41^{st} Annual New York State Regional Graduate Mathematics Conference

Syracuse University

April 9, 2016

Mathematics Graduate Organization

This conference is supported by the Syracuse University Department of Mathematics and the Graduate Student Organization.

We would like to express our thanks to all the people who helped us in making this conference possible, especially the Department of Mathematics here at Syracuse University. We would like to extend special thanks to our departmental office staff, without whom this conference would not be possible.

We would also like to thank the graduate students involved in putting this conference together. The main organizers from the MGO Board are:
Jennifer Edmond, James Heffers, Maureen Jeffery, and Rachel Gettinger.

Lastly, we would like to thank you all for coming and we hope that your stay at Syracuse University is as pleasant as possible.

Time	**CARNEGIE 122**	**CARNEGIE 120**
8:30 - 9:30	Breakfast and Registration (CARNEGIE 111)	
9:30 - 10:30	**Steven Zelditch** ***The Method of Stationary Phase in Mathematics and Physics*** CARNEGIE 122	
10:40 - 11:10	Patrick Biermann *Duality Maps in Banach Spaces*	Laura Ballard *Lights Out: The Effect of Graph Operations on the Nullspace of the Neighborhood Matrix*
11:20 - 11:50	Dann Cuneo *Tools for Analysis of Homeomorphisms between Domains*	Rachel Gettinger *Rigidity of Resolutions and the Rigidity Conjecture*
12:00 - 1:00	Lunch (CARNEGIE 111)	
1:00 - 2:00	**Jeffrey Weeks** ***The Shape of Space*** CARNEGIE 122	
2:10 - 2:40	Caleb McWhorter *Analysis on Surreal Numbers*	Balazs Elek *Pizzas*
2:50 - 3:20	Brendan Murphy *Halfway to Szemeredi-Trotter in Finite Fields*	Robert Tuzun *Computational Investigation of the Jones Unknotting Conjecture*
3:30 - 4:00	James Heffers *Not Quite Harmonic...*	Josh Stangle *Noncommutative Resolutions over Non-Gorenstein Rings*

Opening Address: The Method of Stationary Phase in Mathematics and Physics
Steven Zelditch, Northwestern University
9:30am, Saturday, April 9

Abstract: The stationary phase method (aka the method of steepest descent or the saddle point method) is the method of asymptotically evaluating oscillatory integrals by localization to the critical manifolds of the phase. When physicists express partition functions as Feynman path integrals and evaluate them by Feynman diagram techniques, they are using the stationary phase method. I will explain what oscillatory integrals are and why they are so pervasive in both mathematics and physics, then illustrate the method of stationary phase in simple model cases, then explain its proof. I will also discuss special cases such as the Duistermaat-Heckman theorem, the Berline-Vergne theorem, and perhaps super-symmetric oscillatory integrals.

Keynote Address: The Shape of Space
Jeffrey Weeks, MacArthur Fellow
1:00pm, Saturday, April 9

Abstract: When we look out on a clear night, the universe seems infinite. Yet this infinity might be an illusion. During the first half of the presentation, computer games will introduce the concept of a multiconnected universe. Interactive 3D graphics will then take the viewer on a tour of several possible shapes for space. Finally, we'll see how satellite data provide tantalizing clues to the true shape of our universe. The only prerequisites for this talk are curiosity and imagination. Easily accessible to all.

Duality Maps in Banach Spaces
Patrick Biermann, Syracuse University, 10:40-11:10

Abstract: The Hahn-Banach Theorem implies that for every vector in a Banach space there exists a norming functional. This correspondence is not continuous in general. However, a slight relaxation of the norming condition allows for a continuous vector-functional correspondence in every Banach space. We will see that the attainable modulus of continuity is related to certain isomorphic invariants of Banach spaces. In particular, this approach leads to a geometric characterization of isomorphic images of Hilbert spaces.

Tools for Analysis of Homeomorphisms between Domains
Dann Cuneo, Syracuse University, 11:20-11:50

Abstract: We are interested in studying certain properties about the class of all homeomorphisms between two given domains of $\mathbb{R}^n$. In this talk, I will define some of the tools, including notions of normal and tangential derivatives and differential forms, necessary for the analysis of certain homeomorphisms. Using these tools, I will then introduce free Lagrangian differential forms, and give some examples.

Analysis on Surreal Numbers
Caleb McWhorter, Syracuse University, 2:10-2:40

Abstract: In a single week in 1976, J.H. Conway wrote *On Numbers and Games*, where he introduced the surreal numbers - which he discovered studying combinatorial game theory. However, there is still no complete theory of analysis on the surreals. This talk will be broken up into $\{0, 1 \mid \}$ parts. First, we will construct the surreal numbers and discuss their analytic and topological properties. Second, we shall discuss open problems in the field and progress towards a complete integration theory, particularly the work Salzdeo-Swaminathan, which fixes and extends the work done by Conway, Kruskal, Bach, Norton, Fornasieo, etc.

