The Analysis Seminar

Fourier

The seminar meets Wednesdays in WH-100E at 4:00-5:00 p.m. There are refreshments and snacks in WH-102 at 3:15.

Organizers:
Faculy: Paul Loya, David Renfrew, Minghao Rostami, Emmett Wyman, Xiangjin Xu, Ziyao Xu and Gang Zhou
Post-Docs: Rohan Sarkar

Previous talks

- Fall 2014 to Fall 2025

Spring 2026

* **January 21st, Wednesday** (4-5pm)

Speaker :
Topic: organizational meeting

Abstract:

* **January 28th, Wednesday** (4-5pm)

Speaker : Chad Nelson (Binghamton University)
Topic: Fredholmness of Elliptic Operators on Manifolds with Boundary

Abstract: The classical calculus of pseudodifferential operators extends differential operators in a way that is suited to the construction of parametrices (pseudo-inverses) for elliptic operators. A fundamental consequence is that elliptic operators are Fredholm between appropriate Sobolev spaces on compact manifolds.

On manifolds with boundary, this implication no longer holds. Melrose’s calculus of b-pseudodifferential operators is the analogous class of operators which leads to Fredholm properties for elliptic operators satisfying a certain condition related to the boundary. In this

talk, I will compare the classical case and the boundary case, emphasizing the new features introduced by the boundary—most notably the b-stretched product and the indicial operator—and explain how these lead to Fredholmness on weighted b-Sobolev spaces.

* **February 4th, Wednesday** (4-5pm)

Speaker : Emmanuel Adara (Binghamton University)
Topic: On Methods of Solution to Chemical Master Equation in Biochemical Systems

Abstract: In chemical kinetics, accurately modeling the dynamic behavior of chemical systems is essential for predicting reaction outcomes and optimizing processes. However, the challenge known as the “curse of dimensionality” has posed significant difficulties for conventional techniques employed in addressing the chemical master equation (CME). This predicament arises when the state space of the Markov chain expands exponentially with the number of species, rendering the CME computation practically unsolvable.

In this talk, I will discuss some methods of solving the CME, including Gillespie’s algorithm, the Chemical Langevin Equation, and the Method of Moments, along with an overview of tensor train and machine learning-based methods, which offer promising strategies for gaining insights into complex biological systems.

* **Tuesday, February 10 (Joint with Data Science Seminar)** (12:15-1:15pm)

Speaker : Dr. Yizeng Li (Department of Biomedical Engineering at Binghamton University)
Topic: Multiphase Continuum Models for Cell Migration.

Abstract: Cell migration is a fundamental process in physiology and disease, yet it poses challenging problems in multiscale modeling and continuum mechanics. Cell motility arises from the coupling of intracellular transport, active force generation, and evolving geometry. Cytoskeletal dynamics, in particular actin turnover and force production, provides a rich setting for mathematical analysis. In this talk, I will present a mathematical framework for mammalian cell motility based on multiphase continuum models with moving boundaries. The formulation incorporates fluid-structure interaction and active stresses to describe the coupled evolution of cytoskeletal flow and cell shape. The model predicts how migration efficiency depends on actin dynamics and geometric features of the cell. If time permits, I

will also present a mechanical-electrical-chemical coupled model for water-driven cell motility induced by polarized membrane ion transport. This second framework highlights how transport processes and force balance together generate directed motion.

Biography of the speaker: Yizeng Li is an Assistant Professor in the Department of Biomedical Engineering at Binghamton University. She received MS from Mathematics and PhD from the Department of Mechanical Engineering at the University of Michigan-Ann Arbor. Afterwards, she was a postdoctoral researcher at Johns Hopkins University's Department of Mechanical Engineering and Institute for NanoBioTechnology. Her backgrounds are in theoretical mechanics and applied mathematics with applications to biophysics and mechanobiology. Li develops physiology-based mathematical models for cell motility, polarization, volume regulation, electro-homeostasis, signal transduction, and other biophysics problems. She also combines mathematical models with experimental data to explain non-intuitive cell biology phenomena.

* **(Updated) March 19th, Thursday** (4-5pm)

Speaker: Zheng Sun (University of Alabama, Tuscaloosa)
Topic: On a numerical artifact of solving shallow water equations with a discontinuous bottom

Abstract: The nonlinear shallow water equations are used to model the free surface flow in rivers and coastal areas for which the horizontal length scale is much greater than the vertical length scale. They have wide applications in oceanic sciences and hydraulic engineering. In this talk, we study a numerical artifact of solving the shallow water equations over a discontinuous riverbed. For various first-order methods, we report that the numerical solution will form a spurious spike in the numerical momentum at the discontinuous point of the bottom. This artifact will cause the convergence to a wrong solution in many test cases. We present a convergence analysis to show that this numerical artifact is caused by the numerical viscosity imposed at the discontinuous point. Motivated by our analysis, we propose a numerical fix which works for the nontransonic problems.

