Colloquium, Academic Year 16-17

Thursdays 4:10 pm in 5211 Stevenson Center, unless otherwise noted
Tea at 3:30 pm in 1425 Stevenson Center
Colloquium Chair (2016-2017): Bruce Hughes

September 8, 2016 (Thursday), 4:10 pm

Exponential Bases on Triangles and Other Domains

Laura De Carli, Florida International University
Location: Stevenson 5211
Riesz bases made of exponential functions (or: exponential bases) are one of the best tool to represent L^2 functions on domains of R^d. Unfortunately there are very few domains on which we know how to construct exponential bases and no domain where it is proved that exponential bases do not exist. In this talk I will show that it is possible to construct exponential bases on triangles in R^2, and I will also show example of unbounded domain of finite measure where exponential bases can be constructed. I will also discuss open problems and generalization. This is a joint work with my student Alberto Mizrahi (FIU). Tea at 3:30 pm in SC 1425. (Contact Person: Akram Aldroubi)

September 15, 2016 (Thursday), 4:10 pm

Symplectic Calabi-Yau Surfaces

Tian-Jun Li, University of Minnesota
Location: Stevenson 5211
I will survey what is known about the geometry and topology of the symplectic analogue of Calabi-Yau manifolds. The focus will be on four dimensional symplectic CYs, which resemble the Kahler CY surfaces topologically. In particular, their Betti numbers are bounded. In contrast, in higher dimension, they are known to be much more flexible via both topological and differential geometric constructions. For instance, any finitely presented group can be realized as the fundamental group of a six dimensional symplectic CY. Tea at 3:30 pm in SC 1425. (Contact Person: Ioana Suvaina)

September 22, 2016 (Thursday), 4:10 pm

The Sphere Packing Problem in Dimensions 8 and 24

Maryna Viazovska, Humbolt U of Berlin
Location: Stevenson 5211
The sphere packing problem is to find an arrangement of non-overlapping unit spheres in the d-dimensional Euclidean space in which the spheres fill as large a proportion of the space as possible. In this talk we will present a solution of the sphere packing problem in dimensions 8 and 24. In 2003 N. Elkies and H. Cohn proved that the existence of a real function satisfying certain constrains leads to an upper bound for the sphere packing constant. Using this method they obtained almost sharp estimates in dimensions 8 and 24. We will show that functions providing exact bounds can be constructed explicitly as certain integral transforms of modular forms. Therefore, the sphere packing problem in dimensions 8 and 24 is solved by a linear programming method. Tea at 3:30 pm in SC 1425. (Contact Person: Ed Saff)

October 6, 2016 (Thursday), 4:10 pm

The Einstein Equations and Gravitational Waves

Lydia Bieri, University of Michigan
Location: Stevenson 5211
In Mathematical General Relativity (GR) the Einstein equations describe the laws of the universe. This system of hyperbolic nonlinear pde has served as a playground for all kinds of new problems and methods in pde analysis and geometry. A major goal in the study of these equations is to investigate the analytic properties and geometries of the solution spacetimes. In particular, fluctuations of the curvature of the spacetime, known as gravitational waves, have been a highly active research topic. Last year, gravitational waves were observed for the first time by LIGO. Understanding gravitational radiation is tightly interwoven with the study of the Cauchy problem in GR. I will talk about geometric-analytic results on gravitational radiation and the memory effect of gravitational waves. We will connect the mathematical findings to experiments. I will also address recent work with David Garfinkle on gravitational radiation in asymptotically flat as well as cosmological spacetimes.Tea at 3:30 pm in SC 1425. (Contact Person: Marcelo Disconzi)

October 27, 2016 (Thursday), 4:10 pm

Sharp Energy Minimization for the Triangular Bi-Pyramid

Richard Schwartz, Brown University
Location: Stevenson 5211
For any s>0 one can define the Riesz s-energy potential for a finite configuration of points on the sphere as the sum of the reciprocal s powers of the distances between the points, taken over all pairs. The case of 5 points has been notoriously intractable and it has been long conjectured that there exists a constant S = 15.048… such that the triangular bi-pyramid is the global minimizer for the Riesz s-energy potential if and only if s in (0,S]. I will explain my very recent proof of this result. The argument has some massive (but rigorous) computer calculations in it, but it also involves such ideas as stereographic projection, symmetrization, polynomial interpolation, and divide-and-conquer algorithms. I'll illustrate the talk with a bunch of computer demos. Tea at 3:30 pm in SC 1425. (Contact Person: Ed Saff)

