### Monday, November 28, 2022

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<td>Benjamin Eichinger (Vienna University of Technology) <em>Eigenvalue asymptotics for continuum Schrödinger operators</em> -- ZOOM ID: 926 6491 9790 Virtual</td>
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<tr>
<td>9:00am-10:00am</td>
<td>Special Events</td>
<td>Javier Lopatin (Universidad Adolfo Ibáñez) <em>Sensing Plant Biodiversity and Its Threats: From Drones to Satellites</em> -- 10th Floor Weiser Hall</td>
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| 9:00am-10:00am     | **Variational Analysis and Optimization** -- Quoc Tran-Dinh (UNC-Chapel Hill)  
                      | Root-Finding Algorithms for Co-coercive Equations and Applications -- Virtual |
| 3:00pm-4:00pm      | **Applied Interdisciplinary Mathematics (AIM)** -- Vitaliy Kurkin (University of Liverpool)  
                      | Geometric Data Science: old challenges and new solutions -- 1084 East Hall |
| 3:00pm-3:50pm      | **Student Algebraic Geometry** -- Saket Shah (Michigan)  
                      | Derived Categories for Curves -- 2866 East Hall |
| 3:00pm-4:00pm      | **Combinatorics** -- Lei Xue (University of Michigan)  
                      | A Proof of Grünbaum’s Lower Bound Conjecture for polytopes, lattices, and strongly regular pseudomanifolds -- 4088 East Hall |
| 4:00pm-5:30pm      | **Preprint Algebraic Geometry** -- Stephen Pietromonaco (UM)  
                      | Perverse-Hodge complexes for Lagrangian fibrations -- 4096 East Hall |
| 4:00pm-5:00pm      | **MCAIM Graduate Seminar** -- Chris Stith (University of Michigan)  
                      | Trapped surface formation in general relativity -- 2866 East Hall |
| 4:00pm-5:00pm      | **Geometry** -- Steven Kerckhoff (Stanford)  
                      | Hyperbolic cone-manifolds: degenerating towards flexibility -- 3866 East Hall |
Abstracts for the week of November 27th, 2022 - December 3rd, 2022

RTG Seminar on Number Theory
Monday, November 28, 2022, 3:00pm-4:15pm
4088 East Hall
Guanjie Huang (UM)

The work of Gan--Gomez

Sakellaridis-Venkatesh conjectured a Plancherel decomposition of the local L2 spectrum of a spherical variety coming from the distinguished morphism between the dual groups. In this talk we will introduce how Gan and Gomez verified this conjecture for spherical varieties of low ranks using theta correspondence. If time permits, we will also introduce local relative character identity and its relation with factorization of global period.
Integrable Systems and Random Matrix Theory  
Monday, November 28, 2022, 4:00pm-5:00pm  
ZOOM ID: 926 6491 9790 Virtual  
Benjamin Eichinger (Vienna University of Technology)  
*Eigenvalue asymptotics for continuum Schrödinger operators*

In this talk we survey recent results on asymptotics for the eigenvalues of finite range truncations of continuum Schrödinger operators onto $[0,L]$ as $L \to \infty$. We will study them on different scale levels.

First, we will introduce the notion of Stahl-Totik regularity for continuum Schrödinger operators. This theory is crucially different from the discrete setting, since for unbounded operators $\infty$ becomes a boundary point of the resolvent domain. Recently, we showed that the potential theoretic Green function with pole at $\infty$ and the equilibrium measure, which appear in the theory of bounded operators, should be substituted by the Martin function and the Martin measure. We show that on a macroscopic scale, Stahl-Totik regularity implies that the normalized eigenvalue counting measure converges to the Martin measure.

We will then turn to the microscopic scale and study the local eigenvalue spacing. We show that bulk universality of the Christoffel-Darboux kernel holds for any point $\xi$ where the imaginary part of the $m$-function has a positive finite nontangential limit. In particular, by the Freud-Levin theorem this implies equal asymptotic eigenvalue spacing around $\xi$, where the rate is given by the Christoffel function $L \lambda_L(\xi)$. Finally, we turn to asymptotics of the Christoffel function and show that for Stahl-Totik regular measures, $L \lambda_L(\xi)$ has a limit as $L \to \infty$.

In the course of the talk we will put emphasize on understanding which of those phenomena are local properties and which are global.

