**Weekly Seminar & Events Bulletin**

**February 24th, 2019 - March 2nd, 2019**

### Monday, February 25, 2019

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00am-11:00am</td>
<td><strong>Student Homotopy Theory</strong> -- Ruian Chen (University of Michigan) <em>Differential graded categories from a homotopical point of view</em></td>
<td>3088 East Hall</td>
</tr>
<tr>
<td>3:00pm-4:00pm</td>
<td><strong>Student Dynamics</strong> -- Kostas Tsouvalas (UM) <em>Learning seminar on Benoist's work-Day 3 (The Zariski density theorem)</em></td>
<td>3866 East Hall</td>
</tr>
<tr>
<td>4:00pm-6:00pm</td>
<td><strong>Geometry &amp; Physics</strong> -- Dawei Chen (Boston College) <em>Counting geodesics on flat surfaces</em></td>
<td>4096 East Hall</td>
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<td>4:00pm-5:20pm</td>
<td><strong>Group, Lie and Number Theory</strong> -- Luca Candelori (Wayne State University) <em>Algebraic theta functions, theta groups, and beyond</em></td>
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<td>4:00pm-5:00pm</td>
<td><strong>Integrable Systems and Random Matrix Theory</strong> -- Duncan Dauvergne (University of Toronto) <em>The directed landscape</em></td>
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<td><strong>Teaching Mathematics</strong> -- Discussion () <em>LCIT Discussion</em></td>
<td>4866 East Hall</td>
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<td>3:00pm-4:00pm</td>
<td><strong>Student Geometry/Topology</strong> -- Carsten Peterson (University of Michigan) <em>Coxeter groups and buildings</em></td>
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<td>3:00pm-3:50pm</td>
<td><strong>Student Commutative Algebra</strong> -- Shelby Cox (University of Michigan) <em>Tor and Ext</em></td>
<td>3866 East Hall</td>
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<tr>
<td>4:00pm-5:00pm</td>
<td><strong>Colloquium Series</strong> -- Thomas Walpuski (Michigan State University) <em>Harmonic spinors, gauge theory, and wall-crossing</em></td>
<td>1360 East Hall</td>
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### Wednesday, February 27, 2019

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<tr>
<td>2:30am-4:00am</td>
<td><strong>Student Machine Learning</strong> -- Rishi Sonthalia (University of Michigan) <em>Convolutional Networks</em></td>
<td>3866 East Hall</td>
</tr>
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<td>4:00pm-5:00pm</td>
<td><strong>Financial/Actuarial Mathematics</strong> -- Jose Figueroa-Lopez (Washington University) <em>CANCELED---Utility Maximization in Hidden Regime-Switching Markets with Default Risk</em></td>
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<td><strong>RTG Seminar on Geometry, Dynamics and Topology</strong> -- Andrew Zimmer (LSU) <em>Regularity of limit sets for Anosov representations</em></td>
<td>3866 East Hall East Hall</td>
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<td><strong>Algebraic Geometry</strong> -- Olivia Dumitrescu (Central Michigan University) <em>Standard -1 divisors</em></td>
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<td><strong>Working Group on Anderson Localization</strong> -- Suman Chakraborty (University of Michigan) <em>The Density of States I</em></td>
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<td><strong>Topology</strong> -- Daniel Studenmund (University of Notre Dame) <em>Local residual finiteness of abstract commensurators of Fuchsian groups</em></td>
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<td><strong>Differential Equations</strong> -- Stefan Steinerberger (Yale University) <em>Wasserstein Distance as a Tool in Analysis and PDEs</em></td>
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[http://www.math.lsa.umich.edu/seminars_events/ - Page 1/12](http://www.math.lsa.umich.edu/seminars_events/)
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<td>TBA -- 120 West Hall</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics (AIM) -- Zecheng Gan (University of Michigan)</td>
<td>TBA -- 1084 East Hall</td>
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<tr>
<td>3:00pm-3:50pm</td>
<td>Geometry -- Fangyang Zheng (Ohio State)</td>
<td>TBA -- 3866 East Hall</td>
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<td>3:00pm-4:00pm</td>
<td>Combinatorics -- Martha Precup (Washington University, St. Louis)</td>
<td>TBA -- 4088 East Hall</td>
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<td>An open string analog of Quantum Lefschetz theorem -- 1866 East Hall</td>
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Differential graded categories (DG categories) are generalized (or horizontally categorified, or "oidified") differential graded algebras (DGAs), which appear in different incarnations: abstract algebra (Koszul complex), topology (mod p cohomology), and geometry (de Rham and Dolbeault complex). Moreover, DG categories provide a sort of "enhancement" of triangulated categories and fix various defects of them, such as the lack of functorial cones and intrinsic (homotopy) limits and colimits.

