Monday, November 14, 2022, 4:30pm-5:30pm  
4088 East Hall  
Chen Wan (Rutgers)  
*Local multiplicity for some strongly tempered spherical varieties*  

In this talk, I will discuss the local multiplicity problem for some strongly tempered spherical varieties. First I will show that the summation of the multiplicity is equal to 1 over every tempered local L-packet. Then I will formulate a uniform epsilon dichotomy conjecture for these models. Finally, I will prove the epsilon dichotomy conjecture in many cases. This is a joint work with Lei Zhang.

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Colloquium Series  
Tuesday, November 15, 2022, 3:00pm-4:00pm  
1360 East Hall  
Jianfeng Lu (Duke University)  
*Analysis of score-based generative models*  

Diffusion models, such as score-based generative models, have achieved impressive performance in generation of samples from complex data distributions such as that of images and audio. It is based on evolving a stochastic differential equation (SDE) that transforms white noise into a sample from the learned distribution, using estimates of the score function, or gradient log-pdf. In this talk, we will discuss some recent progress in analysis of such approaches, in particular, assuming L2-accurate score estimates, we obtain polynomial complexity bound for approximating the target distribution without structural assumptions such as log-Sobolev inequalities.
Special Events
Tuesday, November 15, 2022, 4:00pm-6:00pm
University Hall - 2nd Floor Ruthven Museums Building
Karen Smith, Joel Slemrod, and Lutgarde Raskin (UM)
Distinguished University Professorship Lecture Series

President Santa J. Ono and Provost Laurie K. McCauley invite you to join them in honoring and celebrating three Distinguished University Professorship awardees as they present on their career work in our 2022 lecture series, moderated by Michael J. Solomon, Dean and Vice Provost for Academic Affairs - Graduate Studies.

Please register here: https://umich.formstack.com/forms/2022fall_dup
**A livestream link will be provided to those who register to attend virtually.

"Singularities"
KAREN SMITH
William Fulton Distinguished University Professor of Mathematics, College of Literature, Science, and the Arts

"Life and Taxes"
JOEL SLEMROD
David Bradford Distinguished University Professor of Economics, Department of Economics; Paul W. McCracken Collegiate Professor of Business Economics and Public Policy, Stephen M. Ross School of Business

"Managing Microbiomes in Urban Water Systems"
LUTGARDE RASKIN
Vernon L. Snoeyink Distinguished University Professor of Environmental Engineering, Altarum/ERIM Russell O'Neal Professor of Engineering, Department of Civil and Environmental Engineering, College of Engineering
Learning Seminar in Algebraic Combinatorics  
Wednesday, November 16, 2022, 2:30pm-4:00pm  
4088 East Hall  
George Seelinger (University of Michigan)  
*Producing a Poisson cluster variety using dimer models II*

Last time, we discussed how the coordinate ring of the moduli space of line bundles on a graph provided the right object to give gauge invariant functions on bipartite graphs. We then discussed how to glue together such moduli spaces to get a global modified partition function on the graph and how to associate a Newton polygon to it. In this lecture, we will explore how to recover a family of graphs whose moduli spaces of line bundles are all related by a cluster mutation. We will also define a Poisson structure of these varieties and discuss the construction of special Casimir elements with respect to the Poisson structure. Finally, time permitting, we will discuss how this leads to a set of Hamiltonians corresponding to the interior points of the Newton polygon.

Student Arithmetic  
Wednesday, November 16, 2022, 3:00pm-4:00pm  
1866 East Hall  
Oscar Gonzalez ()  
*Cubic Reciprocity*

I will discuss a specific example of cubic reciprocity and show how this is generalized by Langlands' reciprocity conjectures relating Galois representations to modular forms.

