Monday, January 28, 2019

10:00am-11:00am  **Student Homotopy Theory** -- Attilio Castano (UM) *Tannaka Duality* -- 3088 East Hall

3:00pm-4:00pm  **Student Dynamics** -- Bradley Zkoski (UM) *McShane's Identity* -- 3866 East Hall

4:00pm-5:20pm  **Group, Lie and Number Theory** -- Andrew O'Desky (Univ Michigan) *Generalized Prime Counting Functions and p-adic Interpolation* -- 4088 East Hall

4:00pm-6:00pm  **Geometry & Physics** -- Si Li (Tsinghua University) *Categorical primitive forms: a case study of An singularities* -- 4096 East Hall

4:00pm-5:00pm  **Integrable Systems and Random Matrix Theory** -- Benjamin Landon (MIT) *Fluctuations of the overlap of the spherical SK model at low temperature* -- 1866 East Hall

4:00pm-5:00pm  **Student Combinatorics** -- Sameer Kailasa (University of Michigan) *Sheaves on Graphs and the Hanna Neumann Conjecture* -- 3866 East Hall

Tuesday, January 29, 2019

3:00pm-4:00pm  **Student Geometry/Topology** -- Mark Greenfield (University of Michigan) *The Thurston metric on Teichmüller space* -- 1866 East Hall

3:00pm-3:50pm  **Student Commutative Algebra** -- Patricia Klein (University of Kentucky) *The Hilbert-Samuel multiplicity* -- 3866 East Hall

4:00pm-5:00pm  **Colloquium Series** -- Martin Golubitsky (Ohio State University) *Homeostasis and Networks* -- 1360 East Hall

Wednesday, January 30, 2019

2:30pm-4:00pm  **Student Machine Learning** -- Brian Chen (UM) *Deep Feedforward Networks* -- 3866 East Hall

4:00pm-6:00pm  **Algebraic Geometry** -- Eva Elduque (University of Wisconsin) *On the signed Euler characteristic property for subvarieties of abelian varieties.* -- 4096 East Hall

4:00pm-5:00pm  **Student Arithmetic** -- Angus Chung (UM) *L-function on function field* -- 3088 East Hall

5:00pm-6:00pm  **Working Group on Anderson Localization** -- Joe Kraisler (University of Michigan) *The Anderson Model* -- 4088 East Hall

Thursday, January 31, 2019

3:00pm-4:00pm  **Commutative Algebra** -- Patricia Klein (University of Kentucky) *Generalizations of determinantal ideals* -- 4088 East Hall

4:00pm-5:00pm  **Differential Equations** -- Eduardo Garcia Juarez (University of Pennsylvania) *Boussinesq and Navier-Stokes patch-type solutions: Global regularity* -- 4088 East Hall

4:00pm-5:00pm  **Student Algebraic Geometry** -- Devlin Mallory (UM) *Introduction to the minimal model program* -- B735 East Hall
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<td><strong>Applied Interdisciplinary Mathematics (AIM)</strong></td>
<td>Shai Revzen (University of Michigan)</td>
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<td><em>Three legs to stand on: vignettes from the study of locomotion</em></td>
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Abstracts for the week of January 27th, 2019 - February 2nd, 2019

Student Homotopy Theory
Monday, January 28, 2019, 10:00am-11:00am
3088 East Hall
Attilio Castano (UM)

*Tannaka Duality*

In this talk, we will explain and construct the category of quasicoherent sheaves over a general prestack, and we will explain that in certain nice geometric situations the category of quasicoherent sheaves contains all the information about the geometric objects. We will also explain how by passing to quasicoherent sheaves (i.e., going one categorical level up) we will find ourselves in a much more manageable situation. Time permitting we will discuss some applications of this machinery.

