### Weekly Seminar & Events Bulletin
March 17th, 2019 - March 23rd, 2019

#### Monday, March 18, 2019

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<td>10:00am-11:00am</td>
<td><strong>Student Homotopy Theory</strong> -- Ruian Chen (University of Michigan)</td>
<td>Homotopy Groups of Spheres -- 3088 East Hall</td>
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<td>4:00pm-5:00pm</td>
<td><strong>Complex Analysis, Dynamics and Geometry</strong> -- Trevor Hyde (UM)</td>
<td>Arithmetic Dynamical Mordell-Lang -- 3096 East Hall</td>
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<td>4:00pm-5:20pm</td>
<td><strong>Group, Lie and Number Theory</strong> -- TBA</td>
<td>4088 East Hall</td>
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<td>4:00pm-5:00pm</td>
<td><strong>Student Combinatorics</strong> -- Will Dana (UM)</td>
<td>Free hyperplane arrangements -- 3866 East Hall</td>
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<td>4:00pm-5:00pm</td>
<td><strong>Integrable Systems and Random Matrix Theory</strong> -- Tatyana Shcherbyna (Princeton University)</td>
<td>Transfer matrix approach to 1d random band matrices -- 1866 East Hall</td>
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<td>4:00pm-6:00pm</td>
<td><strong>Geometry &amp; Physics</strong> -- Wei Gu (Virginia Tech)</td>
<td>A proposal for nonabelian mirror symmetry -- 4096 East Hall</td>
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<td>7:00pm-8:00pm</td>
<td><strong>Geometric Quantization and Symplectic Geometry</strong> -- Dan Burns (UM)</td>
<td>Toric varieties, real and complex polarizations -- 4088 East Hall</td>
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<td><strong>Student Geometry/Topology</strong> -- Daniel Stoll (University of Michigan)</td>
<td>Klein's icosahedral solution to the quintic -- 1866 East Hall</td>
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<td><strong>Student Commutative Algebra</strong> -- Eloisa Grifo (University of Michigan)</td>
<td>Symbolic Powers -- 3866 East Hall</td>
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#### Wednesday, March 20, 2019

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<td>Practical Workshop on Neural Networks -- 3866 East Hall</td>
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<td><strong>Financial/Actuarial Mathematics</strong> -- Jiequn Han (Princeton)</td>
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<td><strong>Student Arithmetic</strong> -- Hang Yin (University of Michigan)</td>
<td>Central Simple Algebras and the Brauer Group -- 3088 East Hall</td>
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<td>4:00pm-5:30pm</td>
<td><strong>RTG Seminar on Geometry, Dynamics and Topology</strong> -- Konstantinos Tsouvalas (U Michigan)</td>
<td>Topological restrictions on Anosov representations -- 3866 East Hall</td>
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<td>5:00pm-6:00pm</td>
<td><strong>Working Group on Anderson Localization</strong> -- Suman Chakraborty (University of Michigan)</td>
<td>Density of States II -- 4088 East Hall</td>
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Thursday, March 21, 2019

3:00pm-4:00pm  **Commutative Algebra** -- Danny Krashen (Rutgers University)  *The complexity of Brauer classes* -- 3866 EH East Hall

3:00pm-4:00pm  **Topology** -- Fedor Manin (Ohio State University)  *The Lipschitz functional on mapping spaces (and why you should care about it)* -- 4096 East Hall

4:00pm-5:00pm  **Differential Equations** -- Yu Deng (University of Southern California)  *Optimal local well-posedness for the derivative nonlinear Schrodinger's equation* -- 4088 East Hall

4:00pm-5:00pm  **Student Algebraic Geometry** -- Monica Lewis (UM)  *When is a quasi-affine scheme affine?* -- B735 East Hall

4:00pm-5:00pm  **Topology** -- Guchuan Li (Northwestern University)  *The Gross-Hopkins duals of higher real K-theory at prime 2* -- 3021 East Hall East Hall

