Rishik Perugu

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Research Interests

Quantum Many-Body Dynamics, Krylov Complexity, Open Quantum Systems, Quantum Information

Education

University of California, Irvine *Sept 2024 -*

- Ph.D. in Physics, GPA: 3.96/4.0, Advisor: Prof. Thomas Scaffidi
- **Selected Coursework:** Condensed Matter Physics 1, 2, 3, Many-Body Theory, Statistical Field Theory, Tensor Networks and DMRG

Indian Institute of Science, Bangalore *Aug 2023 - May 2024*

- Master of Science in Physics, GPA: 9.1/10
- **Selected Coursework:** Quantum Field Theory 1, Advanced Statistical Physics, Quantum Computation

Indian Institute of Science, Bangalore *Aug 2019 - May 2023*

- Bachelor of Science (Research) in Physics, GPA: 9/10
- **Selected Coursework:** Condensed Matter Physics 1, Topological Phases of Matter, General Relativity

Publications/Preprints

Universal nonequilibrium dynamics of pure states and density-dependent thermalization in the Sachdev-Ye-Kitaev model Nov 2025

Rishik Perugu, Arijit Haldar, Sumilan Banerjee

Published in Physical Review B, arXiv:2504.13258

Krylov Winding and Emergent Coherence in Operator Growth Dynamics Sept 2025

Rishik Perugu, Bryce Kobrin, Michael Flynn, Thomas Scaffidi

Under review in **Physical Review Letters**, arXiv:2509.25331

Conferences/Schools attended

APS Global Summit, Anaheim, CA March 2025

- Presented a research talk at the APS March Meeting, the world's largest physics conference, attended by 14,000+ physicists worldwide [slides]

Maglab Theory Winter School January 2025

- Participated in a week-long theory winter school on strongly correlated electron systems at the National High Magnetic Field Laboratory, Tallahassee, FL

Undergraduate and Master Research Experience

Non-equilibrium dynamics of pure states in the Sachdev-Ye-Kitaev model Sept 2023 - April 2025

Mentor: *Prof. Sumilan Banerjee, Indian Institute of Science, Bangalore* Master's Thesis

- Developed a general and elegant Schwinger-Keldysh (SK) field theory method to describe far-from equilibrium dynamics of arbitrary pure states in interacting fermionic systems
- Applied the method to study the density-dependent thermalization of unentangled and entangled initial pure states in the interacting SYK model and contrasted it with its non-interacting counterpart
- Established a remarkable universality in the non-equilibrium dynamics of pure states in SYK models, where the tim evolutions of all local and non-local correlations for almost all initial pure states are entirely describable through a single universal two-point correlation function

Variational wavefunctions for strongly correlated Fermionic systems May 2023 - April 2024

Mentor: *Prof. Thomas Scaffidi, University of California, Irvine*

- Developed a NetKet -based code to optimize the overlap of a variational wavefunction with the target ground state, extending the package's existing energy-optimization framework
- Investigated various neural network based ansätze if they recover finite energy density of the ground state in strongly correlated Fermionic systems such as the Sachdev-Ye-Kitaev model in the thermodynamic limit

Measures of quantum non-markovianity Nov 2022 - Mar 2023

Mentor: *Prof. Kanupriya Sinha, Arizona State University*

- Studied the fundamentals of open quantum systems such as Completely Positive and Trace preserving (CPT) maps, Redfield and Lindblad master equations and various measures of non-markovianity
- Calculated the amount of non-markovianity in spin-boson model using two standard measures based on the distinguishability of states and on the divisibility of the dynamical map
- Investigated the problem of optimal system-bath partition to maximize the amount of non-markovianity in the dynamics of an artificial atom in a leaky cavity

DMRG study of the one dimensional extended Bose-Hubbard model May 2022 - Apr 2023

Mentors: *Dr. Andreas Haller and Prof. Thomas Schmidt, DPhyMS, University of Luxembourg, Luxembourg* Bachelor's Thesis

- Implemented a single-site (zero-site) DMRG method in Julia with ITensor , providing a faster, more memory-efficient alternative to the standard two-site algorithm
- Simulated the phase diagram of the one-dimensional Bose-Hubbard model with on-site and nearest-neighbor density interactions using zero-site DMRG code developed
- Characterised the supersolid, superfluid and charge density wave phases using correlation functions and quantum state tomography

Molecular Aggregate Photophysics June 2021 - May 2022

Mentor: *Prof. Jayashree Nagesh, Institute of Bioinformatics and Applied Biotechnology, Bangalore*

- Investigated the effects of inter-molecular charge transfer, vibrations, temperature and disorder in molecular aggregates using the Frenkel-Holstein framework
- Developed a MATLAB code to simulate absorption and emission spectra of the aggregates, incorporating the above effects

Plasma Physics Feb 2021 - Sept 2021

Mentor: *Prof. Animesh Kuley, Indian Institute of Science, Bangalore*

- Analytically solved for the trajectories of charged particles in various electromagnetic field configurations
- Simulated the trajectories of charged particle in electromagnetic field using Euler, RK2, RK4 and Boris Push methods

Technical Skills

Programming languages: Python, Julia, MATLAB/Octave, Mathematica, C

Packages and Tools: LaTeX, Numpy, Scipy, Matplotlib, Qiskit, ITensors, NetKet, QuTip

Techniques: Large-N field theory, Variational Quantum Eigensolver, Neural Quantum States, DMRG/Tensor Networks

Scholastic Achievements

- Recipient of the prestigious **Regents fellowship** awarded by the University of California *2024-26*
- Recipient of the prestigious **KVPY Fellowship and Scholarship** awarded by the Department of Science and Technology, Government of India *2019-24*
- Secured **All India Rank of 135** in **JEE Advanced** examination among 0.16 million candidates *2019*
- Secured **All India Rank of 147** in **JEE Mains** examination among 1.2 million candidates *2019*

Leadership

Decoherence event coordinator Pravega '21

Part of the Science and Tech team of Pravega, the undergraduate fest of IISc, Bangalore July 2020 - Aug 2021

- I served as one of the two coordinators for the physics events of Pravega, where we successfully managed and led a team of 15 members
- As part of **Coherence Lecture Series**, we organized ten online advanced undergraduate-level talks by eminent physicists from various fields on their research areas. Notable speakers include **Prof. Steve Simon, Prof. Julia Yeomans, Prof. Shiraz Minwalla** (link)
- We organized an undergraduate-level online physics competition called **Spooky Quizzes** twice spanned over 6 weeks which had a participation of **over 200 students** from across India
- We organized another undergraduate-level online physics competition called **Decoherence** involving solving and presenting long problems to physics professors at IISc Bangalore, with a participation of over **500 students** for the preliminary round. I was involved with designing the structure and question-making of the competition

CovEducation mentor May 2020 - Aug 2021

- Mentored **two high school students** from India during the COVID-19 pandemic as part of the CovEducation initiative
- Helped them improve their conceptual understanding and problem solving skills in Mathematics and Physics
- Guided them for national level college entrance tests such as the Joint Entrance Exam (JEE)