Algebraic Geometry  
Wednesday, November 16, 2022, 4:00pm-5:30pm  
4096 East Hall  
Louis Esser (UCLA)  
*Quotient singularities in the Grothendieck ring of varieties*

The class of a smooth projective variety in the Grothendieck ring of varieties contains a great deal of geometric information. For example, a famous result of Larsen and Lunts shows that this ring detects stable rationality of varieties that are smooth and projective. The interpretation of classes of singular varieties is less clear, but for certain types of singular varieties, we can "pretend" they are smooth for the purpose of detecting stable rationality. In this talk, we'll explore what types of quotient varieties belong to this class. This talk is based on joint work with Federico Scavia (https://arxiv.org/abs/2208.14313).
Financial/Actuarial Mathematics  
Wednesday, November 16, 2022, 4:00pm-5:00pm  
1360 East Hall  
April Nellis (UM)  

A neural network approach to high-dimensional optimal switching problems with jumps

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.

Logic  
Wednesday, November 16, 2022, 4:00pm-5:30pm  
3088 East Hall  
Andreas Blass (UMich)  

Herbrand's Theorem

I'll begin by explaining and proving Herbrand's theorem, which very nearly reduces first-order validity to propositional validity. "Very nearly reduces" sounds overly optimistic, since propositional validity is decidable and first-order validity isn't, but I hope to convince people that it's not unreasonable. I also hope to convince people that Herbrand's theorem can serve as a substitute for the completeness theorem in many situations, and that it's actually better than completeness for some purposes.

Commutative Algebra  
Thursday, November 17, 2022, 3:00pm-4:00pm  
East Hall  
Sasha Pevzner (University of Minnesota)  

Symmetric group fixed quotients of polynomial rings

Let the symmetric group act on the polynomial ring $S$ in $n$ variables via variable permutation. We consider the quotient module $M$ which sets a monomial equal to all of its images under the action. This is a module over the ring of invariants $R$, with relatively little known about its structure. When using integer coefficients, we can embed $M$ as an ideal inside the ring of symmetric polynomials. Doing so gives rise to a family of ideals - one for each $n$. Localizing the coefficient ring of $S$ at a prime $p$ reveals striking behavior in these ideals, which stay stable (in a sense) as $n$ grows, but jump in complexity each time $n$ equals a multiple of $p$. In this talk, we will discuss the construction of this family of ideals, as well as some results and conjectures on its structure.
Church-Ellenberg-Farb and Miller-Wilson proved that for a nice enough manifold X, sequences of homology groups of the ordered configuration space of points in X stabilize as sequences of symmetric group representations. We can generalize the ordered configuration space of points in X by fixing a metric and replacing points with open unit-diameter disks. One of the simplest of these disk configuration spaces is conf(*,w) the ordered configuration space of unit-diameter disks in the infinite strip of width w. Sequences of the homology groups of conf(*,w) do not stabilize as symmetric group representations in the sense of Church-Ellenberg-Farb, Miller-Wilson; however, when the width w=2, Alpert proved they stabilized in a different sense. Alpert's methods do not extend to widths larger than 2. In this talk I discuss the various notions of representation stability, and show how for width w at least 2, the rational homology groups of conf(*,w) stabilize as sequences of symmetric group representations.

In a seminal work, Leray demonstrated the existence of global weak solutions to the Navier-Stokes equations in three dimensions. Are Leray's solutions unique? This is a fundamental question in mathematical hydrodynamics, which we answer in the negative within the 'forced' category, by exhibiting two distinct Leray solutions with zero initial velocity and identical body force. This is joint work with Elia Brué and María Colombo.

In arithmetic geometry, the Brauer--Manin obstruction is a powerful tool to determine the rational points on varieties. However, this obstruction is insufficient in many cases. In this talk, I will discuss instances where the Brauer--Manin obstruction fails to predict the rational points on certain varieties.
We will introduce and discuss the Hodge dual on closed surfaces, as well as a particular class of geometric PDE called Hodge systems. We will discuss the behavior of these systems under conformal isometries, as well as how this behavior, along with a sharp version of the uniformization theorem, can be used to derive estimates to solutions of Hodge systems. Time permitting, applications to problems in general relativity will be discussed.