Student Dynamics
Monday, January 28, 2019, 3:00pm-4:00pm
3866 East Hall
Bradley Zykoski (UM)

*McShane’s Identity*

In his Ph.D. thesis, Greg McShane proved that a certain sum indexed over the simple closed geodesics on a (hyperbolic) punctured torus is equal to a constant independent of the metric. This metric-independence can be understood to mean that this sum is a constant function on the moduli space \( \mathcal{M}_{1,1} \) of hyperbolic metrics on the punctured torus. McShane’s proof gives very explicit geometric insight into punctured tori, and the primary goal of this talk is to convey as much of that geometric insight as possible. We will also discuss Mirzakhani’s method of integrating McShane’s identity, by passing to an infinite cover of \( \mathcal{M}_{1,1} \), in order to calculate the volume of \( \mathcal{M}_{1,1} \) with respect to the Weil-Petersson form.
In the first half of this talk we will introduce the notion of a generalized prime counting function taking values in a vector space. We will also introduce analogous generalizations of the Chebyshev function and the LCM sequence. Our main theorem relates these three quantities by computing an exact formula for the constant of proportionality in the smallest term of their asymptotic expansion. The formula may be understood as a reformulation of Chebotarëv's density theorem and admits a representation-theoretic interpretation. It has the added feature however of making clear a connection with Landau's prime ideal theorem which is not evident from the usual formulation. Furthermore, densities of primes which naturally arise in consideration with non-Galois fields can also be easily calculated by means of the formula.

The second half of the talk will consider an application to p-adic analysis. We do this by giving a general inequality relating quantities associated with any sequence of elements of a number field. By applying our result to the sequence of coefficients of a power series, we will obtain Dwork's Theorem 3 from his paper on the rationality of the local zeta function of an algebraic variety. By applying our result to the sequence of finite differences of another sequence, we will recover and significantly strengthen some existing results in the context of p-adic interpolation.

We introduce a categorical analogue of Saito's notion of primitive forms. For the category of matrix factorizations of An singularity, we prove that there exists a unique, up to non-zero constant, categorical primitive form. The corresponding genus zero categorical Gromov-Witten invariants are shown to match with the invariants defined through geometric unfolding of singularities. This is joint work with Caldararu and Tu.

We consider the fluctuations of the overlap between two replicas in the 2-spin spherical SK model in the low temperature phase. We show that the fluctuations are of order $N^{1/3}$ and are given by a simple, explicit function of the eigenvalues of GOE matrix. We show that this quantity converges and describe its limit in terms of quantities from random matrix theory. Joint work with P. Sosoe.
Student Combinatorics  
Monday, January 28, 2019, 4:00pm-5:00pm  
3866 East Hall  
Sameer Kailasa (University of Michigan)  
*Sheaves on Graphs and the Hanna Neumann Conjecture*  

We present a simplification (due to Warren Dicks) of Joel Friedman’s proof of the Hanna Neumann Conjecture.

Student Geometry/Topology  
Tuesday, January 29, 2019, 3:00pm-4:00pm  
1866 East Hall  
Mark Greenfield (University of Michigan)  
*The Thurston metric on Teichmueller space*  

In a celebrated preprint, Thurston defined an asymmetric metric on Teichmueller spaces of hyperbolic surfaces. This metric is a hyperbolic analog of the Teichmueller metric, utilizing Lipschitz distortion instead of quasiconformal distortion. We will first define the metric and prove a few elementary properties. Then, we will discuss stretch paths, which give explicit geodesic paths through Teichmueller space along with Lipschitz-extremal maps between the endpoints.

Student Commutative Algebra  
Tuesday, January 29, 2019, 3:00pm-3:50pm  
3866 East Hall  
Patricia Klein (University of Kentucky)  
*The Hilbert-Samuel multiplicity*  

We will define the Hilbert function and the Hilbert-Samuel multiplicity. We will compute some basic examples of each and discuss how they relate to the singularities of a local ring.
Colloquium Series  
Tuesday, January 29, 2019, 4:00pm-5:00pm  
1360 East Hall  
Martin Golubitsky (Ohio State University)  
Homeostasis and Networks

Homeostasis occurs when an output variable remains approximately constant as an input parameter varies over an interval. We reformulate homeostasis in the context of singularity theory by replacing 'approximately constant over an interval' with 'zero derivative of the output with respect to the inputs at a point'. We use this reformulation in two ways.