The talk is partly based on joint work with Milivoje Lukić and Brian Simanek.

<b>A recording of the talk can be found <a href='https://youtu.be/a14C_DBIdcw'>here</a>.</b>

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**Student Combinatorics**  
Monday, November 28, 2022, 4:00pm-5:00pm  
3866 East Hall  
Dawei Shen (UM)  
*Plücker algebra, Gröbner basis, and connections to representations of GL_n*

Plücker coordinates arise as homogeneous coordinates for Grassmannians and flag varieties. They can be organized into the Plücker algebra, which can be viewed as the quotient of a polynomial algebra by the ideal of Plücker relations. We will introduce the definitions and applications of the Gröbner bases and sagbi bases. We will then find a Gröbner basis for the ideal of Plücker relations and a sagbi basis for the Plücker algebra. Finally, we discuss results that follow from the bases we found and make connections to the combinatorics of representations of $GL_n(\mathbb{C})$. 
Group, Lie and Number Theory  
Monday, November 28, 2022, 4:30pm-5:30pm  
4088 East Hall  
Ken Ono (University of Virginia)  
*Sato-Tate type distributions for hypergeometric varieties*  

Studying the statistical behavior of number theoretic quantities is presently in vogue. The proof of the Sato-Tate Conjecture on point counts of a fixed elliptic curve over finite fields by Richard Taylor (and collaborators) is one of the most significant recent results in the field. Here we discuss point counts in another aspect, for "hypergeometric families" of elliptic curves and K3 surfaces. We obtain Sato-Tate distributions for these families, which turn out to be of SU(2) type (a.k.a. semicircular) and of O3 type (a.k.a. Batman type).

Student Commutative Algebra  
Tuesday, November 29, 2022, 3:00pm-4:00pm  
3866 East Hall  
Dawei Shen (UM)  
*A brief introduction to Stanley-Reisner theory*  

Stanley-Reisner theory provides a link between commutative algebra and combinatorics. We will define simplicial complexes and give the Stanley-Reisner correspondence between square-free monomial ideals in a polynomial ring and simplicial complexes. We will discuss the Alexander dual of simplicial complexes and of square-free monomial ideals. Finally, we present various criterions for Cohen-Macaulayness of a square-free monomial ideal quotient in terms of combinatorial and geometrical information on the corresponding simplicial complex, such as shellability, pureness, and homology.

Learning Seminar in Algebraic Combinatorics  
Wednesday, November 30, 2022, 2:30pm-4:00pm  
4088 East Hall  
Terrence George (University of Michigan)  
*The spectral transform and the Beauville integrable system*  

I will talk about the spectral transform, which is the torus-analogue of the boundary measurement map to the Grassmannian, and how it identifies the cluster integrable system with the Beauville integrable system.

Student Arithmetic  
Wednesday, November 30, 2022, 3:00pm-4:00pm  
1866 East Hall  
Guanjie Huang ()  
*Eisenstein Series and Spectral Decomposition*  

The theory of Eisenstein series has played an important role in the study of automorphic forms. In this talk, we will define a generalization of the Eisenstein series, and introduce Langlands' work on spectral decomposition of the $L^2$ space of the automorphic quotient of a reductive group using the Eisenstein series.
Algebraic Geometry  
**Wednesday, November 30, 2022, 4:00pm-5:30pm**  
4096 East Hall  
**Sarah Frei (Dartmouth)**  
*Symplectic involutions of hyperkahler fourfolds of Kummer type*

The middle cohomology of hyperkahler fourfolds of Kummer type was studied by Hassett and Tschinkel, who showed that a large portion is generated by cycle classes of fixed-point loci of symplectic involutions. In recent joint work with Katrina Honigs, we study symplectic fourfolds over arbitrary fields which are constructed as fibers of the Albanese map on moduli spaces of stable sheaves on an abelian surface. We have extended the results of Hassett and Tschinkel and characterized the Galois action on the cohomology. We do this by giving an explicit description of the symplectic involutions on the fourfolds. This has natural consequences for derived equivalences between Kummer fourfolds.