Friday, March 22, 2019

2:30pm-3:30pm  **Quant Program Practitioner** -- Ali Nazari (Data Capital Management)  *TBA* -- 120 West Hall

3:00pm-4:00pm  **Applied Interdisciplinary Mathematics (AIM)** -- Jean-Pierre Croisille (University of Lorraine-Metz)  *An embedded Cartesian scheme for the Navier-Stokes equations* -- 1084 East Hall

3:00pm-4:00pm  **Combinatorics** -- Christian Gaetz (MIT)  *A combinatorial duality and the Sperner property for the weak order.* -- 4088 East Hall
Do you find spectral sequences and/or homotopy groups of spheres intimidating? Have you ever played with concrete spectral sequence computations? Are you curious about Serre’s celebrated finiteness result on the homotopy groups of spheres? Join us to see the Serre Spectral Sequence worked out to give (arguably) the first attack on $\pi_i(S^n)$.

Following Serre’s thesis, we develop a method of computing homotopy groups from homology via iterated construction of universal covers and loop spaces. Then we deduce Serre’s finiteness result by computing the desired (co)homology using spectral sequences associated to fibrations, including the universal covers and the path-loop fibrations.

In this talk, no precise definitions will be given; instead, all concepts involved will be explained in context via examples and illustrations. Therefore, while this talk is a natural follow-up to Yunze’s talk earlier in the semester, it should be accessible to an audience with the background of a first course in algebraic topology, plus a little courage.

The (cyclic) dynamical Mordell-Lang conjecture asserts that if the orbit of an endomorphism $f$ of a variety $V$ visits a subvariety infinitely often, then it must do so periodically. We prove an arithmetic version of this conjecture in dimension one proposed by Cahn, Jones, and Spear. Our methods extend to give a generalization for orbits under finitely generated semigroups of endomorphisms, making a surprising connection with the theory of formal languages. This is joint work with Michael Zieve.
Student Combinatorics  
Monday, March 18, 2019, 4:00pm-5:00pm  
3866 East Hall  
Will Dana (UM)  
*Free hyperplane arrangements*

One of the notable features of the theory of hyperplane arrangements is that key geometric properties (such as number of regions in the complement of a real arrangement, or the cohomology of the complement of a complex one) can be expressed in purely combinatorial terms, in the sense that they only depend on the partially ordered set of intersections of the hyperplanes.

The algebro-geometric property of freeness of an arrangement (specifically, freeness of its module of derivations) also tells us about its combinatorics in an interesting way, but whether this is a combinatorial property in the above sense is still unknown. In this talk, I'll go over the basic theory of hyperplane arrangements, introduce the concept of a free arrangement, and survey what is known about them. As time permits, I'll say a bit about reflection arrangements, an important class of examples which are known to be free.

As a special gift, the first 200 people who show up to this talk will receive a free hyperplane arrangement.

Integrable Systems and Random Matrix Theory  
Monday, March 18, 2019, 4:00pm-5:00pm  
1866 East Hall  
Tatyana Shcherbyna (Princeton University)  
*Transfer matrix approach to 1d random band matrices*

Random band matrices (RBM) are natural intermediate models to study eigenvalue statistics and quantum propagation in disordered systems, since they interpolate between mean-field type Wigner matrices and random Schrödinger operators. In particular, RBM can be used to model the Anderson metal-insulator phase transition (crossover) even in 1d.

In this talk we will discuss some recent progress in application of the supersymmetric method (SUSY) and transfer matrix approach to the analysis of local spectral characteristics of some specific types of 1d RBM.

Joint project with Maria Shcherbina.
Geometry & Physics
Monday, March 18, 2019, 4:00pm-6:00pm
4096 East Hall
Wei Gu (Virginia Tech)
A proposal for nonabelian mirror symmetry

At the beginning of the talk, we will give a short review of gauged linear sigma models (GLSMs) from a physical point of view, and will quickly mention some new developments in GLSMs in the physics literature. After that, we will review the Hori-Vafa mirror construction of mirror of 2d abelian gauge theories. Finally, we propose the mirror construction for non-abelian GLSMs, solving a long-standing open problem. Several non-trivial examples will be discussed, and the proposal satisfies a number of consistency checks, including (but not limited to): matching quantum cohomology rings (twisted chiral rings) with the mirror Jacobi rings (chiral rings), matching (topological) correlation functions, for Calabi-Yau cases, correct central charges, etc.