This talk is a light introduction to DG categories with emphasis on the homotopical aspect. Using the machinery (no heavy technical use will be made!) of model categories introduced last week, we discuss various equivalences between DG categories, including a notion of Morita equivalences. We also explore the connection of DG categories to triangulated categories. Our main point, however, is that DG categories themselves should be regarded as a kind of "spaces" worth studying in its own right (as done in derived noncommutative geometry), and we will do so by introducing (Morita) invariants on DG categories, namely K-theory and Hochschild cohomology.

Abstract: In this talk we will discuss the proof of Y. Benoist's Zariski density theorem in the strictly convex case. The theorem provides a dichotomy for the Zariski closure of a discrete subgroup of SL(n+1,R) which divides a properly convex, strictly convex domain in the n-projective space: either it is Zariski dense or its Zariski closure is conjugate to the indefinite special orthogonal group SO(n,1).
Geometry & Physics  
Monday, February 25, 2019, 4:00pm-6:00pm  
4096 East Hall  
Dawei Chen (Boston College)  
*Counting geodesics on flat surfaces*

An abelian differential induces a flat metric with saddle points such that the underlying Riemann surface can be realized as a polygon with edges pairwise identified by translation. Varying the shape of such polygons induces an $\text{SL}(2,\mathbb{R})$ action on moduli spaces of abelian differentials, called Teichmüller dynamics. Generic flat surfaces in an $\text{SL}(2,\mathbb{R})$ orbit closure exhibit similar properties from the viewpoint of counting geodesics of bounded lengths, whose asymptotic growth rates satisfy a formula of Siegel-Veech type. In this talk I will give an introduction to this topic, with a focus on computing certain Siegel-Veech constants via intersection theory on moduli spaces.

Group, Lie and Number Theory  
Monday, February 25, 2019, 4:00pm-5:20pm  
4088 East Hall  
Luca Candelori (Wayne State University)  
*Algebraic theta functions, theta groups, and beyond*

Classical theta functions have been employed since the 19th century in the solution to several problems in mathematics, from combinatorial formulas for the number of ways to represent an integer as a sum of squares to giving equations for explicit embeddings of abelian varieties in projective space. In this talk, we first review the algebraic theory of theta functions, where the theta functions themselves are replaced by their underlying vector bundles, defined over suitable moduli stacks of abelian schemes. This algebraic theory is made possible thanks to the machinery of theta groups, as pioneered by Mumford in the 1960s. We discuss in detail the transformation laws of algebraic theta functions in terms of theta groups and some new auxiliary constructions. The algebraic perspective lends itself to many possible avenues of generalizations. In particular, we discuss how the theory of theta groups could be generalized to the projectively flat connections arising from modular functors and/or modular tensor categories.
Integrable Systems and Random Matrix Theory  
Monday, February 25, 2019, 4:00pm-5:00pm  
1866 East Hall  
Duncan Dauvergne (University of Toronto)  
*The directed landscape*

In this talk, I will discuss recent work with Janosch Ortmann and Balint Virag on constructing the four-parameter scaling limit of Brownian last passage percolation (and other models in the KPZ universality class). The limit is the directed landscape, a random "directed metric" on the plane. Rescaled last passage paths converge to geodesics in this metric, and previous constructions including the Airy process, the KPZ fixed point, and multi-time limits, are all functions/marginals of the directed landscape.

**Student Combinatorics**  
Monday, February 25, 2019, 4:00pm-5:00pm  
3866 East Hall  
Gracie Ingermanson (University of Michigan)  
*Pipe dreams and Schubert polynomials: a 50-minute free trial*

Pipe dreams are tilings of a grid by "crosses" and "elbows" that connect to form a network of pipes. A pipe dream with crosses only in the upper left half of an nxn grid is associated to a permutation on n letters. Schubert polynomials are indexed by permutations and are defined recursively using divided difference operators. They arise as representatives of cohomology classes of flag manifolds. Reduced pipe dreams for a word w give terms in the Schubert polynomial for w. This talk will give an example-based overview of Knutson and Miller's "mitosis" algorithm for constructing reduced pipe dreams to compute Schubert polynomials.