Financial/Actuarial Mathematics  
**Wednesday, November 30, 2022, 4:00pm-5:00pm**  
1360 East Hall  
**Joseph Jackson (UT Austin)**  
*Approximately distributed stochastic control beyond the mean field setting*

Mean field control (MFC) theory allows us to conclude that certain high-dimensional control problems are "approximately distributed", in the sense that (i) we can construct a "distributed control" (a feedback whose ith component depends only on the position of the ith particle) which is approximately optimal and (ii) the law of the optimally controlled state process is approximately a product measure. Of course, this analysis applies only when the controller's cost functional is symmetric. Nevertheless, it makes sense to ask when we can expect non-symmetric control problems to be approximately distributed as well. In an ongoing joint work with Daniel Lacker, we provide an answer to this question through several explicit estimates. When specialized to the mean field setting, our estimates give a new approach to the (quantitative) convergence problem for MFC which does not require an analysis of the relevant HJB equation on the space of measures.

RTG Seminar on Geometry, Dynamics and Topology  
**Wednesday, November 30, 2022, 4:00pm-5:03pm**  
3866 East Hall  
**Karen Butt (U Michigan)**  
*Quantitative marked length spectrum rigidity.*

The marked length spectrum of a closed Riemannian manifold of negative curvature is a function on the free homotopy classes of closed curves which assigns to each class the length of its unique geodesic representative. It is known in certain cases that the marked length spectrum determines the metric up to isometry, and this is conjectured to be true in general. In this talk, we explore to what extent the marked length spectrum on a sufficiently large finite set approximately determines the metric.
Special Events
Thursday, December 01, 2022, 2:00pm-3:00pm
10th Floor Weiser Hall
Gonzalo Ruz (Universidad Adolfo Ibáñez)
Learning Approaches for the Tree Augmented Naive Bayes Classifier
This talk will review the classical tree augmented naive Bayes classifier (TAN) and then present two alternative learning approaches. The first approach automatically controls the number of edges supported by the training examples in the Bayesian network classifier by adopting a Bayes factor strategy, yielding more realistic network structures. In the second approach, we construct TAN classifiers without estimating conditional mutual information. Instead, the model learns the weights from the data using an evolution strategy to obtain a good classification performance. Applications of these learning approaches will be presented for Twitter sentiment analysis and Orthodontics.

Commutative Algebra
Thursday, December 01, 2022, 3:00pm-4:00pm
https://umich.zoom.us/j/96274532499 (password: algebra) Virtual East Hall
Alexis Hardesty (Texas Tech)
Realizing Differential Graded Algebra Structures on Resolutions of Length Three
Let R be a regular local ring with residue field k and I a perfect ideal of R of grade 3. In 1978, Buchsbaum and Eisenbud showed that a minimal free resolution of R/I has a differential graded (DG) algebra structure, which induces a structure on the Tor algebra. By independent results of Weyman and of Avramov, Kustin, and Miller, this graded algebra structure may be classified into different classes. The classification is incomplete in the sense that it remains open which algebra structures actually occur; this realizability question was formally raised by Avramov in 2012. We survey which classes have been realized in the literature and detail the presenter's contributions to further answer the realizability question.

Arithmetic Geometry Learning
Thursday, December 01, 2022, 4:00pm-6:00pm
4096 East Hall
Nick Rome (UM)
Rational points on average
We've seen in the seminar that while the BMO is explicitly computable, showing that it is the only obstruction can be a tricky issue. Indeed, one of the most successful strategies is to rely on a very difficult conjecture about prime values of polynomials. However, such number theoretic input is a little easier to prove “on average”. We'll discuss what this means for the study of rational points and survey some recent results in this direction.
Monitoring plant biodiversity and its threats are critical for maintaining Earth's functions and services. First, this talk will discuss recent approaches for sensing different components of plant biodiversity, like species presence, abundance, and functions of native and invasive species, using various remote sensing data sources. Secondly, we will discuss alternative approaches to upscale these biodiversity and invasion patterns to the landscape level using a combination of drones and satellites with Machine and Deep Learning algorithms. Finally, we will present the development of our current project, where we are sensing the relationship between plant functional diversity and drought adaptations in Mediterranean environments.
Geometric Data Science develops continuous parameterizations on moduli spaces of data objects up to important equivalences. The key example is a finite or periodic set of unlabeled points considered up to rigid motion or isometry preserving inter-point distances. Periodic point sets model all solid crystalline materials (periodic crystals) with zero-size points at all atomic centers. A periodic point set is usually given by a finite motif of points (atoms or ions) in a unit cell (parallelepiped) spanned by a linear basis. The underlying lattice can be generated by infinitely many bases. Even worse, the set of possible motifs for any periodic set is continuously infinite.