November 1, 2016 (Tuesday), 4:10 pm

Special Colloquium: Stochastic Homogenization for Reaction-Diffusion Equations

Jessica Lin, University of Wisconsin-Madison
Location: Stevenson 5211
We study heterogeneous reaction-diffusion equations in stationary ergodic random media with both ignition and KPP-type nonlinearities. Under suitable hypotheses on the environment, we prove the existence of deterministic asymptotic speeds of propagation for solutions with both compactly supported and front-like initial data. We subsequently obtain a general stochastic homogenization result which shows that, in the large-scale-large-time limit, the behavior of typical solutions in such environments is governed by a simple deterministic Hamilton-Jacobi equation modeling front propagation. This talk is based on joint work with Andrej Zlatos. Tea at 3:30 pm in Stevenson 1425. (Contact Person: Ed Saff)

November 10, 2016 (Thursday), 4:10 pm

Periodicity in Homotopy Theory

Haynes Miller, MIT
Location: Stevenson 5211
In 1950 Jean-Pierre Serre calculated the rational homotopy groups of spheres. This work proved to be the vanguard of an extensive campaign of understanding homotopy theory through its localizations, resulting in the "chromatic" perspective on homotopy theory. I'll review some of that history, and describe some recent work on analogous calculations in "motivic" homotopy theory. Tea at 3:30 pm in SC 1425. (Contact Person: Anna Marie Bohmann)

November 17, 2016 (Thursday), 4:10 pm

On Weyl's Spectral Decomposition Theorem

Nigel Higson, Penn State
Location: Stevenson 5211
Early in his career, Hermann Weyl examined and solved the problem of decomposing a function on a half-line as a continuous combination of the eigenfunctions of a Sturm-Liouville operator with asymptotically constant coefficients. Weyl's theorem served as inspiration for Harish-Chandra in his pursuit of the Plancherel formula for semisimple groups, and for this and other reasons it continues to be of interest. I'll try to explain how Weyl's theorem arises again in efforts to view Harish-Chandra's work from the perspective of noncommutative geometry, and I'll describe a new, geometric, proof of Weyl's theorem that seems to fit better with representation theory. This is joint work with Tyrone Crisp and Qijun Tan. Tea at 3:30 pm in SC 1425. (Contact Person: Rudy Rodsphon)

December 1, 2016 (Thursday), 4:10 pm

Thurston's Asymmetric Metric on Teichmuller Space

Jing Tao, University of Oklahoma
Location: Stevenson 5211
In this talk, I will explain some new developments in Teichmuller theory from the perspective of the Thurston metric. This is an asymmetric Finsler metric defined on Teichmuller space, using the hyperbolic lengths of geodesic laminations on a surface and Lipschitz maps between surfaces, as opposed to using measured foliations and quasicomformal maps which give rise to the Teichmuller metric. This metric was introduced by Thurston in 1986 but it has not been studied extensively until recently. It has a distinctive and rich structure that is already apparent in two-dimensional Teichmuller space. In this case, we now have a clear picture of the infinitesimal and the coarse geometry of this metric. Using our understanding, we derive several applications, including an analogue of Royden's theorem. Tea at 3:30 pm in SC 1425. (Contact Person: Ed Saff)

December 6, 2016 (Tuesday), 4:10 pm

Special Colloquium: Fast Alternating Direction Algorithms for Nonsmooth, Convex/Nonconvex Optimization with Imaging Applications

