# Conference “Resonances in the Mathematical World”
# August 1-4, 2024

University of Science, Vietnam National University - Ho Chi Minh City
Faculty of Mathematics and Computer Science and High School for the Gifted

## Program and Titles

Thursday, August 1, 2024

8:30-9:10 **Nguyễn Quốc Hưng:** Singular mean-field limits via multiscale mollification

9:15-9:30 **Nguyễn Minh Quân:** A Crank-Nicolson finite difference scheme for (2+1)D nonlinear Schrödinger equations with a modified nonlinearity and damping

10:00-10:40 **Trần Minh Bình**: Some Results On the Kinetic Theory for Classical and Quantum Waves

10:45-11:25 **Trần Vĩnh Hưng**: TBA

14:00-14:40 **Nguyễn Tiến Dũng**: TBA

14:45-15:00 **Nguyễn Tiến Đạt**: Statistical deconvolution of the free Fokker-Planck equation at fixed time

15:30-16:10 **Nguyễn Thị Hoàng Oanh:** Phương trình đạo hàm riêng và đa thức ngẫu nhiên

16:15-16:30 **Nguyễn Đình Thi:** 2D rotating Bose-Einstein condensate at the critical rotation speed.

Friday, August 2, 2024

8:30-9:10 **Phạm Tuấn Huy**: When are structures robust under randomness?

9:15-9:30 **Trần Nguyễn Nam Hưng**: A graph-theoretical approach to a question in geometric group theory

10:00-10:40 **Nguyễn Tiến Trình**: The inviscid limit of Navier-Stokes on domains with curved boundaries

10:45-11:25 **Hồ Phạm Minh Nhật**: Mixture of Experts in Large-scale and Multimodal AI Models

14:00-14:40 **Nguyễn Tiến Khải**: Quantitative analysis of the transversality theorem

14:45-15:00 **Vương Trung Dũng**: Some distance functions in matrix theory and related problems

15:30-16:10 **Chung Nhân Phú**: Some generalizations of optimal transport and their applications

16:15-16:55 **Lê Long Triều**: Căn bậc hai của toán tử tuyến tính

Saturday, August 3, 2024

8:30-9:10 **Trương Trung Tuyến**: The Riemann hypothesis and the dynamics of Backtracking New Q-Newton's method

9:15-9:30 **Phùng Trọng Thực**: A $L^{1}-L^{p}$ estimate for the $\overline{\partial}-$equation in $\mathbb{C}^{n}$

10:00-10:40 **Trần Vũ Khanh**: $L^p$ Estimates for the$\bar\partial$-Problem on Pseudoconvex Domains in ${\mathbb C}^2$

10:45-11:25 **Nguyễn Huy Tuấn**: Some important contributions of Professor Dang Duc Trong and his research group to the backward in time problem

Sunday, August 4, 2024

10:00-10:40 **Nguyễn Công Phúc**: Capacitary strong type inequalities and related function spaces

10:45-11:25 **Nguyễn Hoài Minh**: Controllability and stabilization.

# Abstracts

Thursday, August 1, 2024

8:30-9:10 **Nguyễn Quốc Hưng** (Chinese Academy of Sciences, China)

Title: Singular mean-field limits via multiscale mollification

Abstract: In this talk, I introduce a new approach via multiscale mollification to justify mean-field limits for the first and second-order particle systems with singular interactions. This is a joint work with Sylvia Serfaty (Courant Institute).

9:15-9:30 **Nguyễn Minh Quân** (International University, VNU-Ho Chi Minh City)

Title: A Crank-Nicolson finite difference scheme for (2+1)D nonlinear Schrödinger equations with a modified nonlinearity and damping

Abstract: We propose a Crank-Nicolson finite difference scheme for solving a class of perturbed (2+1)D nonlinear Schrödinger equations with a modified nonlinearity and a nonlinear damping. We demonstrate the boundedness, existence, and uniqueness of a numerical solution, and show the convergence of the numerical solution. The convergence rate is at the second order in both time step and spatial mesh size. The numerical scheme is validated by the extensive simulations of the (2+1)D modified nonlinear Schrödinger equation with damping. This talk is based on joint work with Le Anh Ha and Huynh Thanh Toan.

10:00-10:40 **Trần Minh Bình** (Texas A&M, USA)

Title: Some Results On the Kinetic Theory for Classical and Quantum Waves

Abstract: Kinetic equations can be used to describe the dynamics of nonlinear classical and quantum waves out of thermal equilibrium, as well as the propagation of waves in a random medium. In this talk, I will present some of our recent results on the kinetic theory

of waves. I will discuss the analysis of those kinetic equations for waves. Next, I will focus on the numerical schemes we have been developing to resolve those equations. I will also address some control problems concerning kinetic equations for waves. The last part is devoted to some physical applications of wave kinetic theory for Bose-Einstein Condensates.