First, we classify three-node networks that can exhibit homeostasis. Second, unfolding theory classifies all small perturbations of the input-output function. In one input systems we give a mathematical explanation of why the 'chair' singularity of Best, Nijhout, and Reed is especially important in applications. We show that the hyperbolic umbilic can also organize evolution to homeostasis in two input systems. We discuss several applications in biochemical and gene regulatory motifs.

This work is joint with Fernando Antoneli, Janet Best, Fred Nijhout, Mike Reed, Ian Stewart, and Yangyang Wang.
We begin this chapter with a simple example of a feedforward network. Next, we address each of the design decisions needed to deploy a feedforward network. First, training a feedforward network requires making many of the same design decisions as are necessary for a linear model: choosing the optimizer, the cost function, and the form of the output units. We review these basics of gradient-based learning, then proceed to confront some of the design decisions that are unique to feedforward networks. Feedforward networks have introduced the concept of a hidden layer, and this requires us to choose the activation functions that will be used to compute the hidden layer values. We must also design the architecture of the network, including how many layers the network should contain, how these layers should be connected to each other, and how many units should be in each layer. Learning in deep neural networks requires computing the gradients of complicated functions. We present the back-propagation algorithm and its modern generalizations, which can be used to efficiently compute these gradients. Finally, we close with some historical perspective.

On the signed Euler characteristic property for subvarieties of abelian varieties.

Franecki and Kapranov proved that the Euler characteristic of a perverse sheaf on a semi-abelian variety is non-negative. This result has several purely topological consequences regarding the sign of the (topological and intersection homology) Euler characteristic of a subvariety of an abelian variety, and it is natural to attempt to justify them by more elementary methods. In this talk, we'll explore the geometric tools used in the proof of the signed Euler characteristic property. Joint work with Christian Geske and Laurentiu Maxim.

We will define and discuss L-functions and p-adic L-functions attached to the rational function field \( F_\mathbb{Q}(T) \). We will also discuss quadratic extensions of the rational functional field, and see what we can say for a "real" or "imaginary" extension.
Working Group on Anderson Localization
Wednesday, January 30, 2019, 5:00pm-6:00pm
4088 East Hall
Joe Kraisler (University of Michigan)

The Anderson Model

Reading piece: Chapters 2 and 3 of Kirsch.

Commutative Algebra
Thursday, January 31, 2019, 3:00pm-4:00pm
4088 East Hall
Patricia Klein (University of Kentucky)

Generalizations of determinantal ideals

Myriad techniques have been developed over the past several decades to study ideals generated by t-minors of mxn matrices of indeterminates. The varieties they determine are known to be normal, Cohen-Macaulay domains. These results were first due to Hochster and Eagon in 1971. In this talk, we will describe how liaison theory can be used to recover the Cohen-Macaulay component of these results and extend them other types of varieties, such as minors of mixed size in a ladder of a symmetric matrix of indeterminates. This approach, due to Gorla, Migliore, and Nagel, also shows that the natural generators of the ideal form a Groebner basis with respect to any diagonal term order. We will close by describing progress on an open problem surrounding another family of ideals conjectured to exhibit these same desirable properties held by determinantal ideals.

Differential Equations
Thursday, January 31, 2019, 4:00pm-5:00pm
4088 East Hall
Eduardo Garcia Juarez (University of Pennsylvania)

Boussinesq and Navier-Stokes patch-type solutions: Global regularity

The main goal of this talk is to show global regularity results for parabolic fluid interface problems, without assuming any smallness on the initial data. In particular, we will consider two models: the Boussinesq system, used as an approximation in heat-induced flows, and the density-dependent Navier-Stokes.