Geometric Quantization and Symplectic Geometry
Monday, March 18, 2019, 7:00pm-8:00pm
4088 East Hall
Dan Burns (UM)
Toric varieties, real and complex polarizations

Toric varieties have two natural polarizations, a real one given by orbits of a Hamiltonian torus action of maximal dimension, and a complex one, coming from the invariant complex structure and a holomorphic line bundle. This is one of the few compact cases where one can demonstrate a relation between the two families of wave functions. This will lead us to begin studying the Bergman kernel for the complex polarization which will be important later for Berezin-Toeplitz quantization.

Special Events
Tuesday, March 19, 2019, 11:30am-1:00pm
4866 East Hall
() IBL Lunch

The next IBL lunch of this semester will take place next Tuesday, 11.30-1, in the faculty lounge. I hope to see many of you there. Feel free to invite anyone who might be interested in IBL.
Student Geometry/Topology
Tuesday, March 19, 2019, 3:00pm-4:00pm
1866 East Hall
Daniel Stoll (University of Michigan)
*Klein’s icosahedral solution to the quintic*

While it is well known that the general degree 5 polynomial cannot be solved using radicals, there is still rich geometry hidden within this polynomial that may be used to produce a solution using more general functions. In 1984, Felix Klein gave a comprehensive solution to the quintic using icosahedral symmetries. We will begin by describing these symmetries of the icosahedron, followed by outlining Klein’s solution, demonstrating how the icosahedral symmetries may be used to reduce the problem of solving the quintic to that of computing a conformal isomorphism of a triangle with the half-plane.

Student Commutative Algebra
Tuesday, March 19, 2019, 3:00pm-3:50pm
3866 East Hall
Eloisa Grifo (University of Michigan)
*Symbolic Powers*

Hilbert’s Nullstellensatz gives a dictionary between algebra and geometry: solution sets to polynomial equations over the complex numbers (varieties) translate to (radical) ideals in polynomial rings. A classical theorem of Zariski and Nagata gives a deeper layer to this correspondence: polynomial functions that vanish up to a certain order along a variety correspond to a natural algebraic notion, called symbolic powers.

In this talk, we will introduce symbolic powers and discuss some of the main open problems in the area. No prior knowledge of the subject will be assumed.

Colloquium Series
Tuesday, March 19, 2019, 4:00pm-5:00pm
1360 East Hall
Yaiza Canzani (University of North Carolina)
*Understanding the growth of Laplace eigenfunctions.*

In this talk we will discuss a new approach to understanding eigenfunction concentration. We characterize the features that cause an eigenfunction to saturate the standard supremum bounds in terms of the distribution of $L^2$ mass along geodesic tubes emanating from a point. We also show that the phenomena behind extreme supremum norm growth is identical to that underlying extreme growth of eigenfunctions when averaged along submanifolds. Using the description of concentration, we obtain quantitative improvements on the known bounds in a wide variety of settings.
Weekly Seminar & Events Bulletin  
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Student Machine Learning  
Wednesday, March 20, 2019, 2:30pm-4:00pm  
3866 East Hall  
Umang Varma (University of Michigan)  
Practical Workshop on Neural Networks

We have spent the last two months learning the basics of neural networks. In this hour-long workshop I will talk about actually training a neural network. You are encouraged to bring a laptop to the seminar this week. We will work through a Python notebook where we will experiment with different kinds of layers, activations, optimizers, and regularization to try to solve a well-known problem.

We will use a (free) online service to avoid setting up various libraries on our own computers. You do not need any python/numpy experience to participate in this workshop, but having some will help.