This typical ambiguity of data representation was recently resolved by generically complete and continuous isometry invariants: Pointwise Distance Distributions (PDD) of periodic point sets. The near-linear time algorithm for PDD invariants was tested on more than 200 billion pairwise comparisons of all 660K+ periodic crystals in the world's largest collection of real materials: the Cambridge Structural Database.

The huge experiment above took only two days on a modest desktop and detected five pairs of isometric duplicates. In each pair, the crystals are truly isometric to each other but one atom is replaced with a different atom type, which seems physically impossible without perturbing distances to atomic neighbors. Five journals are now investigating the integrity of the underlying publications that claimed these crystals.

The more important conclusion is the Crystal Isometry Principle meaning that all real periodic crystals have unique geographic-style locations in a common continuous Crystal Isometry Space (CRISP). This space is parameterized by complete isometry invariants and continuously extends Mendeleev's table of elements to all crystals.

Student Algebraic Geometry
Friday, December 02, 2022, 3:00pm-3:50pm
2866 East Hall
Saket Shah (Michigan)

Derived Categories for Curves

For a smooth projective variety X, the derived category is a natural object to study, containing the data of complexes of (quasi-)coherent sheaves with morphisms being maps of complexes up to a weak notion of equivalence. This turns out to be not only a natural bookkeeping device with which to define derived functors in algebraic geometry and commutative algebra, but an interesting geometric invariant in its own right. I will present the definition of the derived category in this setting and some preliminary results, before describing how they classify curves up to isomorphism with some explanation of how the theory extends to higher-dimensional settings. Some exposure to homological algebra and (quasi-)coherent will be useful, but not necessary.

Combinatorics
Friday, December 02, 2022, 3:00pm-4:00pm
4088 East Hall
Lei Xue (University of Michigan)

A Proof of Grünbaum’s Lower Bound Conjecture for polytopes, lattices, and strongly regular pseudomanifolds

In 1967, Grünbaum conjectured that any d-dimensional polytope with d+s ≤ 2d vertices has at least \( \binom{d+1}{k+1} + \binom{d}{k+1} - \binom{d+1-s}{k+1} \) k-faces. In the talk, we will prove this conjecture and discuss equality cases. We will then extend our results to lattices with diamond property (the inequality part) and to strongly regular normal pseudomanifolds (the equality part). We will also talk about recent results on d-dimensional polytopes with 2d+1 or 2d+2 vertices.

Preprint Algebraic Geometry
Friday, December 02, 2022, 4:00pm-5:30pm
4096 East Hall
Stephen Pietromonaco

Perverse-Hodge complexes for Lagrangian fibrations

https://arxiv.org/abs/2201.11283
Trapped surfaces are a central topic of study in mathematical general relativity. Penrose's incompleteness theorem (1965) tells us that the presence of these surfaces in a suitable class of spacetimes implies that the spacetime is geodesically incomplete, thus tying the concept of trapped surfaces to the study of incompleteness and singularity formation in GR. In this talk, we will introduce the concept of trapped surfaces and discuss Christodoulou's breakthrough result from 2009 showing that closed trapped surfaces can form in vacuum via the focusing of incoming gravitational radiation.

Hyperbolic structures on 3-manifolds tend to be rigid, relative to certain boundary data. Families of such structures, with varying boundary data, can degenerate to other types of geometric structures that are much more flexible. The particular limit structures typically are solutions to extremal problems. This lecture will discuss several examples of this phenomenon.

In this talk, we first discuss a connection between the Halpern fixed-point iteration and Nesterov's accelerated schemes for a root-finding problem involving a co-coercive operator. We also study this connection for different recent schemes, including extra anchored gradient method and its variants. We show how the convergence results from one scheme can be transferred to another. Next, we develop a randomized block-coordinate algorithm for solving the above root-finding problem, which is different from existing randomized coordinate methods in optimization. Finally, we consider the applications of this randomized coordinate scheme to monotone inclusions and finite-sum monotone inclusions. The latter one can be applied to a federated learning setting.