Maryam Yashtini, Georgia Tech
Location: Stevenson 5211
In this talk, I propose several efficient, reliable, and practical computational algorithms to solve challenging optimization problems arising in medical imaging and image processing. These problems are non-differentiable and can be ill-conditioned, non-convex, and/or highly nonlinear such that traditional sub-gradient based methods converge very slowly. To tackle the computational complexities, I use relaxation and approximation techniques. In addition, I exploit splitting variables and alternating direction method of multipliers to decouple the original challenging problems into sub-problems which are easier to solve. To obtain fast results, I develop innovative line search strategies and solve the sub-problems using Fourier transforms and shrinkage operators. I present the analytical properties of these algorithms as well as various numerical experiments on parallel Magnetic Resonance Imaging, image inpainting, and image colorization. The comparison with other methods are given to show the efficiency and the effectiveness of the proposed methods. Tea at 3:30 pm in SC 1425. (Contact Person: Alex Powell).

December 8, 2016 (Thursday), 4:10 pm

Roots, Schottky Semigroups, and a Proof of Bandt's Conjecture

Danny Calegari, University of Chicago
Location: Stevenson 5211
In 1985, Barnsley and Harrington defined a "Mandelbrot Set" M for pairs of similarities — this is the set of complex numbers z with norm less than 1 for which the limit set of the semigroup generated by the similarities x -> zx and x -> z(x-1)+1 is connected. Equivalently, M is the closure of the set of roots of polynomials with coefficients in {-1,0,1}. Barnsley and Harrington already noted the (numerically apparent) existence of infinitely many small "holes" in M, and conjectured that these holes were genuine. These holes are very interesting, since they are "exotic" components of the space of (2 generator) Schottky semigroups. The existence of at least one hole was rigorously confirmed by Bandt in 2002, but his methods were not strong enough to show the existence of infinitely many holes; one difficulty with his approach was that he was not able to understand the interior points of M, and on the basis of numerical evidence he conjectured that the interior points are dense away from the real axis. We introduce the technique of *traps* to construct and certify interior points of M, and use them to prove Bandt's Conjecture. Furthermore, our techniques let us certify the existence of infinitely many holes in M. This is joint work with Sarah Koch and Alden Walker. Tea at 3:30 pm in SC 1425. (Contact Person: Mark Sapir)

January 10, 2017 (Tuesday), 4:10 pm

Special Colloquium: Towards a Higher Dimensional Analog of Uniform Boundedness of Torsion on Elliptic Curves

Bianca Viray, University of Washington

Location: Stevenson 1206

Let E be an elliptic curve over a number field K. Mordell proved that E(K), the set of K-rational points on E, forms a finitely generated abelian group. So one can ask how this abelian group varies as E and K vary, in particular one can ask whether the torsion subgroup can be arbitrarily large. In 1996, Merel gave a definitive answer to this question, showing that the size of the torsion subgroup of E(K) can be bounded by a constant that depends only on the degree of K over Q. K3 surfaces are in many ways similar to elliptic curves, although there is no group structure on a K3 surface. Despite this key difference, we explain how one can formulate an analog of Merel's theorem for K3 surfaces and state some results in this direction. This talk will be suitable for a general audience. Tea at 3:30 pm in SC 1425. (Contact Person: John Ratcliffe)

January 17, 2017 (Tuesday), 4:10 pm

Special Colloquium: Challenges in Computational Hemodynamics: Multiphysics and Cost Reduction

Annalisa Quaini, University of Houston

Location: Stevenson 1206

Modeling and computational analysis play an increasingly important role in the investigation of blood flow problems. Significant challenges in the context of computational hemodynamics are the multiphysics nature of the problems (e.g., interaction of blood with artery walls or valve leaflets) and the associated high computational cost. We discuss efficient algorithms to simulate the interaction of blood (an incompressible fluid) and an elastic structure. Two cases are considered: 1. the elastic structure covers part of the fluid boundary and undergoes small displacement and 2. the elastic structure is immersed in the fluid and it features large displacement. Then, we consider the simulation of blood flow at high Reynolds numbers (in the range of few thousand). In order to contain the computational cost associated to a Direct Numerical Simulation, we propose a Leray model with a deconvolution-based indicator function. Finally, we report on some recent developments of Reduced Order Modeling in order to lower the computational cost in a numerical study to understand the causes of the Coanda effect in cardiology. We show that a Reduced Basis method allows to capture such a complex physical and mathematical phenomenon at a fraction of the computational cost required by full order order methods. Tea at 3:30 pm in SC 1425. (Contact Person: Gieri Simonett)