**Geometric Quantization and Symplectic Geometry**  
Monday, February 25, 2019, 7:00pm-8:00pm  
4088 East Hall  
Dan Burns (UM)  
*Complex polarizations*

A complex polarization is given by an integrable complex Lagrangian sub-bundle of the complexified tangent bundle. The integrability condition means that it defines a complex structure on the underlying phase space and the pre-quantum line bundle. The space of wave functions is closely related to holomorphic functions. We will discuss examples on Euclidean space (Bargman space), homogeneous manifolds and toric varieties. The latter give good examples where we can compare real and complex polarizations, checking the principle/conjecture that "quantization is independent of polarization".
Teaching Mathematics
Tuesday, February 26, 2019, 12:00pm-1:30pm
4866 East Hall
Discussion ()
LCIT Discussion

A discussion session of our Learning Community on Inclusive Teaching.

Student Geometry/Topology
Tuesday, February 26, 2019, 3:00pm-4:00pm
1866 East Hall
Carsten Peterson (University of Michigan)
Coxeter groups and buildings

Coxeter groups are an abstraction of the concept of a reflection group. We shall begin by discussing finite reflection groups. To such a group W we may associate a hyperplane arrangement partitioning the vector space into simplicial cones. From this hyperplane arrangement we may construct a simplicial complex encapsulating the key geometric and combinatorial features of the hyperplane arrangement and on which W acts. Using finite reflection groups as our guide, we shall carry out an analogous procedure for an arbitrary Coxeter group W to construct what is known as the Coxeter complex for W. Lastly we shall discuss buildings, which are simplicial complexes "glued together" from Coxeter complexes satisfying certain axioms. The talk should be accessible to anyone who knows about groups and simplicial complexes. Lots of pictures and examples will be included.

Student Commutative Algebra
Tuesday, February 26, 2019, 3:00pm-3:50pm
3866 East Hall
Shelby Cox (University of Michigan)
Tor and Ext

In this talk, we will define "almost exact" sequences and how to extend them to long exact sequences using Tor and Ext. We will prove some useful properties of Tor and Ext and compute Tor and Ext in several explicit examples. If time permits, we will discuss some applications of Tor and Ext including Serre's definition of intersection multiplicity. No knowledge beyond Math 594 will be assumed.
In 1928, trying to find a square-root of the Laplacian on Minkowski space, Dirac discovered the Dirac operator. This operator naturally acts on the space of spinors, introduced by E. Cartan already in 1913. Atiyah and Singer transported Dirac operators and spinors to Riemannian geometry; thus opening up the path to the development of Spin Geometry.

Recently, Taubes introduced the notion of harmonic Z/2Z spinors and initiated the study of their singular sets. These are special cases of harmonic multi-valued spinors; arguably the simplest instance being harmonic multi-valued 1-forms. I will explain this notion from scratch and discuss what is known about them in some detail. No prior knowledge of spinors will be assumed.

The importance of harmonic Z/2Z spinors is that they appear in various compactifications of gauge-theoretic PDE which are of great interest in geometry, topology and physics. Arguably, the most important instance of such a PDE is the Kapustin-Witten equation. One of the simplest cases of such a PDE is the Seiberg-Witten equation with two spinors.

Although, various compactness theorems "predict" the existence of harmonic Z/2Z spinors they do not actually guarantee it. Nevertheless, in joint work with Aleksander Doan, we prove a concrete existence result. Our proof is of a topological nature: at its heart lies a wall-crossing formulae for the Seiberg-Witten equation with two spinors.
In this chapter, we first describe what convolution is. Next, we explain the motivation behind using convolution in a neural network. We then describe an operation called pooling, which almost all convolutional networks employ. Usually, the operation used in a convolutional neural network does not correspond precisely to the definition of convolution as used in other fields, such as engineering or pure mathematics. We describe several variants on the convolution function that are widely used in practice for neural networks. We also show how convolution may be applied to many kinds of data, with different numbers of dimensions. We then discuss means of making convolution more efficient. Convolutional networks stand out as an example of neuroscientific principles influencing deep learning. We discuss these neuroscientific principles, then conclude with comments about the role convolutional networks have played in the history of deep learning.