Financial/Actuarial Mathematics  
Wednesday, March 20, 2019, 4:00pm-5:00pm  
1360 East Hall  
Jiequn Han (Princeton)  
Deep Learning-Based Numerical Methods for High-Dimensional Parabolic PDEs and Forward-Backward SDEs

Developing algorithms for solving high-dimensional partial differential equations (PDEs) and forward-backward stochastic differential equations (FBSDEs) has been an exceedingly difficult task for a long time, due to the notorious difficulty known as the curse of dimensionality. In this talk we introduce the "deep BSDE method", to solve general high-dimensional parabolic PDEs and FBSDEs. Starting from the BSDE formulation, we approximate the unknown $Z$ component by neural networks and design a least squares objective function based on the terminal condition to optimize parameters. Numerical results of a variety of examples demonstrate that the proposed algorithm is quite effective in high-dimensions, in terms of both accuracy and speed. We furthermore provide a theoretical error analysis to illustrate the validity and property of the objective function.

Algebraic Geometry  
Wednesday, March 20, 2019, 4:00pm-5:20pm  
4096 East Hall  
Angela Gibney (Rutgers)  
Classes on the moduli space of curves from affine Lie algebras, Gromov Witten theory, and vertex algebras: Identities and generalizations

In this talk I will introduce classes on the moduli space of curves that arise in two different constructions; on the one hand, as Chern classes of Verlinde bundles, constructed from integrable modules over affine Lie algebras, and on the other hand, as the Gromov-Witten loci of smooth homogeneous varieties. We'll see that in the simplest cases these classes are equivalent. Examples, conjectures, and generalizations via conformal vertex algebras will be discussed. This talk will be about joint work with Prakash Belkale, Chiara Damiolini, and Nicola Tarasca.
Central simple algebras (CSA) play an important role in class field theory, formalized in terms of cohomology theory.

The plan for the talk is to introduce CSA and the Brauer group. There are several ways of interpreting the Brauer group. We will mention the Galois descent method, the second cohomology interpretation and the geometric view through Severi-Brauer variety.

The basic example is quaternion algebra. We will examine how this concrete example fits into the general picture.

Hope to see you there!

Anosov representations of word hyperbolic groups into real reductive Lie groups were first introduced by Labourie. They are discrete representations with special dynamical properties and they are recognized as the higher rank analogue of convex cocompact representations into rank one Lie groups. In this talk, we are going to discuss several topological restrictions on Anosov groups including upper bounds for their cohomological dimension and characterizations in certain low dimensional special linear groups. Moreover, we will give several characterizations of Benoist representations which are a large class of examples of projective Anosov representations. This is joint work with Richard Canary.

Reading assignment for this week: Review section 5.1 and read sections 5.2 and 5.3 (pages 35-41).
Commutative Algebra
Thursday, March 21, 2019, 3:00pm-4:00pm
3866 EH East Hall
Danny Krashen (Rutgers University)

The complexity of Brauer classes

Brauer classes, which classify division algebras contain a great deal of information about the arithmetic of fields and the behavior of various types of algebraic structures, such as quadratic forms. While various techniques have been developed which have informed our understanding of Brauer classes on $p$-adic curves and function fields of more general arithmetic surfaces, relatively little progress has been made in the case of function fields of higher dimensional schemes. In this talk I will discuss some conjectures concerning the complexity of Brauer classes, and describe some recent joint work with Antieau, Auel, Ingalls and Lieblich in the case of $p$-adic surfaces.

Topology
Thursday, March 21, 2019, 3:00pm-4:00pm
4096 East Hall
Fedor Manin (Ohio State University)

The Lipschitz functional on mapping spaces (and why you should care about it)

I will introduce two theorems: one about the geometry of cobordisms, and one about metrics on the 3-sphere. The proofs of both, at their core, are based on a new geometric interpretation of Sullivan's model of rational homotopy theory. I will try to give a bit of the flavor of these ideas (without assuming any knowledge of rational homotopy theory.)