February 2, 2017 (Thursday), 4:10 pm

Title: Algebraic, Geometric, and Dynamical Aspects of Surfaces

Dan Margalit, Georgia Tech
Location: Stevenson 5211
To each homeomorphism of a surface we can associate a real number, called the entropy, which encodes the amount of mixing being effected. This number can be studied from topological, geometrical, dynamical, analytical, and algebraic viewpoints. We will start by explaining Thurston's beautiful insight for how to compute the optimal entropy within a homotopy class and explain a new, fast algorithm based on his ideas, which is joint work with Balazs Strenner and Oyku Yurttas. We will also discuss some classical results and recent work with Ian Agol, Benson Farb, and Chris Leininger on the problem of understanding homeomorphisms with small entropy. One theme is that algebraic complexity and geometric complexity both imply dynamical complexity.
Tea at 3:30 pm in SC 1425. (Contact Person: Spencer Dowdall)

February 7, 2017 (Tuesday), 3:00 pm

Special Colloquium: Rational and Irrational Varieties

Yuri Tschinkel, The Simons Foundation and Courant Institute of Mathematical Sciences, New York University
Location: Stevenson 5211
I will discuss recent advances in the study of rationality properties of higher-dimensional algebraic varieties (joint work with B. Hassett and A. Pirutka). Tea at 4pm in SC 1425 (Contact Person: Mike Neamtu)

February 9, 2017 (Thursday), 4:10 pm

Discrepancy and Energy Optimization (On the Sphere)

Dimitri Bilyk, University of Minnesota
Location: Stevenson 5211
There are many different ways to measure how well a discrete set is distributed in a given domain, in particular, on the sphere: discrepancy and discrete energy are among the most popular ones. In various situations these two objects turn out to be intricately related to each other. In recent work, we have found several new manifestations and generalizations of this phenomenon with some surprising consequences in energy optimization. We shall present a non-technical survey of old and recent results and interactions between these areas, as well as connections to problems in other fields: combinatorial geometry, one-bit-compressed sensing, embeddings of metric spaces, etc. Tea at 3:30 pm in SC 1425. (Contact Person: Ed Saff)

February 16, 2017 (Thursday), 4:10 pm

Cycling Amenable Groups and Soficity

Kate Juschenko, Northwestern University
Location: Stevenson 5211
I will give introduction to sofic groups and discuss a possible strategy towards finding a non-sofic group. I will show that if the Higman group were sofic, there would be a map from Z/pZ to itself, locally like an exponential map, satisfying a rather strong recurrence property. The approach to (non)-soficity is based on the study of sofic representations of amenable subgroups of a sofic group. This is joint work with Harald Helfgott.
Tea at 3:30 pm in SC 1425. (Contact Person: Denis Osin)

February 23, 2017 (Thursday), 4:10 pm

The subpower membership problem

Miklos Maroti, University of Szeged
Location: Stevenson 5211
For a given a finite algebra A one can compute the subalgebra generated by a set of tuples in the direct power of A. For example, if A is a one-dimensional vector spaces over a finite field,then the generated subalgebra is a subspace whose basis can be calculated in polynomial time from the generators. Once we know the basis, we have an efficient way to check whether a tuple is a member of the generated subspace or not. The same is true for arbitrary algebras, but the exact algorithmic complexity class of the membership problem for the generated subpower is not known for various classes of algebras. We will review the basic results in these fields (for example for groups and for algebras in general) and then show how ideas developed for the constraint satisfaction problem can be used to study this problem for finite algebras in a congruence modular variety.
Tea at 3:30 pm in SC 1425. (Contact Person: Ralph McKenzie)

March 16, 2017 (Thursday), 4:10 pm

The 16th Hilbert Problem: Disclosed and Hidden.