* **March 25th, Wednesday** (4-5pm)

Speaker: Yiming Zhao(Syracuse University)
Topic: $SL(n)$-invariant isoperimetric and Minkowski problems

Abstract: In convex geometry, where convex bodies are the primary objects of study, a central goal is to discover geometric invariants and measures that can be used to recover or characterize their shapes. Two intertwined lines of research pursue this objective. Isoperimetric inequalities involving geometric invariants, including the classical isoperimetric inequality and the celebrated Brunn–Minkowski inequality, seek to identify special shapes as extremals. Minkowski problems, a family of problems originating in the work of Minkowski, aim to recover, sometimes uniquely, the shape of an arbitrary convex body by solving measure equations that, under additional but unnecessary smoothness assumptions, reduce to Monge–Ampère-type equations. In this talk, after giving some historical background, I will discuss recent joint work with Dongmeng Xi that continues this line of research through the study of integral affine surface area and radial mean bodies.

* **April 1st, Wednesday** (4-5pm)

Speaker: Spring Break (Binghamton University)
Topic: A lower bound on sleep duration under optimal conditions

Abstract:

We show that in the absence of homework, sleep duration increases without bound. Applications to stress reduction are discussed.

* **April 8th, Wednesday** (4-5pm)

Speaker: Gang Zhou (Binghamton University)
Topic: Exact characterizations for quantum conditional mutual information and some other entropies

Abstract: I will present my latest results on quantum information theory. I will start with an introduction to the quantum theory for preparation, and then present the results.

Lieb and Ruskai's strong subadditivity theorem, which shows that the conditional mutual information must be nonnegative, is fundamental in quantum theory. It has numerous applications, such as in quantum error correction.

When the mutual information is zero, the Petz recovery map can be used to reconstruct the

quantum channel.

When the mutual information is small, one seeks to define an optimal recovery channel. To this end, a mathematical characterization of the mutual information is desirable. In my latest paper I provided an exact characterization of the mutual information, along with characterizations for other entropies. My controls are sharp, leaving no room for improvement, in the sense that I provided equalities, regardless of whether the mutual information (or remainder) is small or large.

I transformed the definitions of these entropies into a summation of explicitly constructed terms, and the definition of each term obviously demonstrates the desired positivity/convexity/concavity. The summation converges rapidly and absolutely in a chosen elementary norm.

An exposition for the general public was provided by git.science and emailed to me, see the link https://gist.science/paper/2603.14650

* **April 15th, Wednesday,** 4:00-6:00pm (PhD Thesis Defense)

Speaker: Brian Kirby(Binghamton University)
Topic: On Resolving the Singularities of the Reissner-Nordström Penrose Diagram via Method of Blow-Ups

Abstract: The Penrose Diagram was first developed by Roger Penrose in the early 1960's, taking an infinite spacetime and representing it in a concise diagram. This was first used to model the Schwartzchild spacetime metric, a black hole with no electric charge. The Penrose Diagram for the Reissner-Nordstrom metric was a result of the works of Brandon Carter, Stephen Hawking, and George Ellis, primarily in the late 1960's to early 1970's. These diagrams are still used today, primarily by physicists and astronomers to help better understand black holes, event horizons, and causality. This thesis focuses on better understanding the Penrose Diagram for the Reissner-Nordstrom metric. While work has been done recently to develop algorithms and explicitly construct these diagrams, current understanding of Penrose Diagrams works only on the interior of the diagrams, giving an incomplete picture of spacetime with infinitely many discontinuities with highly discontinuous behavior. In this thesis, we generalize the Reissner-Nordstrom metric and expand on its standard Penrose Diagram construction. Through the method of blow-ups of manifolds with corners, we resolve each singularity in the standard Penrose Diagram, and classify the asymptotic behavior of the metric at $r = 0$. In particular, we prove:

Theorem: Any Reissner-Nordstrom metric lifts to its blown-up Penrose Diagram to be a C^{∞} b-metric everywhere, up to and including the front faces, except at the $r = 0$ hypersurface, where it has an expansion of the form $r^{-2/3} F(r^{1/3})$.

The Thesis Committee members are: Paul Loya (Chair and Faculty Advisor), Emmett Wymann, Xiangjin Xu and Bruce White (Outside Examiner).

* **April 22th, Wednesday** (4-5pm)

Speaker: Cancelled
Topic:

Abstract:

April 29th, Wednesday (4-5pm)

Speaker: Yahong Yang (Georgia Institute of Technology)
Topic: Multiscale Neural Networks for Approximating Green's Functions and Operators

Abstract: Neural networks (NNs) have been widely used to solve partial differential equations (PDEs) with broad applications in physics, biology, and engineering. One effective approach for solving PDEs with a fixed differential operator is to learn the associated Green's function. However, Green's functions are notoriously difficult to approximate due to their poor regularity, often requiring large neural networks and long training times.

In this talk, we address these challenges by leveraging multiscale neural networks to learn Green's functions efficiently. Through theoretical analysis based on multiscale Barron space techniques, together with numerical experiments, we show that the multiscale approach significantly reduces the required network size and accelerates training. We then extend this framework to operator learning, enabling neural networks to efficiently and accurately learn the mapping from coefficient functions to Green's functions.

* **May 6th, Wednesday** (4-5pm)

Speaker:Santiago Alzate (Binghamton University)
Topic: Masters thesis

Abstract:
