Junhao Yin

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Profile

I am majoring in Mathematics and Applied Mathematics at Nanjing University and have been studying at the University of Wisconsin-Madison through its VISP Pre-Master Program since Spring 2024. My research interests span a broad range of topics in physical mathematics, including fluid dynamics, stochastic modeling, and dynamical systems.

Education

BS **Nanjing University**, Mathematics and Applied Mathematics — Sept 2021 – June 2025

- **Coursework:** Completed rigorous coursework in analysis, algebra, topology, differential equations, probability, and scientific computing, with a solid foundation in both theoretical and applied mathematics.

University of Tokyo — June 2023 – Aug 2023

- **Coursework:** Completed advanced coursework in McKay Correspondence and Quantum Nanophotonics, with research visits to the Kavli Institute for the Physics and Mathematics of the Universe and the Iwamoto Laboratory. These experiences emphasized the intersection of theoretical physics, advanced mathematics, and cutting-edge quantum technologies.
- **Instructors:** Yukari Ito, Iwamoto Satoshi

MA **University of Wisconsin-Madison**, Department of Mathematics — Jan 2024 –

- **Coursework:** Completed and ongoing graduate coursework in Methods of Applied Mathematics, Real Analysis, Complex Analysis, Mathematical Fluid Dynamics, and Stochastic Analysis, with active studies in advanced topics including Dynamical Systems, Nonlinear Wave Equations, and Fourier Analysis.
- **Research Instructor:** Saverio Spagnolie | **Faculty Advisor:** Mihaela Ifrim
- **For more Information:** https://yoon-1023.github.io/courses/

Publication

Interactions of an Immersed Body in a Semi-Infinite Nematic Liquid Crystal (***In preparation***) — Aug 2024-May 2025 (ETA)

Supervisor: Saverio Spagnolie, Department of Mathematics, University of Wisconsin-Madison, WI, USA

Abstract: Analyzed the equilibrium configurations, forces, and torques for bodies immersed in a semi-infinite nematic liquid crystal, using complex variable methods inspired by Darren Crowdy's approach to multiply connected domains. Derived general analytic solutions for body-boundary interactions, incorporating elastic energy minimization and far-field conditions, with examples including cylinders in half-planes and polygons in wedge domains. Results provide insights into defect positioning, anchoring effects, and their influence on the material's elastic stresses.

Highlight: Advanced generalizations of Modified Green's Functions and the Schwarz-Christoffel mapping, extended to multiply-connected semi-infinite domains with curved boundaries. Applied numerical methods, including PlgCirMap, for precise computational implementations.

Current Draft: https://yoon-1023.github.io/research/

Projects

Fokas Method for IBVPs of Heat Equations Spring 2024

- **Supervisor**: Jean-Luc Thiffeault, Chair, Department of Mathematics, UW-Madison
- Explored solutions to Initial Boundary Value Problems (IBVPs) for the heat equation using the Fokas method (unified transform method). Derived solutions in Ehrenpreis's form for a half-line problem with general Robin boundary conditions and a source term dependent on both time and space, comparing the method with the classical image approach. For a finite interval problem with Dirichlet boundary conditions, derived a similar form and recovered the traditional series solution using the Half-Residue Theorem.

Selected Problems in Complex Analysis Spring 2024

- **Supervisor**: Alexei Poltoratski, Department of Mathematics, UW-Madison
- This project involves solving a series of complex analysis problems that delve into advanced topics to deepen understanding. Covered areas include modulus estimates for subcollections of complex numbers, injective extensions of holomorphic functions, and zeros analysis of transcendental equations. Additionally, the project applies Gauss-Lucas theorem to convex hulls, explores subharmonicity and Laplacians in strict harmonicity problems, and investigates "Swiss Cheese" sets related to Mergelyan's theorem, illustrating limits of polynomial approximation on non-dense subsets in the complex plane.

Hardy-Littlewood Maximal Inequalities and Their Applications in Interpolations Fall 2023

- **Supervisor**: Yong Lu, Department of Mathematics, Nanjing University
- This project delves into the Hardy-Littlewood maximal inequalities, both strong and weak forms, in the context of real analysis. By systematically deriving and analyzing these inequalities, we investigate their applications, including their extension to function spaces such as $L^p(R^n)$ and the characterization of singular integral operators. Furthermore, the study provides insights into related inequalities and their significance in the broader framework of harmonic analysis and PDEs.

Investigation of Kummer Theory and its application to the Galois Theory Fall 2023

- **Supervisor**: Hourong Qin, Department of Mathematics, Nanjing University
- In this project, we focus on the Kummer Theory and its application to the Galois Theory. Explicitly, We will answer how to make the Galois Group $G = Gal(K/F)$ of a finite Galois expansion K/F include as many crossed homomorphism groups Z as possible.

Representing Function Values Through Integrals: Applications in Harmonic and Potential Theory Fall 2022

- **Supervisor**: Dong Miao, Department of Mathematics, Nanjing University
- In this project, we investigate methods to represent the value of a function at a specific point using integrals. Inspired by analogies between Cauchy Integral Formula in Complex Analysis and fundamental results in Mathematical Analysis, we explore key results in harmonic and potential theory. Specifically, we analyze representation formulas for harmonic functions and their connection to boundary integrals, using tools such as Green's identities and spherical coordinate transformations. The methods are demonstrated through detailed proofs and examples.