Differential Equations
Thursday, March 21, 2019, 4:00pm-5:00pm
4088 East Hall
Yu Deng (University of Southern California)

Optimal local well-posedness for the derivative nonlinear Schrodinger's equation

In joint work with Andrea Nahmod and Haitian Yue, we prove local well-posedness for the derivative nonlinear Schrodinger's equation (DNLS) in Fourier-Lebesgue space which has the same scaling as $H^s$ for any $s>0$. This improves the previous result of Grunrock-Herr where $s>1/4$. Here there is no trilinear estimate in any standard function space, instead we will construct the solution in a nonlinear submanifold (of a function space) by exploiting its structure. This is inspired by the theory of para-controlled distributions that Gubinelli et al. developed for stochastic PDEs, and is the first result where similar ideas are applied in the deterministic setting.
**Student Algebraic Geometry**  
**Thursday, March 21, 2019, 4:00pm-5:00pm**  
**B735 East Hall**  
**Monica Lewis (UM)**  
*When is a quasi-affine scheme affine?*

A quasi-affine scheme is an open subset of Spec(R) where R is a commutative ring. Such an open set can be expressed as the complement of the vanishing locus V(I) of some ideal I of R. In this talk, we will investigate two problems. First, can the question of whether Spec(R)-V(I) is affine be rephrased in purely algebraic terms involving the ideal I and the ring R? Second, if question is indeed algebraic, then can we use algebra to give criteria on the ideal which answer it (either in the positive or in the negative)? We will assume familiarity with 614, but we won't assume much from 632.

**Topology**  
**Thursday, March 21, 2019, 4:00pm-5:00pm**  
**3021 East Hall East Hall**  
**Guchuan Li (Northwestern University)**  
*The Gross-Hopkins duals of higher real K-theory at prime 2*

The Hopkins-Mahowald higher real K-theory spectra $E_n^G$ are generalizations of real K-theory; they are ring spectra which give some insight into higher chromatic levels while also being computable. This will be a talk based on joint work with Drew Heard and XiaoLin Danny Shi, in which we compute that higher real K-theory spectra with group $G=C_2$ at prime $2$ and height $n$ are Gross-Hopkins self duals with a shift $4+n$. This will allow us to detect exotic invertible $K(n)$-local spectra.

**Quant Program Practitioner**  
**Friday, March 22, 2019, 2:30pm-3:30pm**  
**120 West Hall**  
**Ali Nazari (Data Capital Management)**  
*TBA*
We consider the discretization of the Navier-Stokes (NS) equations in pure streamfunction form in an irregular domain, embedded in a Cartesian grid. By means of a high order interpolating polynomial with compact stencil, a discrete NS operator is defined at each point inside the domain. The approach extends to an irregular domain a previously introduced high order compact scheme in Cartesian geometries. The approach is reminiscent of early works on finite differences, in particular of the Shortley-Weller scheme for the Laplacian.

Numerical results will be presented for various irregular domains. A particular attention is devoted to flows in elliptical domains. In the case of the ellipse, we also demonstrate the ability of the scheme for accurate computations of the eigenvalues and eigenfunctions of the biharmonic problem on the ellipse.

Joint work with Matania Ben-Artzi and Dalia Fishelov.

Combinatorics
Friday, March 22, 2019, 3:00pm-4:00pm
4088 East Hall
Christian Gaetz (MIT)
A combinatorial duality and the Sperner property for the weak order.

A poset is Sperner if its largest antichain is no larger than its largest rank. In the 1980's, Stanley used the Hard-Lefschetz Theorem to prove the Sperner property for strong Bruhat orders on Weyl groups. I will describe joint work with Yibo Gao in which we prove Stanley's conjecture that the weak Bruhat order on the symmetric group is also Sperner, by exhibiting a combinatorially-defined representation of $\mathfrak{sl}_2$ respecting the structure of the weak and strong orders. I will explain how this representation gives rise to a combinatorial duality between the weak and strong Bruhat orders and leads to a strong order analogue of Macdonald's reduced word identity for Schubert polynomials.