Viatcheslav Kharlamov of Strasbourg University, France
Location: SC 5211
The talk will be focused on the first part of this problem: the part devoted by Hilbert to topological properties of real algebraic curves and surfaces. It is this part, together with 9 other problems of the famous list that was chosen by Hilbert for the oral presentation. In this talk we will present certain milestones achieved in the directions influenced by this problem. In particular, we will mention those which allowed to respond to at least those of Hilbert questions he posed precisely. We will try to explain at least some of the multitude of new ideas, methods and theories disclosed (giving preference to topological and geometrical settings), but also to list selected, still open, questions.
Tea at 3:30 pm in SC 1425. (Contact Person: Rares Rasdeaconu)

March 23, 2017 (Thursday), 4:10 pm

Lipschitz Properties of General Convolutional Neural Networks

Radu Balan, University of Maryland
Location: SC 5211
In this talk we give a general framework for convolutional neural networks (ConvNets) which covers most popular ConvNets in use. We prove that the Lipschitz bound of such a ConvNet can be determined by solving a linear program. Additionally we provide a simpler and more explicit expression for an upper bound. We use our framework to analyze some examples of ConvNets. This is a joint work with Dongmian Zou (UMD) and Maneesh Singh (Verisk).
Tea at 3:30 pm in SC 1425. (Contact Person: Akram Aldroubi)

March 30, 2017 (Thursday), 4:10 pm

Paths of Minimal Lengths on the Set of Exact Differential 2–Forms.

Wilfrid Gangbo, UCLA
Location: Stevenson 5211
In this talk, we recall the definition of the group S of Hamiltonian symplectomorphisms on a contractible subset of a finite dimensional space. We first show that the L^2–projection onto S induces a metric on the set of exact differential 2–forms. We then show how all of these connect to what we term, the symplectic factorization of vector fields. We strive to characterize the geodesics of minimal length and the regularity properties of the projections onto S (this talk is based on joint work with B. Dacorogna and O. Kneuss).
Tea at 3:30 pm in SC 1425. (Contact Person: Gieri Simonett)

April 13, 2017 (Thursday), 4:10 pm

Efficient Modeling of Incompressible Fluid Dynamics at Moderate Reynolds Numbers by Deconvolution LES Filters

Annalisa Quaini, University of Houston

Location: Stevenson 5211

We consider a Leray model with a deconvolution-based indicator function for the simulation of incompressible fluid flow at moderately large Reynolds number (in the range of a few thousand) with under-refined meshes. For the implementation of the model, we adopt a three-step algorithm called evolve-filter-relax (EFR) that requires the solution of a Navier-Stokes problem, the solution of a Stokes-like problem to filter the Navier-Stokes velocity field, and a final relaxation step. We take advantage of a reformulation of the EFR algorithm as an operator splitting method to analyze the impact of the filter on the final solution vs a direct simulation of the Navier-Stokes equations. In addition, we provide some direction for tuning the parameters involved in the model based on physical and numerical arguments. Our approach is validated against experimental data for fluid flow in an idealized medical device (consisting of a conical convergent, a narrow throat and a sudden expansion, as recommended by the Food and Drug Administration). Numerical results are in good quantitative agreement with the measured axial components of the velocity and pressures for two different flow rates corresponding to turbulent regimes, even for meshes with a mesh size more than 40 times larger than the smallest turbulent scale. Through a large set of numerical experiments, we perform a preliminary sensitivity analysis of the computed solution to the parameters involved in the model.

Tea at 3:30 pm in SC 1425. (Contact Person: Mike Neamtu)

April 20, 2017 (Thursday), 4:10 pm

Transversally Elliptic Operators and K-theory

Gennadi Kasparov, Vanderbilt University

Location: SC 5211

The class of (pseudo-) differential operators transversally elliptic with respect to a Lie group action on a manifold was introduced by M. Atiyah in the 70s. He also made an attempt to obtain a formula which calculates the index of such operators by topological means. This class of operators is interesting both from the point of view of geometry and analysis, but particularly by its relations with representation theory of Lie groups. In the 90s, N. Berline and M. Vergne have obtained a certain very complicated index formula. However, this did not stop further attempts to obtain something more reasonable and more useful in applications. I will try to explain the background of the theory and a different approach to an index formula.

Tea at 3:30 pm in SC 1425. (Contact Person: Bruce Hughes)