10:45-11:25 **Trần Vĩnh Hưng** (University of Wisconsin-Madison, USA): TBA

14:00-14:40 **Nguyễn Tiến Dũng** (University of Technology, VNU-Ho Chi Minh City): TBA

14:45-15:00 **Nguyễn Tiến Đạt** (University of Science, VNU-Ho Chi Minh City)

Title: Statistical deconvolution of the free Fokker-Planck equation at fixed time

Abstract: We are interested in reconstructing the initial condition of a non-linear partial differential equation (PDE), namely the Fokker-Planck equation, from the observation of a Dyson Brownian motion at a given time $t > 0$. The Fokker-Planck equation describes the evolution of electrostatic repulsive particle systems and can be seen as the large particle limit of correctly renormalized Dyson Brownian motions. The solution of the Fokker-Planck equation can be written as the free convolution of the initial condition and the semi-circular distribution. We propose a nonparametric estimator for the initial condition obtained by performing the free deconvolution via the subordination functions method. This statistical estimator is original as it involves the resolution of a fixed point equation, and a classical deconvolution by a Cauchy distribution. This is due to the fact that, in free probability, the analogue of the Fourier transform is the R-transform, related to the Cauchy transform. The convergence of the estimator is proved and the integrated mean square error is computed, providing rates of convergence similar to the ones known for non-parametric deconvolution methods. Finally, a simulation study illustrates the good performances of our estimator.

15:30-16:10 **Nguyễn Thị Hoàng Oanh** (Brown University, USA)

Title: Phương trình đạo hàm riêng và đa thức ngẫu nhiên

Abstract: Nhân dịp kỷ niệm sinh nhật thầy Đặng Đức Trọng, chúng ta sẽ trao đổi về phân phối nghiệm của đa thức ngẫu nhiên khi được thay đổi theo phương trình nhiệt. Đây là một hướng nghiên cứu khá mới với nhiều câu hỏi mở thú vị mà người nói được truyền cảm hứng khi đọc một bài blog của bác Terence Tao và một vài kết quả nổi bật gần đây. Bài nói chuyện bằng tiếng Việt.

16:15-16:30 **Nguyễn Đình Thi** (Uppsala University, Sweden)

Title: 2D rotating Bose-Einstein condensate at the critical rotation speed.

Abstract: We study the minimizers of a magnetic 2D non-linear Schrödinger energy functional in a harmonic trapping potential, describing a rotating Bose-Einstein condensate. In the case of a repulsive interaction potential, we derive an effective Thomas-Fermi-like model in the rapidly rotating limit where the centrifugal force compensates the confinement. The available states are restricted to the lowest Landau level. The coupling constant of the Thomas-Fermi functional is to link the emergence of vortex lattices (the Abrikosov problem). When turning from repulsive to attractive interactions, the system is unstable since there is a balance between kinetic and interaction energies. In the regime where the strength of the interaction approaches a critical value from below, the system collapses to a profile obtained from the (unique) optimizer of a Gagliardo-Nirenberg interpolation inequality. This was established before in the case of fixed rotation frequency. We extend the result to rotation frequencies approaching, or even equal to, the critical frequency at which the centrifugal force compensates the trap. We prove that the blow-up scenario is to leading order unaffected by such a strong deconfinement mechanism. In particular, the blow-up profile remains independent of the rotation frequency.

Friday, August 2, 2024

8:30-9:10 **Phạm Tuấn Huy** (Stanford University, USA)

Title: When are structures robust under randomness?

Abstract: Given a collection of substructures of a large discrete system, when are they robust under random subsampling of the system? For instance, among the substructures in the collection, we may require at least one complete substructure to survive the subsampling; or alternatively, we may ask for ‘’most’’ of a substructure, for appropriate notions of ‘’most’’, to survive. This theme entails a number of important questions in probabilistic combinatorics; including in particular questions about thresholds in random graphs and hypergraphs. The Kahn-Kalai conjecture predicts that a natural necessary condition to guarantee a complete substructure to survive the random subsampling is also roughly sufficient. Interestingly, this condition on the collection of substructures — so-called ‘’being not p-small’’ — also appears in other contexts. In particular, it arises in several important conjectures of Michel Talagrand on the suprema of positive stochastic processes,

which are intimately linked to appropriate notions of robustness. I will discuss recent developments around the robustness of structures under randomness, as well as a new understanding of how to verify conditions for robustness in applications of interest.