Variational Analysis and Optimization
Thursday, November 17, 2022, 9:00am-10:00am
Virtual
Patrick Mehlitz (Institute of Mathematics, Brandenburg University of Technology Cottbus-Senftenberg)
A nonsmooth Newton-type method for MPCCs

We show that the M-stationarity system associated with a mathematical program with complementarity constraints (MPCC) can be equivalently written as a system of discontinuous equations which can be tackled with a nonsmooth Newton-type method based on the idea of using Newton-derivatives instead of the classical notion of semismoothness. Local fast convergence of the method is guaranteed under validity of an MPCC-tailored version of LICQ and a suitable strong second-order condition. In case of linear-quadratic MPCCs, the LICQ-type constraint qualification can be replaced by a weaker condition which depends on the underlying multipliers. We discuss a suitable globalization strategy for our method. Some comments regarding numerical results are presented in order to illustrate these theoretical findings.

This talk is based on joint work with Felix Harder and Gerd Wachsmuth (Cottbus, Germany).
Applied Interdisciplinary Mathematics (AIM)
Friday, November 18, 2022, 3:00pm-4:00pm
1084 East Hall
Maria Han Veiga (University of Michigan)
Towards high fidelity numerical simulations: using machine learning models

Many engineering and scientific problems can be described by equations of fluid dynamics, namely, systems of time dependent nonlinear hyperbolic PDEs. The mathematical description of these processes, as well as the numerical discretisation of the resulting PDEs, will depend on the level of detail required to study them.

In this talk, I will present two approaches towards higher fidelity numerical simulations: 1) we develop a new variable shape parameter selection strategy for Radial Basis Function approximations using an unsupervised learning strategy, leading to an adaptive, parameter-free shape parameter estimation for RBFs. 2) we develop fast and accurate data-driven surrogate models to better describe planetary collisions and planetary system formation, by mimicking the coupling of two hydro-dynamics solvers through data-driven surrogate models.

I will finish by presenting some extensions to the frameworks presented, using uncertainty estimates to guide active learning strategies or to better sample datasets.

Combinatorics
Friday, November 18, 2022, 3:00pm-4:00pm
4088 East Hall
Yurii Burman (Higher School of Economics, Moscow)
Matrix-tree theorems, higher determinants, and the Tutte-Bernardi polynomial

The Matrix-Tree Theorem is a mid-19th century result by G. Kirchhoff, representing the minors of the Laplace matrix as sums of positive monomials of matrix elements indexed by directed rooted forests. We will present higher-degree generalizations of both notions appearing above: a minor and a forest. The theorem involves an analog, due to O. Bernardi, of the classical Tutte polynomial for directed graphs. Applications include a formula, due to B. Epstein and M. Polyak, for the Casson-Walker invariant of a rational homology 3-sphere.
The Hamiltonian, which is for many systems the energy function, plays an important role in both classical and quantum evolution of systems. Generally, it is a positive real-valued function in classical mechanics corresponding to a positive self-adjoint operator in quantum mechanics. But what happens if we allow it to be complex-valued (i.e., non-Hermitian in the quantum sense)? In this talk, we will explore some interesting geometric aspects of this question. In particular, we will give a quick overview of the Hamiltonian formulation of classical mechanics and how to get a quantum description using a quantization scheme. Then, we will describe the (classical) time evolution of a system under a complex Hamiltonian and finally, we will make a few remarks about what this tells us about quantum evolution.

Integral Fourier transforms and the integral Hodge conjecture for one-cycles on abelian varieties

https://arxiv.org/abs/2202.05230

In the first part of the talk, we analyze an optimization problem constrained by Darcy's law, to design permeability that achieve uniform flow properties despite having nonuniform geometries. We establish well-posedness of the problem, as well as differentiability, which enables the use of rapidly converging, derivate-based optimization methods.

The second part of the talk will focus on ALESQP, which is a general purpose augmented Lagrangian based optimization algorithm that can handle generic constraints such as PDEs. Extensions of ALESQP to risk-averse optimization problems will also be considered.

The talk will end with a few realistic interdisciplinary applications of the above frameworks. Examples include, optimal HVAC outlay to minimize pathogen propagation and numeromorphic imaging.