### Weekly Seminar & Events Bulletin

**February 16th, 2020 - February 22nd, 2020**

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**Monday, February 17, 2020**

<table>
<thead>
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<tr>
<td>4:00pm-5:00pm</td>
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<td><strong>Group, Lie and Number Theory</strong> -- Lea Beneish (Emory University) <em>Module constructions for certain subgroups of the largest Mathieu group.</em> -- 4096 East Hall</td>
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<td><strong>Student Algebraic Geometry</strong> -- Zhi Jiang (UM) <em>An invitation to geometric invariant theory.</em> -- B745 East Hall</td>
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<td>4:00pm-5:00pm</td>
<td><strong>Colloquium Series</strong> -- Laura DeMarco (Northwestern University) <em>Ziwet Lectures #1: Complex Dynamics and Elliptic Curves.</em> -- 1360 East Hall</td>
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<td><strong>Financial/Actuarial Mathematics</strong> -- Xin Zhang (UM) <em>Finite-Time 4-Expert Prediction Problem.</em> -- 4096 East Hall</td>
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<td>4:00pm-5:30pm</td>
<td><strong>Special Events</strong> -- Laura DeMarco (Northwestern University) <em>Ziwet Lecture #2: Complex Dynamics and Elliptic Curves.</em> -- 1360 East Hall</td>
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<td><strong>Student Representation Theory</strong> -- Ilia Nekrasov (University of Michigan) <em>Deligne’s Theorem on Tensor Categories and Supergroups.</em> -- 2866 East Hall</td>
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<td><strong>Topology</strong> -- Tommaso Cremaschi (University of Southern California) <em>Hyperbolic 3-manifolds with infinitely generated fundamental group.</em> -- 3866 East Hall</td>
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<td><strong>Student Commutative Algebra</strong> -- Monica Lewis (University of Michigan) <em>TBA.</em> -- 3088 East Hall</td>
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<td><strong>Preprint Algebraic Geometry</strong> -- Devlin Mallory (UM) <em>Asymptotic growth of global sections on open varieties, following Di Cerbo.</em> -- 4096 East Hall</td>
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Integrable Systems and Random Matrix Theory  
**Monday, February 17, 2020, 4:00pm-5:00pm**  
1866 East Hall  
Andrei Prokhorov (University of Michigan)  
*Review of Tracy-Widom type formulas.*

The relation between distribution of soft edge largest eigenvalue and Painlevé II tau function is called sometimes Tracy-Widom formula. We will review quite recently discovered other formulas of such type involving coupled Painlevé equations.

Group, Lie and Number Theory  
**Monday, February 17, 2020, 4:10pm-5:00pm**  
4096 East Hall  
Lea Beneish (Emory University)  
*Module constructions for certain subgroups of the largest Mathieu group*

For certain subgroups of $\text{M}_{24}$, I will describe vertex operator algebraic module constructions whose associated trace functions are meromorphic Jacobi forms. These meromorphic Jacobi forms are canonically associated to the mock modular forms of Mathieu moonshine. The construction is related to the Conway moonshine module and employs a technique introduced by Anagiannis--Cheng--Harrison. This construction gives concrete vertex algebraic realizations of certain cuspidal Hecke eigenforms of weight two. In particular, the construction gives explicit realizations of trace functions whose integralities are equivalent to divisibility conditions on the number of $\mathbb{F}_p$ points on the Jacobians of modular curves.

Special Events  
**Tuesday, February 18, 2020, 11:30am-1:00pm**  
4866 East Hall  
*Math Learning Community on Inclusive Teaching Meeting*

Our topic for this week will be transparency in teaching, especially in assignment design. We'll have guest Theresa Braunschneider from CRLT helping us frame this conversation. Lunch will be provided.
Student Geometry/Topology  
Tuesday, February 18, 2020, 3:00pm-4:00pm  
1866 East Hall  
Reebhu Bhattacharyya ()  
Duality Theorems

We will talk about duality theorems in the context of homotopy theory, in particular about Spanier-Whitehead duality. We will see how this motivates the idea of the stable homotopy category and gives other duality theorems like Alexander duality and Atiyah duality. No prior knowledge of spectra or the homotopy category will be assumed.