Academic Accolades

First prize, The 14th Chinese Mathematics Competition (Mathematics Major Category) Fall 2022

- Recognized for exceptional problem-solving skills in Mathematical Analysis, Lin-

ear Algebra, and Analytic Geometry.

The People's Scholarship, Department of Mathematics, Nanjing University 2022 & 2023

- Awarded for notable progress in academic performance during the last academic year.

Visiting International Student Scholarship, University of Wisconsin-Madison 2024

- Awarded for academic merit as a representative student from Nanjing University, a collaborating institution with University of Wisconsin-Madison.

Nomination of High-Value Scholarship, Nanjing University (Under Review) 2024

- Recognized for exceptional academic performance and excellence in coursework during the previous academic year.

Seminars

Attendee, Physical Applied Math, Department of Mathematics, University of Wisconsin-Madison 2024

- Diverse research topics including filament growth and buckling in viscous fluids, active liquid crystals, shear flow dynamics, finite-depth water waves, and advancements in the Maxey-Riley equation for active particles.

Attendee, Applied and Computational Mathematics Seminar, Department of Mathematics, University of Wisconsin-Madison 2024

- Wide range of talks on advanced topics in applied mathematics, including entropy methods, hydrodynamic modeling, data-driven chemical sciences, and optimization in physics.

Attendee, Applied and Computational Mathematics Seminar, Department of Mathematics, University of Wisconsin-Madison 2024

- Diffusion models, geometric effects in fluid mechanics, neural networks, constrained differential equations, and numerical optimization.

Attendee, Youth Scholars' Forum in Mathematics, Department of Mathematics, Nanjing University 2023

- Advanced topics in analysis, geometry, and quantum dynamics, including bounds for oscillatory integral operators, criteria in Kähler geometry, Heegaard Floer homology, accelerated methods for inverse problems, and quantum many-body dynamics.

Attendee, Undergraduate Math Forum, Department of Mathematics, Nanjing University 2022 & 2023

- Delivered by distinguished professors, the seminars cover topics such as computational reliability in regional calculations, local analytic rigidity of isometries on compact Riemannian manifolds, stability in inviscid fluid dynamics, quantum algorithms for stochastic equations, curvature-induced rigidity in geometric flows, and active matter dynamics in anisotropic fluids.

Mentoring Experience

Mentor, Calculus Exam Preparation Project, Nanjing University Fall 2023

- Officially appointed by the Department of Mathematics to mentor a class of 50+ students from other departments as part of an inter-departmental academic support program. This initiative, requested by other departments, aimed to strengthen students' calculus skills in preparation for their examinations. I provided structured guidance on foundational topics such as limits, derivatives, integrals, and

their applications, using curated problem sets to foster understanding and confidence in problem-solving.

Presentations

Comprehensive Explorations in Partial Differential Equations, Nanjing University Fall 2023

- Delivered detailed presentations as part of a students' PDE study group at Nanjing University. The talks centered on foundational topics from L.C. Evans' Partial Differential Equations, including Green's functions, energy and maximum modulus estimates, and classical theories for wave and heat equations. The discussions further encompassed advanced applications of Sobolev Spaces, the Cole-Hopf transformation, weak solutions, the Fredholm alternative, and variational methods.

A Robust Method for Measuring Refractive Indices, Iwamoto Laboratory, University of Tokyo Jul 2023

- I presented a robust method for measuring material refractive indices, developed with my team in Prof. Iwamoto Satoshi's Nanophotonics class. The method used trigonometric principles to validate results with red and green lasers, achieving high accuracy and uncovering wavelength-dependent variations. My presentation highlighted the precision, reliability, and practical applications of this approach, showcasing its potential impact in optical materials research.

Service

Volunteer, COVID-19 pandemic control service at Changxing Police Station, Guangzhou, China

- **Time:** Jun 2022- Aug 2022
- **Responsibilities**: I volunteered at Changxing Police Station to assist in pandemic control efforts as part of China's dynamic zero-COVID policies. My primary responsibility involved making phone calls to foreign residents to investigate potential exposure to outbreak areas and urging them to undergo nucleic acid amplification testing to identify potentially infected individuals.
- **Significance**: This role required me to bridge cultural and linguistic gaps, leveraging my English proficiency to communicate the necessity of stringent pandemic measures to individuals from countries with minimal governmental action against COVID-19. At a time when China's borders were partially open, I contributed to supporting public safety and ensuring the effectiveness of these critical health policies.

Organizer, NJU-Star Dream Project, Guangzhou No.2 High School, Guangzhou, China

- **Time:** Jan 2022
- **Description:** As an alumnus of Guangzhou No.2 High School and a representative of Nanjing University, I participated in the NJU-Star Dream Project to inspire and guide high school students about university education. My team and I conducted virtual presentations to showcase Nanjing University's academic programs, campus culture, and opportunities. We later visited our high school for in-person promotions, answering questions about admissions, academic paths, and student life. This initiative aimed to connect with prospective students and provide them with meaningful insights into university experiences.

Skills

Language

Programming