9:15-9:30 **Trần Nguyễn Nam Hưng** (University of Science, VNU-Ho Chi Minh City)

Title: A graph-theoretical approach to a question in geometric group theory

Abstract: One of the questions in geometric group theory, raised by Gromov in 1992 is: “Does every one-ended word-hyperbolic group have a hyperbolic surface subgroup?”. We focus on a particular case, where the group is the Baumslag double of a free group with finite rank. The existence was proved by Wilton in 2017. Meanwhile, another more constructive approach leads to the Tiling Conjecture, which can be converted into a purely graph-theoretic statement by Kim and Oum. As a result, methods that are largely inspired by the development of graph theory can be applied. In 2010, Kim and Oum proved that the statement holds if the graph has four vertices or it is regular. In my joint work with Le Xuan Hoang, we naively develop their approaches and add a computational flavor. We prove the statement when the difference between the number of edges and the number of vertices is sufficiently small.

References: [1] M. Gromov. “Asymptotic Invariants of Infinite Groups”. IHES, 1992. [2] Sang-hyun Kim and Sang-il Oum. “Hyperbolic surface subgroups of one-ended doubles of free groups”. Journal of Topology, 2010. [3] Henry Wilton. “Essential surfaces in graph pairs”. Journal of the American Mathematical Society, 2017.

10:00-10:40 **Nguyễn Tiến Trình** (University of Wisconsin-Madison, USA)

Title: The inviscid limit of Navier-Stokes on domains with curved boundaries

Abstract: Understanding fluids with small viscosity is one of the most fundamental problems in mathematical fluid dynamics. This issue remains unresolved in general for domains with curved boundaries due to the presence of boundary layers and large vorticity in the inviscid limit. We present a framework that precisely captures the pointwise behavior of the vorticity for the Navier-Stokes equations on domains with boundaries, under no-slip boundary conditions. Through an in-depth study of the linear problem with a nonlocal boundary condition for vorticity on the half-space, we demonstrate that the inviscid limit holds for the fully nonlinear Navier-Stokes equations if the initial data is locally analytic near the boundary, whether on a general bounded domain or the exterior of a disk.

10:45-11:25 **Hồ Phạm Minh Nhật** (University of Texas at Austin, USA)

Title: Mixture of Experts in Large-scale and Multimodal AI Models

Abstract: Since the release of the original Transformer model, extensive efforts have been devoted to scaling up the model complexities to take advantage of massive datasets and advanced computing resources. To go beyond simply increasing the network depth and width, Sparse Mixture-of-experts (SMoE) has risen as an appealing solution for scaling Large Language Models. By modularizing the network and activating only subsets of experts per input, SMoE offers constant computational costs while scaling up the model complexity, which often results in improved performances. Despite the initial success, effective SMoE training has been well-known to be notoriously challenging because of the representation collapse issue where all experts converge to learn similar representations, or all tokens are only routed to a few experts. As a result, SMoE often suffers from limited representation capabilities and wasteful parameter usage. In this talk, to address its core challenge of representation collapse, we propose a novel competition mechanism for training SMoE, which enjoys the same convergence rate as the optimal estimator in hindsight. Second, we develop CompeteSMoE, a scalable and effective training strategy for SMoE training via competition. CompeteSMoE employs a router trained to predict the competition outcome in a scheduled manner. Thus, the router can learn high quality routing policy that are relevant to the current task. Lastly, we conduct extensive experiments to demonstrate strong learning capabilities of CompeteSMoE and show its promising scalability to large scale architectures.

In the second part of the talk, we introduce a novel mixture-of-experts (MoE) framework, which we call FuseMoE, for handling a variable number of input modalities, which has remained an open challenge in multimodal fusion due to challenges with scalability and lack of a unified approaches for addressing missing modalities. FuseMoE incorporates sparsely gated MoE layers in its fusion component, which are adept at managing distinct tasks and learning optimal modality partitioning. In addition, FuseMoE surpasses previous transformer-based methods in scalability, accommodating an unlimited array of input modalities. Furthermore, FuseMoE routes each modality to designated experts that specialize in those specific data types. This allows FuseMoE to adeptly handle scenarios with missing modalities by dynamically adjusting the influence of experts primarily responsible for the absent data, while still utilizing the available modalities. Lastly, another key innovation in FuseMoE is the integration of a novel Laplace gating function, which not only theoretically ensures better convergence rates compared to Softmax functions, but also demonstrates better predictive performance. We demonstrate that our approach shows superior ability, as compared to existing methods, to integrate diverse input

modality types with varying missingness and irregular sampling on three challenging ICU prediction tasks.

14:00-14:40 **Nguyễn Tiến Khải** (North Carolina State University, USA)

Title: Quantitative analysis of the transversality theorem

Abstract: The talk presents a quantitative version of the transversality theorem and its application in quantifying the total number of shock curves in weak entropy solutions to scalar conservation laws. Additionally, it provides a sharp quantitative estimate for the critical sets of smooth functions and establishes an explicit bound for the (d - 1)-Hausdorff measure of zeros of nontrivial multivariable polynomials.