Financial/Actuarial Mathematics
Wednesday, February 27, 2019, 4:00pm-5:00pm
1360 East Hall
Jose Figueroa-Lopez (Washington University)

CANCELED---- Utility Maximization in Hidden Regime-Switching Markets with Default Risk

We consider the problem of maximizing expected utility from terminal wealth for a power investor who can allocate his wealth in a stock, a defaultable security, and a money market account. The dynamics of these security prices are governed by geometric Brownian motions modulated by a hidden continuous time finite state Markov chain. We reduce the partially observed stochastic control problem to a complete observation control problem via the filtered regime switching probabilities. We separate the latter into a pre-default and a post-default dynamic optimization subproblems, and obtain two coupled Hamilton-Jacobi-Bellman (HJB) partial differential equations. We prove existence and uniqueness of a globally bounded classical solution to the pre-default HJB equation, and give a verification theorem characterizing each value function as the solution of the corresponding HJB equation.

This is joint work with Agostino Capponi and Andrea Pascucci.
RTG Seminar on Geometry, Dynamics and Topology  
*Wednesday, February 27, 2019, 4:00pm-5:30pm*  
3866 East Hall East Hall  
*Andrew Zimmer (LSU)*  
*Regularity of limit sets for Anosov representations*

In contrast to the case of convex-cocompact subgroups of the isometry group of real hyperbolic space, there are many examples of Anosov representations where the limit set is a $C^1$ manifold. In this talk I will discuss necessary and sufficient conditions for this to happen. I will focus on the case of representations of surface groups into $SL_n(\mathbb{R})$, so the talk should be very accessible. This is joint work with T. Zhang.

Student Arithmetic  
*Wednesday, February 27, 2019, 4:00pm-5:00pm*  
3088 East Hall  
*Gilyoung Cheong (University of Michigan)*  
*Random matrices over finite fields follow the Cohen-Lenstra distribution*

Given a random $n \times n$ matrix over the finite field of $p$ elements for a fixed prime $p$, we will compute the probability that its Jordan normal form contains a specified 0-Jordan block. As $n$ goes to infinity, we will see that our answer converges to the Cohen-Lenstra distribution, which is conjectured to compute the probability that the class group of a random imaginary quadratic field has a specified $p$-part (when $p$ is odd). We will see why this happens by making connections between our statistics of random matrices and a heuristic distribution of finite abelian groups given by Cohen and Lenstra.

Much of the talk is from a joint work with Yifeng Huang and Zhan Jiang. We will not assume any background from the audience beyond basic graduate algebra classes.

Algebraic Geometry  
*Wednesday, February 27, 2019, 4:00pm-5:20pm*  
4096 East Hall  
*Olivia Dumitrescu (Central Michigan University)*  
*Standard -1 divisors*

In this talk we introduce concept of standard $(-1)$ divisors on blown up projective space in general points, generalizing the notion of $(-1)$ curves. We generalize Noether's inequality, and prove that standard $-1$ divisors are in bijective correspondence with the orbit of the Weyl group action on one exceptional divisor. Moreover, we show that the irreducibility condition from the definition of standard $(-1)$ divisors can be replaced by the numerical condition of having positive intersection with all standard $(-1)$ divisors of smaller degree via the Mukai pairing. This project is based on joint work with Nathan Priddis.
Working Group on Anderson Localization
Wednesday, February 27, 2019, 5:00pm-6:00pm
4088 East Hall
Suman Chakraborty (University of Michigan)
The Density of States I

Pages 29-35 of Kirsch's notes.

Topology
Thursday, February 28, 2019, 3:00pm-4:00pm
4096 East Hall
Daniel Studenmund (University of Notre Dame)
Local residual finiteness of abstract commensurators of Fuchsian groups

The abstract commensurator of a group Gamma is the group Comm(Gamma) of "germs of automorphisms of Gamma," a natural generalization of Aut(Gamma). Commensurators of lattices Gamma in Lie groups G are well-understood for almost all G, due to work of Borel, Mostow, Prasad, Margulis, and others, and in particular are known to be linear groups. Notably thorny exceptions are lattices in the Lie group G = SL_2(R), whose commensurators are somewhat wild. In this talk we will shed some light on their wildness by showing that such commensurators are not locally residually finite; that is, finitely generated subgroups cannot be fully understood through their finite quotients. The proof methods are elementary and the complete proof is computer-assisted. This covers work joint with Khalid Bou-Rabee.

