Colloquium 2022-2023

Unless stated otherwise, colloquia are scheduled for Thursdays 4:15-5:15pm in WH-100E with refreshments served from 4:00-4:15 pm in WH-102.

Organizers: Vladislav Kargin, Cary Malkiewich, Hung Tong-Viet, and Adrian Vasiu

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Fall 2022

Thursday November 3, 4:15-5:15pm, WH-100E
Speaker: **Avy Soffer** (Rutgers University)
Topic: ***The Asymptotic States of Nonlinear Dispersive Equations with Large Initial Data and General Interactions***

Abstract: I will describe a new approach to scattering theory, which allows the analysis of interaction terms which are linear and space-time dependent, and nonlinear terms as well. This is based on deriving (exterior) propagation estimates for such equations, which micro-localize the asymptotic states as time goes to infinity. In particular, the free part of the solution concentrates on the propagation set (x=vt), and the localized leftover is characterized in the phase-space as well. The NLS with radial data in three dimensions is considered, and it is shown that besides the free asymptotic wave, in general, the localized part is smooth, and is localized in the region where |x|^2 is less than t. Furthermore, the localized part has a massive core and possibly a halo which may be a self-similar solution. This work is joint with Baoping Liu. This is then followed by new results on the non-radial case and Klein-Gordon equations (Joint works with Xiaoxu Wu).

Thursday November 17, 2:50-3:50pm, WH-100E
Speaker: **Emmett Wyman** (University of Rochester)
Topic: ***Improved Weyl law remainders for products of spheres***

Abstract: The Laplacian is a fundamental operator in mathematics. It arises, for example, in the heat, wave, and Schrödinger equations. Its eigenfunctions can be viewed as natural vibrational modes and their eigenvalues their respective frequencies.

A fundamental problem in harmonic analysis is to estimate the number $N(\lambda)$ of Laplace eigenvalues less than or equal to λ, counting multiplicity. The Weyl law gives a main term + remainder term estimate for $N(\lambda)$. The remainder is sharp in general but generically can be improved. It is hard to obtain polynomially improved remainders–let alone optimal remainders–except for a handful of very nice examples.

In this talk, we will discuss the remainder of the Weyl law for two classic cases: the sphere and the torus. We will then compare these results through the lense of the dynamics of the geodesic flow via the Duistermaat-Guillemin theorem. Finally, I will present recent joint work with Iosevich which explores the prospect of obtaining polynomially improved Weyl remainders for products of manifolds, which we

illustrate by obtaining polynomially improved remainders for products of spheres.

Tuesday November 22, 4:15–5:15pm, WH-100E
Speaker: **Alexander Dunlap** (NYU Courant)
Topic: ***Stochastic partial differential equations in supercritical, subcritical, and critical dimensions***

Abstract: A pervading question in the study of stochastic PDE is how small-scale random forcing in an equation combines to create nontrivial statistical behavior on large spatial and temporal scales. I will discuss recent progress on this topic for several related stochastic PDEs - stochastic heat, KPZ, and Burgers equations - and some of their generalizations. These equations are (conjecturally) universal models of physical processes such as a polymer in a random environment, the growth of a random interface, branching Brownian motion, and the voter model. The large-scale behavior of solutions on large scales is complex, and in particular, depends qualitatively on the dimension of the space. I will describe the phenomenology, and then describe several results and challenging problems on invariant measures, growth exponents, and limiting distributions.

Wednesday November 30, 4:30–5:30pm, WH-100E
Speaker: **Anibal Medina-Mardones** (Universite Sorbonne Paris Nord)
Topic: ***Effective Algebro-Homotopical constructions and their applications***

Abstract: It is necessary in order to incorporate ideas from homotopy theory into concrete contexts – such as topological data analysis and topological lattice field theory – to have effective constructions of concepts defined only indirectly or transcendentally. In groundbreaking work, Mandell showed that the entire homotopy type of a space was encoded in the quasi-isomorphism type of its cochains enhanced with an E_∞-structure. In this talk, we will present a concrete construction of such structure by explicitly restoring up to coherent homotopies the broken symmetry of the diagonal of cellular spaces, and, on the way, we will explore connections of these ideas to data science, theoretical physics, knot theory, higher category theory, and convex and toric geometry.

Friday December 2, 4:30–5:30pm, WH-100E
Speaker: **Beibei Liu** (MIT)
Topic: ***The critical exponent: old and new***

Abstract: The critical exponent is an important numerical invariant of discrete isometry groups acting on negatively curved Hadamard manifolds, Gromov hyperbolic spaces, and higher-rank symmetric spaces. In this talk, I will focus on discrete isometry groups acting on hyperbolic spaces. In particular, I will explain how the numerical invariant is closely related to geometry, dynamics, and representation of the group action on hyperbolic spaces.

Monday December 5, 4:30–5:30pm, WH-100E
Speaker: **Jia Zhao** (Utah State University)
Topic: ***Physics-informed Computational Modeling of Multiphase Complex Fluids with Applications in Life***

Science

Abstract: Complex fluids are ubiquitous in nature and in synthesized materials, such as biofilms, cytoplasm, mucus, synthetic and biological polymeric solutions. Modeling and simulation of complex fluids have been listed as one of the 21st-century mathematical challenges by DARPA, which is therefore of great mathematical and scientific significance. In this talk, I will first explain our research motivations by introducing several complex fluids examples and traditional modeling techniques. We propose physics- informed PDE models for multiphase complex fluid flows by integrating the generalized Onsager Principle and phase-field approaches. Then, I will introduce a numerical analysis platform for developing accurate, efficient, and structure-preserving numerical approximations for solving complex-fluid PDE models. The computational modeling strategy is rather general in that it can be applied to investigate a host of complex-fluid problems. Finally, I will present several applications in life science with our modeling and numerical analysis toolkits.

Wednesday December 7, 4:30–5:30pm, WH-100E
Speaker: **Minghao W. Rostami** (Syracuse University)
Topic: ***Learning from data: a beginner's journey***

Abstract: The behavior of a complex physical system is often modeled by Partial Differential Equations (PDEs) derived from fundamental physical laws. We can apply various numerical methods to the PDEs to make predictions about the physical system, uncover the causal factors behind observed behaviors of the system, and optimize the design of the system for a task at hand. When sufficient data and computing resources are available, we can also make discoveries by processing data instead. The speaker, as a classically trained applied mathematician who is "learning the ropes" of this alternative approach, will review and discuss the basics of PDE models, numerical methods, and machine learning models. A new data-driven model for calculating particle trajectories in a fluid flow will also be presented, which, unlike conventional methods, does not entail costly flow computations. This is joint work with Jianchen Wei (PhD student), Lixin Shen from Syracuse University and Melissa Green from University of Minnesota, Twin Cities.