Halfway to Szemeredi-Trotter in Finite Fields
Brendan Murphy, University of Rochester, 2:50-3:20

Abstract: The Szemeredi-Trotter incidence bound is an important tool in geometric and additive combinatorics; given a finite set of points in the real plane, the Szemeredi-Trotter bound controls the number of lines that contain a given number of points of these points. In finite fields, only weak analogs of Szemeredi-Trotter theorem are known. We will present an incidence bound over finite fields that is essentially half-way between the trivial bound and the Szemeredi-Trotter theorem. Any improvements to this bound would have interesting consequences for problems in classical number theory; the proof uses sum-product techniques. This is joint work with Esen Aksoy-Yazici, Misha Rudnev, and Ilya Shkredov.

Not Quite Harmonic...
James Heffers, Syracuse University, 3:30-4:00

Abstract: Harmonic functions (functions which satisfy the laplacian equation $\Delta = 0$) serve as useful tools, but due to the restrictive conditions on them, they are not always applicable. We will look at a larger class of functions called subharmonic functions, which have the property that $\Delta \geq 0$. Then we look at the laplacian in the sense of distributions, which allows us to consider the laplacian of subharmonic functions that are not twice differentiable, as well as see that it is a measure. Finally we will use these new tools to prove that in $\mathbb{C}$, we have $\Delta log|z| = 2\pi\delta_0$, the Dirac mass at the origin. It should be noted that some knowledge of basic measure theory necessary for this talk.

Lights Out: The Effect of Graph Operations on the Nullspace of the Neighborhood Matrix
Laura Ballard, Syracusel University, 10:40 - 11:10

Abstract: Based on a puzzle by Tiger Electronics, Lights Out can be formulated as a problem in graph theory and linear algebra. The objective of Lights Out is to turn off all of the lights (vertices), in which case a graph has been won. In our research, we worked with generalized Lights Out puzzles in which each light is in one of several states, one of which is designated as off. We not only studied winnable states of graphs, but also investigated the null space of the neighborhood matrices of these graphs, and how the null space changes when a graph is altered. In my talk, I will give an overview of how the Lights Out Problem is built up, and will talk about some of our results. Our goal is that these results lead to a more complete understanding of how the null space (and hence, the number of winnable states) changes as graphs are built up from paths and cycles, or as subgraphs are removed.

Rigidity of Resolutions and the Rigidity Conjecture
Rachel Gettinger, Syracuse University, 11:20 - 11:50

Abstract: Auslander conjectured that over a local ring, a resolution of a finitely generated module of finite projective dimension is rigid with respect to all finitely generated modules. In this talk, we will define rigidity of a resolution and work through several basic examples. We will then prove a classic result on rigidity due to Auslander and discuss its relationship to the Rigidity Conjecture. This talk is made to be accessible to all graduate students.

Pizzas
Balazs Elek, Cornell University, 2:10 - 2:40

Abstract: We will bake polygonal pizzas from specific quadrilaterals for slices. Despite the rather simple nature of the question (and of pizzas), there is a surprising amount of math kitchenware that we will use. We will try very hard to stick with vocabulary associated to pizzas. If the baking finishes early, we might discuss the background of the problem.

Computational Investigation of the Jones Unknotting Conjecture
Robert Tuzun, University at Buffalo, 2:50 - 3:20

Abstract: We computationally investigate the conjecture by Jones that the Jones polynomial distinguishes the unknot. This is done by representing knot diagrams as closures of algebraic tangles or as algebraic tangles embedded in vertices of 4-regular planar simple graphs, then computing quantities related to the Jones polynomial. Diagrams with unit Jones polynomial are later checked for unknottedness using the software SnapPy. Numerous strategies for eliminating algebraic tangles, graphs, and knot diagrams from consideration and for reducing computation time per case and memory usage make it practical to perform the calculations on single machines. So far, no counterexamples for the Jones conjecture have been found for up to 21 crossings.

Noncommutative Resolutions over Non-Gorenstein Rings
Josh Stangle, Syracuse University, 3:30 - 4:00

Abstract: In 2004, Van den Bergh introduced the notion of a *noncommutative (crepant) resolution* of a commutative ring R as an algebraic analog of desingularizations in algebraic geometry. This is a certain endomorphism ring, $\mathrm{End}_R(M)$, over a commutative ring R, which is also a maximal Cohen-Macaulay R-module and has finite global dimension. When the base ring R is Gorenstein, many strong theorems supply examples. In the case where R is only Cohen-Macaulay, the situation is less clear. We'll discuss possible amendments to the definition in the non-Gorenstein case and provide some obstructions. We'll also examine a certain endomorphism ring and discuss when it has the properties we would desire.