Differential Equations
Thursday, February 28, 2019, 4:00pm-5:00pm
4088 East Hall
Stefan Steinerberger (Yale University)
Wasserstein Distance as a Tool in Analysis and PDEs

Wasserstein Distance is a way of measuring the distance between two probability distributions (minimizing it is a main problem in Optimal Transport). We will give a gentle Introduction into what it means and then use it to prove (1) a completely elementary but possibly new inequality for real-valued functions and (2) a statement along the following lines: linear combinations of eigenfunctions of elliptic operators corresponding to high frequencies oscillate a lot and vanish on a large set of co-dimension 1. (This is already interesting for trigonometric polynomials on the 2-torus which have to vanish on long lines.)

Quant Program Practitioner
Friday, March 01, 2019, 2:30pm-3:30pm
120 West Hall
David Rashty (Flagstar Bank)
TBA
Applied Interdisciplinary Mathematics (AIM)
Friday, March 01, 2019, 3:00pm-4:00pm
1084 East Hall
Zecheng Gan (University of Michigan)
Interaction between charged dielectric spheres: algorithms and computer simulations

Modern particle-based simulations increasingly incorporate polarization charges arising from spatially nonuniform permittivity, for the study ranging from colloidal suspensions to protein-protein interactions, etc. Numerical calculation of these induced many-body effects typically requires large amount of computational effort. For the special case of dielectric spheres, we will present two different approaches for solving the 3D Poisson equation, including 1. a semi-analytical hybrid method which combines the method of images and method of moments. Singularity in the multipole expansion is removed through the addition of image charges for close sphere pairs, making the problem well-conditioned. 2. a more general and flexible numerical boundary element method, higher order accuracy is achieved by combining the singularity subtraction and extrapolation techniques.

We further use our methods to explore the role of dielectric effect in the interaction between charged dielectric spheres. Through a few concrete numerical examples, we will show that the dielectric effect can lead to interesting phenomena such as like-charge attraction and qualitatively different self-assembled structures.

Geometry
Friday, March 01, 2019, 3:00pm-3:50pm
3866 East Hall
Fangyang Zheng (Ohio State)
TBA

Combinatorics
Friday, March 01, 2019, 3:00pm-4:00pm
4088 East Hall
Martha Precup (Washington University, St. Louis)
Hessenberg varieties and the Stanley--Stembridge conjecture

In 2015, Brosnan and Chow proved the Shareshian--Wachs conjecture, which links an open conjecture of Stanley and Stembridge to the geometry of Hessenberg varieties through Tymoczko's permutation group action on the cohomology ring of regular semisimple Hessenberg varieties. This talk will give a brief overview of that story and present a new set of linear relations satisfied by the multiplicities of certain permutation representations in Tymoczko's representation. As an application of these results, we prove an inductive formula for the multiplicity coefficients corresponding to partitions with a maximal number of parts. This talk is based on joint work with M. Harada.
Geometry & Physics  
Friday, March 01, 2019, 3:00pm-4:00pm  
1866 East Hall  
Weiwei Wu (University of Georgia)  

An open string analog of Quantum Lefschetz theorem

I'll explain an open string analog of the Quantum Lefschetz theorem for quantum periods, which is the unit component of the small J-function. Recently, Tonkonog proved that the quantum periods, in particular, all descendant invariants with one point insertion of a Fano manifold can be recovered by the superpotential of a single monotone Lagrangian torus. Given a Lagrangian submanifold $L$ in a symplectic hypersurface $Y \subset X$, I'll explain how to obtain the superpotential of the "rim Lagrangian" $\tilde{L}$ by an extra term coming from the relative (descendant) Gromov-Witten invariant when X and Y both satisfy certain positivity assumptions. In spirit, this is also a special case of the surgery formula in the open-string context compared to the closed-string surgery formula derived by Li-Ruan.

Junior Colloquium Series  
Friday, March 01, 2019, 4:00pm-5:30pm  
1068 East Hall  
Alumni in Industry (Various)  

Non-Academic Career Panel (**Note unusual location**)  

The Panel will feature Brian Wyman, Rafe Kinsey, Nic Ford, Bill Correll, and Sarah Kitchen, all of whom are Math PhDs now working in non-academic jobs that they love (including: his own start-up consulting firm (Wyman), strategic operations for a large finance firm (Kinsey), AI research for google (Ford), remote sensing (Correll) and deep learning and robotics research (Kitchen).

You will have an opportunity to submit questions before hand, as well as to meet informally with panelists. The panel will be followed by a social event. Please join us!

If you are currently looking for a job or expect to do so in the near-ish future, please also bring your resume.