We will first show that 2D sharp fronts of temperature modeled by the Boussinesq equations propagate their structure and interface regularity globally in time. The results also hold in 3D and include initial temperatures given by piecewise Hoelder patches with $C^{1+\gamma}$, $W^{2,\infty}$ and $C^{2+\gamma}$ interfaces.

Then, we will show analogous results in relation to 96 Lions’ open problem on inhomogeneous 2D Navier-Stokes density patches. We will highlight the added difficulties as well as some open questions.
Student Algebraic Geometry  
Thursday, January 31, 2019, 4:00pm-5:00pm  
B735 East Hall  
Devlin Mallory (UM)  
*Introduction to the minimal model program*

The minimal model program is one of the major developments of algebraic geometry in recent decades, although its roots go back to the classical study of the birational geometry of surfaces. In this talk, we'll discuss how the study of surfaces leads naturally to the core objects of study in the MMP, including the cone of curves of a projective variety and its relation to morphisms from a variety. We'll then discuss the generalization to higher dimensions, the resulting difficulties, and the necessary introduction of certain "mild" singularities. Throughout, we'll focus on examples rather than technical details. The talk should be accessible to anyone who's taken 631 or another introductory algebraic geometry course.

Applied Interdisciplinary Mathematics (AIM)  
Friday, February 01, 2019, 3:00pm-4:00pm  
1084 East Hall  
Shai Revzen (University of Michigan)  
*Three legs to stand on: vignettes from the study of locomotion*

The study of multi-legged locomotion provides a rich collection of mathematical challenges. In this talk I will present three vignettes from our work in recent years and highlight the ongoing progress in each: (1) differentiability of of the flows of some classes of non-smooth (hybrid) dynamical systems and ongoing work on efficient algorithms for estimating those differentials; (2) geometric mechanics at the singular limit of friction and ongoing work on data driven geometric gait optimization; (3) motivating examples for a Koopman theory for non-smooth systems and ongoing work discovering a refined understanding of non-resonance conditions necessary and sufficient for eigenfunction uniqueness. In each of these cases the needs arising from practical problems in robotics and biology lead us to theoretical advances with direct practical applications and implications. I will conclude with some general remarks on how to push the mathematical envelope in highly applied problem domains.
A classical result of Siegel asserts that the (2,3,7)-triangle group attains the smallest covolume among lattices of SL(2, R). In general, given a semisimple Lie group G over some local field F, one may ask which lattices in G attain the smallest covolume. A complete answer to this question seems out of reach at the moment; nevertheless, many steps have been made in the last decades. Inspired by Siegel's result, Lubotzky determined that a lattice of minimal covolume in SL(2,F_q[1/t]). He noted that, in contrast with Siegel's lattice, the quotient by SL(2,F_q[1/t]) was not compact, and asked what the typical situation should be: « for a semisimple Lie group over a local field, is a lattice of minimal covolume a cocompact or nonuniform lattice? ».

In the talk, we will review some of the known results, and then discuss the case of SL(n,R) for n > 2. It turns out that, up to automorphism, the unique lattice of minimal covolume in SL(n,R) (n > 2) is SL(n,Z). In particular, it is not uniform, giving a partial answer to Lubotzky's question in this case.

The symmetric group acts naturally on configurations of distinct, labeled point in R^n, giving the cohomology of these configuration spaces the structure of a symmetric group representation. I will discuss how these representations are connected to statistical properties of polynomials over finite fields, and how we can use this connection to gain new insights about both.

I will discuss the distribution of the eigenvalues of a large Hermitian matrix when the matrix is chosen randomly. I will also talk about surprising appearances of those distributions in other problems such as tiling problems and growth models.
Student AIM Seminar
Friday, February 01, 2019, 4:00pm-5:00pm
1084 East Hall
Jack Wakefield (University of Michigan)
TBA