14:45-15:00 **Vương Trung Dũng** (PTNK, VNU-Ho Chi Minh City)

Title: Some distance functions in matrix theory and related problems

Abstract: In this presentation, we introduce some types of distance functions and study their properties. Concurrently, we investigate several related problems surrounding these distance functions.

15:30-16:10 **Chung Nhân Phú** (University of Economics, Ho Chi Minh City)

Title: Some generalizations of optimal transport and their applications

Abstract: Optimal transport problems and various generalized Wasserstein distances on the space of finite measures have been investigated by numerous authors in many fields. In this talk, we will review first on the theory of the classical optimal transport and then the unbalanced/generalized optimal transport, and we will discuss their applications in barycenters, and PDEs. Part of these works are joined by Quoc-Hung Nguyen, Minh-Nhat Phung, and Thanh-Son Trinh.

16:15-16:55 **Lê Long Triều** (University of Toledo, USA)

Title: Căn bậc hai của toán tử tuyến tính

Abstract: Chúng ta biết rằng mọi số phức đều có căn bậc hai. Trong bài nói chuyện này, tôi sẽ thảo luận về căn bậc hai của ma trận và toán tử tuyến tính trong không gian Hilbert. Chúng ta sẽ thấy rằng có những toán tử quen thuộc không có căn bậc hai trong khi một số toán tử khác lại có khá nhiều căn bậc hai.

Saturday, August 3, 2024

8:30-9:10 **Trương Trung Tuyến** (University of Oslo, Norway)

Title: The Riemann hypothesis and the dynamics of Backtracking New Q-Newton's method

Abstract: Backtracking New Q-Newton's method is a Newton-type method for root finding and optimization by the speaker. This talk will present some non-technical ideas of joint works, in particularly with Thuan Quang Tran (Master's student, University of Oslo), on some connection between this method and the Riemann hypothesis. In particular, a new equivalence of the Riemann hypothesis is given. In the last few minutes of the talk, I will present some more general and applicable facts about optimization methods and their software.

9:15-9:30 **Phùng Trọng Thực** (University of Technology, VNU-Ho Chi Minh City)

Title: A $L^{1}-L^{p}$ estimate for the $\overline{\partial}-$equation in $\mathbb{C}^{n}$

Abstract: We obtain a $L^{1}\rightarrow L^{p}$ estimate in weighted $L^{p}$ norms for the $\overline{\partial}$-equation in $\mathbb{C}^{n}$ under a coercivity condition of the associated weighted Kohn Laplacian.

10:00-10:40 **Trần Vũ Khanh** (International University, VNU-Ho Chi Minh City)

Title:$L^p$ Estimates for the$\bar\partial$-Problem on Pseudoconvex Domains in ${\mathbb C}^2$

Abstract: In this talk, we will discuss the $L^p$ estimates for the $\bar\partial$ problem on pseudoconvex domains (both smooth and non-smooth cases) in ${\mathbb C}^2$. We will particularly focus on the following classes of domains in ${\mathbb C}^2$: pseudoconvex domains of finite type, convex domains, product domains, and Hartogs triangles. Part of this talk is joint work with Nguyen Anh Tu.

10:45-11:25 **Nguyễn Huy Tuấn** (Van Lang University, Ho Chi Minh City)

Title: Some important contributions of Professor Dang Duc Trong and his research group to the backward in time problem

Abstract: The backward in time problem for partial differential equations is an interesting research direction and has attracted the attention of many domestic and foreign mathematicians in the past few decades. This is a research direction with many applications in physics and engineering. Professor Dang Duc Trong is one of the mathematicians in Vietnam who has made many important and profound contributions to this research direction. During the discussion, we will present some important contributions of Professor Dang Duc Trong and his students and research team on the backward problem. We introduce the key ideas, methods, and techniques of his group over the past twenty years. Some related inverse problems are also presented and discussed in this talk.

Saturday, August 4, 2024

10:00-10:40 **Nguyễn Công Phúc** (Louisiana State University, USA)

Title: Capacitary strong type inequalities and related function spaces

Abstract: We answer the question posed by D. R. Adams on a capacitary strong type inequality that generalizes the classical capacitary strong type inequality of V. G. Maz'ya. As a result, we characterize related function spaces as K\"other duals to a class of Sobolev multiplier type spaces. The boundedness of the Hardy-Littlewood maximal function and the spherical maximal function on related Choquet spaces are also discussed. This talk is based on joint work with Keng H. Ooi.

10:45-11:25 **Nguyễn Hoài Minh** (Sorbonne University, France)

Title: Controllability and stabilization.

Abstract: In this talk, I first review several well-known results on the controllability and stabilization of a linear control system both in finite and infinite dimensional cases. I then mention an important open question on unbounded control and present some recent progress in a general framework of semigroup. Finally, I discuss its applications to nonlinear settings such as Schrödinger and KdV ones.