Joint Mathematics–Statistics PhD Homecoming

Mathematics Talks
IMS Executive Seminar Room
02 Oct 2025–03 Oct 2025

September 12, 2025

Abstracts

A Unified Approach for Data Synthesis in Imaging: Integrating Paired and Unpaired Datasets

2 Oct
9.30-9.50

Bao Chenlong

Tsinghua University, China

A significant gap between theory and practice in imaging sciences arises from inaccuracies in mathematical models, including imperfect imaging models and complex noise. Recent advancements have seen deep neural networks directly mapping observed data to clean images using paired training data. While these approaches deliver promising results across various tasks, collecting paired training data remains challenging and resource-intensive in practice. To address this limitation, we propose a unified generative model capable of leveraging both paired and unpaired data during training. Once trained, the model can generate high-quality synthetic data for direct use in downstream tasks. Experimental results on diverse real-world datasets demonstrate the effectiveness of the proposed methods. Finally, I will present recent progress in addressing the preferred orientation problem in cryo-EM, showcasing how these tools contribute to advancing the field.

Multiscale numerical methods and analysis for oscillatory dispersive equations

2 Oct
10.00–10.20

Cai Yongyong

Beijing Normal University, China

Dispersive PDEs, such as Klein-Gordon equation, Dirac equation, Schrodinger equation, arise from many different areas, e.g. computational chemistry, plasma physics, quantum mechanics. Typical computational tasks in dispersive PDEs are finding the ground/stationary states and solving the dynamics. In this talk, we report some recent advances on the multiscale numerical methods and analysis for the time-dependent dispersive PDEs, paying particular attention to the highly oscillatory PDEs, which usually exhibit solutions with high frequency waves in time and/or in space, and are generally computational expensive.

Uncertainty in Optimization: A Primal Approach to Certifying Distributional Robustness

2 Oct
10.30–10.50

Chu Thi Mai Hong
VinUniversity, Vietnam

Certifying robustness against distributional shifts is a central challenge in many optimization areas. Existing methods rely on dual certificates to bound the worst-case loss, which typically requires Lipschitz continuity, local gradient information, or strong duality theory. This talk presents an alternative, primal approach to this certification problem. Instead of relying on dual properties, the proposed framework operates directly on the primal problem by explicitly constructing a candidate for the worst-case distribution. This direct method yields a computationally efficient lower bound on the worst-case loss and offers advantages where traditional certificates are loose or inapplicable. The talk will detail the theoretical underpinnings of this primal framework and provide comparisons against established dual-certificate methods, demonstrating its potential for providing tighter and more widely applicable robustness guarantees.

From Theory to Practice: the Power of Optimization

2 Oct
11.00–11.20

Li Xudong
Fudan University, China

Mathematical optimization plays a central role in modern applied mathematics, bridging rigorous theory with practical decision-making. In this talk, I will share how NUS Math alumni have transformed optimization theory into practice to tackle real-world challenges. Through representative cases, I will illustrate how mathematical rigor and innovative algorithms generate tangible value across diverse industries. Finally, I will reflect on why NUS-trained optimizers are uniquely positioned to shape the future of this field.

On the Core of Markets with Co-Ownerships and Indivisibilities

2 Oct
11.30–11.50

Sun Xiang
Wuhan University, China

Following Balbuzanov and Kotowski (2019), we study the exchange of indivisible objects among agents with unit demand, where initially each object is either privately owned or is co-owned by multiple agents. We propose a new notion of core called the effective core for these problems to address the inadequacies of conventional notions of core. We say that a coalition effectively blocks an assignment if it weakly blocks it–as in the definition of the strong core–and the blocking is credible in the sense that no agent in the coalition takes any redundant object owned by a self-feasible subcoalition. We show that the effective core is a nonempty subset of the weak core and a superset of the strong core, and all assignments in it are Pareto efficient. We also propose an algorithm to find assignments in the effective core. Lastly, we make a detailed comparison between the effective core and Balbuzanov and Kotowski's exclusion core.

On the size of genuine representations of central covers

3 Oct
9.30–9.50

Gao Fan
Zhejiang University, China

One apparent invariant of a finite group representation is its dimension, which measures the size of the representation. For linear algebraic groups over a p-adic local field or their finite degree central covers, there are several invariants (e.g., formal degrees, wavefront sets) which generalize this notion of dimension for finite groups. We discuss some of the known results and problems along this line, especially regarding their dual side picture through the local Langlands correspondence. The talk is largely expository with a focus more on central covers and their genuine representations.

An Adventure in the World of Formalized Mathematics

3 Oct
10.00–10.20

Ma Jiajun

Xiamen University, China

I will share my personal experiences exploring formalized mathematics with the Lean theorem prover. I will introduce several projects where I used Lean to formalize algebraic structures connected to my research. Additionally, I will talk about my experiments with Lean as a teaching tool in abstract algebra courses and how this approach has enriched classroom dynamics and improved student performance. Through these stories, I hope to inspire discussion and reflection on how mathematics teaching and research may evolve in the era of artificial intelligence.

On the dynamical Iitaka program

3 Oct
10.30–10.50

Meng Sheng

East China Normal University, China

The Dynamical Iitaka Program seeks to offer a comprehensive framework for investigating endomorphisms of projective varieties. Its applications encompass a range of conjectures in both algebraic and arithmetic dynamics. Many fundamental open questions will be introduced.

Strengthening the Knaster property induces the forcing axiom

3 Oct
11.00-11.20

Peng Yinhe

Academy of Mathematics and Systems Science
Chinese Academy of Sciences, China

A poset (partially ordered set) $\mathcal{P}$ has property K_n (K for Knaster), for $n \geq 2$, if every uncountable subset of $\mathcal{P}$ has an uncountable subset that is n-linked where a subset is n-linked if every n-element subset has a common lower bound. It is easy to see that K_{n+1} implies K_n.

We show that the reverse implication has the same strength as $\mathrm{MA}_{\omega_1}(\mathrm{K}_n)$, Martin's axiom for posets with property K_n. More precisely, for $n \geq 2$, if every poset with property K_n has property K_{n+1}, then $\mathrm{MA}_{\omega_1}(\mathrm{K}_n)$ holds.

Consequently, $\mathscr{K}_3$ implies MA_{ω_1}, i.e., MA_{ω_1} holds if every ccc poset has property K_3.

Modularity of Nahm sums and Rogers–Ramanujan type identities

3 Oct
11.30–11.50

Wang Liuquan
Wuhan University, China

Let $r \geq 1$ be a positive integer, A a real positive definite symmetric $r \times r$ matrix, B a vector of length r, and C a scalar. Nahm's problem is to determining all such A, B and C with rational entries for which the Nahm sum

$$f_{A,B,C}(q) = \sum_{n=(n_1,\dots,n_r)^{\mathrm{T}} \in (\mathbb{Z}_{\geq 0})^r} \frac{q^{\frac{1}{2}n^{\mathrm{T}}An+n^{\mathrm{T}}B+C}}{(q)_{n_1} \cdots (q)_{n_r}}$$

is modular. Zagier solved the rank one case by showing that there are exactly seven rank one modular Nahm sums. In the rank two and three cases, Zagier presented many examples of (A, B, C) for which $f_{A,B,C}(q)$ appears to be modular, and he suggested a possible duality principle among modular Nahm sums. By establishing a number of Rogers–Ramanujan type identities involving double and triple sums, we confirm the modularity of Zagier's examples. We also find some counterexamples to the duality principle. Moreover, we will discuss the modularity of some other generalized Nahm sums.