Student Algebraic Geometry  
Tuesday, February 18, 2020, 3:00pm-4:00pm  
B745 East Hall  
Zhi Jiang (UM)  
An invitation to geometric invariant theory

Geometric invariant theory is a method for constructing quotients by group actions in algebraic geometry. In differential geometry, if the group action is 'good', we have a construction of quotient. However, in algebraic geometry, besides the topology structure, we also have algebraic structure, which makes the problem tricky.

In this talk, we will discuss what is a 'good' group action and how to construct quotients in algebraic geometry with examples. We will also discuss stability, which plays an important role in the construction. This talk would be accessible to anyone who has basic knowledge about algebraic varieties and group actions.
In these two talks, I will present connections between the theory of dynamical systems and certain problems in arithmetic geometry. On the dynamical side -- specifically in the study of iteration of rational functions (Julia sets, bifurcations, the Mandelbrot set) but originating in the mathematical study of planetary motion -- the first connections to number theory were observed about 100 years ago. On the arithmetic side, it was probably the 1960s when dynamical ideas were first used as tools to understand the arithmetic geometry of elliptic curves and abelian varieties. My goal is to provide examples of how these relationships developed and where they have brought us today. (The first talk is designed for a very general audience, and the second talk will be at the level of a Department Colloquium.)

Reception to Follow in Math Department Upper Atrium

Student Arithmetic
Wednesday, February 19, 2020, 3:00pm-4:00pm
3088 East Hall
Sridhar Venkatesh (University of Michigan)
Hasse-Minkowski Theorem

A local-global principle is a statement that asserts that a certain property is true globally if and only if it is true everywhere locally. We will give a proof of Hasse-Minkowski theorem over Q, which is the best known example of such a principle. The theorem states that a quadratic form with rational coefficients represents zero in the field of rational numbers if and only if it represents zero in the field of real numbers and in all fields of p-adic numbers.
We explicitly solve the nonlinear PDE that is the continuous limit of dynamic programming equation of the expert prediction problem in finite horizon setting with \(N = 4\) experts. The expert prediction problem is formulated as a zero sum game between a player and an adversary. By showing that the solution is \(C^2\), we are able to show that the comb strategies, as conjectured in Peres et al., form an asymptotic Nash equilibrium. We also prove the "Finite vs Geometric regret" conjecture proposed by Peres et al. for \(N = 4\), and show that this conjecture in fact follows from the conjecture that the comb strategies are optimal for all \(N\).

Joint work with Erhan Bayraktar and Ibrahim Ekren.

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Special Events

**Wednesday, February 19, 2020, 4:00pm-5:30pm**

1360 East Hall

**Laura DeMarco (Northwestern University)**

*Ziwet Lecture #2: Complex Dynamics and Elliptic Curves*

In these two talks, I will present connections between the theory of dynamical systems and certain problems in arithmetic geometry. On the dynamical side -- specifically in the study of iteration of rational functions (Julia sets, bifurcations, the Mandelbrot set) but originating in the mathematical study of planetary motion -- the first connections to number theory were observed about 100 years ago. On the arithmetic side, it was probably the 1960s when dynamical ideas were first used as tools to understand the arithmetic geometry of elliptic curves and abelian varieties. My goal is to provide examples of how these relationships developed and where they have brought us today. (The first talk is designed for a very general audience, and the second talk will be at the level of a Department Colloquium.)
Student Representation Theory  
Wednesday, February 19, 2020, 4:00pm-5:00pm  
2866 East Hall  
Ilia Nekrasov (University of Michigan)  
Deligne's Theorem on Tensor Categories and Supergroups  

For every algebraic group scheme we can associate a tensor category. And most of the examples of such categories are coming from representations of group schemes. So, are they all equivalent to categories of representations of groups? The theorem of Deligne answers this question. Every tensor category (satisfying some natural conditions) is equivalent to the category of representations of some supergroup.

In this talk, after the formulation of the main result, I will give the necessary definitions and (counter)examples. If we'll have time, I will also talk about the physical significance of the result.

Commutative Algebra  
Thursday, February 20, 2020, 3:00pm-4:00pm  
1866EH East Hall  
Anurag Singh (University of Utah)  
Differential operators on invariant rings  

Work of Levasseur and Stafford describes the rings of differential operators on various classical invariant rings of characteristic zero; in each of these cases, the differential operators form a simple ring. Towards an attack on the simplicity of rings of differential operators on invariant rings of reductive groups over the complex numbers, Smith and Van den Bergh asked if reduction modulo p works for differential operators in this context. In joint work with Jack Jeffries, we establish that this is not the case for various classical groups.

Topology  
Thursday, February 20, 2020, 4:00pm-5:00pm  
3866 East Hall  
Tommaso Cremaschi (University of Southern California)  
Hyperbolic 3-manifolds with infinitely generated fundamental group  

I will give an example of an open 3-manifold $M$ that is locally hyperbolic, its fundamental group has no divisible subgroup, but $M$ is not hyperbolic. This example answers a question of Agol. Moreover, I will use it to illustrate a result on hyperbolization for a particular class of open 3-manifolds with infinitely generated fundamental group.

Differential Equations  
Thursday, February 20, 2020, 4:00pm-5:00pm  
4088 East Hall  
Zaher Hani (Michigan)  
An informal discussion on mathematical wave turbulence  

We will discuss some mathematical questions in mathematical wave turbulence, focusing on the rigorous understanding of the so-called wave kinetic equation.
Special Events
Friday, February 21, 2020, 2:30pm-4:00pm
2330 Mason Hall
Emanuel Reinecke (UM)
Learning Seminar on BMS2: Quasi-syntomic site

Applied Interdisciplinary Mathematics (AIM)
Friday, February 21, 2020, 3:00pm-3:00pm
1084 East Hall
Osman Basaran (Purdue University)
High-accuracy simulation of free surface flows near finite-time pinch-off and coalescence singularities

Motivated by applications such as ink jet printing, drop-by-drop manufacturing, sprays, emulsions, and chemical separations, we study the dynamics of breakup and coalescence through high-accuracy simulation, theory, and experiment. In this talk, I will highlight our group's work on accurately capturing the fluid dynamics that takes place in the vicinity of finite-time singularities. The free surface flow algorithms and solvers that we develop and use rely on a sharp interface representation of phase boundaries. In the simulations, we are able to analyze situations that involve disparate length scales that differ by up to seven orders of magnitude (commercial codes can handle about 2-3 orders and custom codes can capture at most 3-4 orders of magnitude disparity in length scales). The primary focus of the talk will be on simulations of the breakup of surfactant covered filaments where I will pay special attention to the pinch-off singularity. I will also summarize some of our recent work on the pre- and post-coalescence singularities that arise when two drops or bubbles are driven together and made to merge into one.
Combinatorics  
Friday, February 21, 2020, 3:00pm-4:00pm  
4096 East Hall  
Daping Weng (Michigan State University)  
*Cluster structures on double Bott-Samelson cells and applications*

Let $G$ be a Kac-Peterson group associated to a symmetrizable generalized Cartan matrix. Let $(b, d)$ be a pair of positive braids associated to the root system. We define the double Bott-Samelson cell associated to $G$ and $(b,d)$ to be the moduli space of configurations of flags satisfying certain relative position conditions. We prove that they are affine varieties and their coordinate rings are upper cluster algebras. We construct the Donaldson-Thomas transformation on double Bott-Samelson cells and show that it is a cluster transformation. In the cases where $G$ is semisimple and the positive braid $(b,d)$ satisfies a certain condition, we prove a periodicity result of the Donaldson-Thomas transformation, and as an application of our periodicity result, we obtain a new geometric proof of Zamolodchikov’s periodicity conjecture in the cases of $(D, A_r)$. In the cases where $G$ is of Dynkin type $A_r$, we prove that the undecorated double Bott-Samelson cell is an Legendrian invariant associated to the closure of the pair of positive braids $(b,d)$. This is joint work with Linhui Shen.

Student Commutative Algebra  
Friday, February 21, 2020, 3:00pm-4:00pm  
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Monica Lewis (University of Michigan)  
*TBA*

Preprint Algebraic Geometry  
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Devlin Mallory (UM)  
*Asymptotic growth of global sections on open varieties, following Di Cerbo*