Sayak Guha Roy

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PhD Researcher in Quantum Many-Body Physics | *Tensor Networks, Open & Closed Quantum Dynamics, HPC-Scale Simulation, QEC-adjacent Algorithms*

EDUCATION

Rice University, Houston, Texas

Ph.D. in Physics and Astronomy (Current GPA: 3.96)	*2022 - present*
M.S. in Physics and Astronomy	*2022 - 2025*

Indian Institute of Technology Madras, Chennai

M.S. in Physics (Final CGPA: 9.48)	*2017 - 2022*
B.S. in Physics	*2017 - 2022*

SKILLS AND SOFTWARE PROFICIENCY

- **Methods/Algorithms:** Tensor Networks (MPS, MPO, MERA), Quantum Monte Carlo, Exact diagonalization with error bounds, Optimization and stochastic simulation
- **Programming Languages:** Python, C++, Julia, Mathematica, Shell Script
- **High-Performance Computing & Scientific Software** Parallel numerical simulation, performance-aware algorithm design, large-scale parameter sweeps, memory-efficient tensor contractions
- **Quantum Information/Computation:** Surface codes, stabilizers, quantum control and decoding, open quantum systems (Lindblad and quantum trajectories), quantum error correction, quantum optics
- **Python Packages:** Scikit-Learn, NumPy, PyTorch, Pandas, SciPy, Matplotlib, Cirq, QuTip, Qiskit
- **Tools/Framework:** LaTeX, Git, Linux

PUBLICATIONS

- **Sayak Guha Roy**, Ian White, Zhiyuan Wang, Bhuvanesh Sundar, Kaden R. A. Hazzard *Geometry-Adapted Exact Diagonalization with Rigorous Error Bounds* (*in preparation*)
- Yongtao Deng, **Sayak Guha Roy**, Kevin Slagle, Kaden R. A. Hazzard *Reducing Qubit Idling in MERA with Qubit Reuse* (*in preparation*)
- **Sayak Guha Roy**, Vaibhav Sharma, Kaidi Xu, Umberto Borla, Jad C. Halimeh, Kaden R. A. Hazzard *Repulsively Bound Hadrons in a $\mathbb{Z}_2$ Lattice Gauge Theory* arXiv:2510.23618v1 (*under review*)
- **Sayak Guha Roy**, Kevin Slagle *Reweighted Time Evolving Block Decimation for Improved Quantum Dynamics Simulations.* arXiv:2412.08730 (*under review*)
- **Sayak Guha Roy**, Kevin Slagle *Interpolating Between the Gauge and Schrödinger Pictures of Quantum Dynamics.* SciPost Phys. Core 6, 081 (2023) (*Published*)
- **Sayak Guha Roy**, Anirban Das, Shantanu Mukherjee *Non-trivial impurity and field effects in Topological Kondo Insulator SmB_6.* Materials Today: Proceedings 2022, ISSN 2214-7853 (*Published*)

RESEARCH EXPERIENCE

Rice University | **Doctoral Researcher** | Houston, TX **Aug 2022 – Present**
Advisors: Dr. Kaden R. A. Hazzard and Dr. Kevin Slagle
Collaborators: Dr. Vaibhav Sharma, Dr. Jad C. Halimeh, Dr. Umberto Borla, Yongtao Deng, Kaidi Xu

- *Tensor Network (TN) Algorithms for Quantum Dynmics* —
  - Developed Matrix Product States and Density Operators based Time Evolving Block Decimation codes, enabling efficient simulations of open and closed quantum systems.
  - Designed reweighting schemes to develop a new algorithm (Reweighted Time Evolving Block Decimation) that is shown to outperform existing algorithms in several physical regimes. arXiv:2412.08730
  - Implemented the MPS based TEBD code to discover the novel physical phenomena of repulsive bound states in lattice gauge theories. arXiv:2510.23618v1

- *Reducing Qubit Idling in Quantum Circuits* —
  - Worked on developing a dynamic grouping quantum algorithm to reduce qubit idling using Qubit Reuse.
  - Implemented the technique in Multiscale Entanglement Renormalization Ansatz (MERA), a type of tensor network. (*Article in preparation*)
- *Error-bounded exact diagonalization* —
  - Designed a geometry-adapted exact diagonalization approach with Lieb–Robinson–type error control.
  - Designed custom cluster geometries to reduce finite-size effects, enabling more accurate extrapolation to the thermodynamic limit. (*Article in preparation*)
- *Gauge vs Schrödinger pictures* —
  - Built a simulation framework interpolating between gauge and Schrödinger pictures of Quantum Dynamics. SciPost Phys. Core 6, 081 (2023)
  - Implemented custom numerical solvers for differential equations and optimization tasks.

Indian Institute of Technology Madras | Chennai, India **Jul 2019 – May 2022**
Masters thesis and Research projects
Advisors: Dr. Rajesh Narayanan, Dr. Shantanu Mukherjee and Dr. James Libby
Collaborators: Dr. Ferdinand Evers, Dr. Krishnendu Sengupta, Dr. Kajari Mazumdar

- *Quantum Monte Carlo (QMC) Simulations* —
  - Implemented stochastic series expansion QMC code finite-size scaling to study quantum phase transitions in the extended Bose-Hubbard model.
- *Topological Kondo Insulator SmB_6* —
  - Simulated impurity and field effects in realistic tight-binding model of SmB_6 which is known to be a topological Kondo insulator; Materials Today: Proceedings 2022, ISSN 2214-7853
- *High Energy Physics Detector Optimization* —
  - Optimized silicon vertex detector layout for proposed CERN TauFV experiment.

CONFERENCES PRESENTATIONS & POSTER SESSIONS

- eQMA workshop on Hidden Orders and Quantum Entanglement - Poster — Oct 6-8 2025
- APS DAMOP 2025, Portland, Oregon - Oral presentation — Jun 16-20, 2025
- Workshop on Quantum Materials and Entanglement, Rice University - Poster — Oct 7-9 2024
- Coherent Quantum Dynamics Summer School, OIST, Okinawa, Japan - Poster — Sept 24 - Oct 4 2024
- Modeling Strongly Correlated Electrons, ASC School, Munich, Germany - Poster — Sept 16-20, 2024
- SCI Summer Colloquium, Rice University - Oral presentation — Aug 2, 2024
- March Meeting 2024, Minneapolis, MN - Oral presentation — Mar 4-8, 2024
- QuantIPS 2023, Rice University - Poster — Oct 26-27, 2023

INVITED TALKS

- Rice Quantum Initiative (RQI) Sept 12, 2025 — Repulsively Bound Hadrons in a $\mathbb{Z}_2$ Lattice Gauge Theory
- RQI group meeting Apr 26, 2024 — Interpolating Between the Gauge and the Schrödinger pictures of Quantum Dynamics

AWARDS & HONORS

- ROBERT L CHUOKE AWARD 2023-2024 - Rice University - *for speedy progress in research*
- PROF. J SOBHANADRI PRIZE - Convocation Day 2022, IIT Madras - *for highest final CGPA*
- MR S. VENKITARAMANAN, I.A.S RETD PRIZE - Institute Day 2022, IIT Madras - *for highest GPA in 4th year*
- ELECTRONICS FOR YOU PRIZE - Institute Day 2021, IIT Madras - *for highest GPA in 3rd year*
- INSPIRE Scholarship awardee at IIT Madras (2017-2021)