

Anantha S Rao

Curriculum Vitae

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Research Interests

Quantum Information Science, Condensed Matter Physics, Artificial Intelligence

Education

- 2023–present **PhD** in Physics (*GPA: 4.0*)
University of Maryland, College Park, MD
- 2018–2023 **B.S-M.S** in Physics (*GPA: 8.9/10*)
Indian Institute of Science Education and Research, Pune, India

Publications and preprints

- **A.S. Rao**, D. Buterakos, F. Borsoi, JP. Zwolak, MJ. Gullans. Interdot-assisted noise learning in semiconductor quantum systems. (*in preparation*)
- **A.S. Rao**, S. Muleady, CD. White, A. Sigilito, MJ. Gullans. Wigner crystal physics in the 1D resistive-topgate for spin shuttling. (*in preparation*)
- **A.S. Rao**, D Buterakos, B van Straaten, V John, CX. Yu, SD. Oosterhout, L Stehouwer, G Scappucci, M Veldhorst, F Borsoi, JP. Zwolak. MAViS: Modular Autonomous Virtualization System for Two-Dimensional Semiconductor Quantum Dot Arrays. (*Submitted to PRX*)
- **A Rao**, D Madan, A Ray, D Vinayagamurthy, MS Santhanam. Learning hard distributions with quantum-enhanced Variational Autoencoders. *arXiv:2305.01592*
- **A Rao**, S Carr, C Snider, DE Feldman, C Ramanathan, VF Mitrović. Machine-learning-assisted determination of electronic correlations from magnetic resonance. (*Physical Review Research 5 (4), 043098*)

Research Experience

- Nov 2023 **Graduate Research Assistant**
-present PI: Michael Gullans and Justyna Zwolak, University of Maryland, College Park, MD
- Semiconductor quantum devices**
- Performed analytical calculations and tensor-network simulations to probe the ground state and disorder landscape of electronic systems within resistive interconnects for semiconductor systems.
 - Developed a modular and scalable framework to construct virtual-gates for quantum dot devices and verified the framework on the largest 2D quantum-dot device.
 - Developing an automated insitu method for noise learning in quantum-dot devices.
- Manybody physics with feedback**
- Studying feedback as a model of phase-stabilization in cavity-QED systems.
 - Studying phase transitions in brownian random circuits with driven-dissipative effects.
- June 2022 – **Master's Intern at IBM Research, India**
May 2023 PI: Venkata Subramaniam and D. Vinayagamurthy
- Topic: Variational quantum algorithms for generative learning ([arXiv](https://arxiv.org/abs/2305.01592))
- Proposed and implemented a novel hybrid quantum-classical neural network for generative machine learning that can learn classically hard distributions with exponentially fewer parameters.
 - Verified results on IBM's superconducting qubits with error mitigation and error suppression methods.

- Jan 2021–May 2022 **Undergraduate Research Assistant at IISER Pune, India**
 PI: M.S. Santhanam
 Topic: Continuous-time Quantum Walks and the Quantum Kicked Rotor ([summary](#))
- Reproduced results of out-of-time-order correlators (OTOCs) for integrable systems, and developed an efficient algorithm to compute OTOCs for the 3-dimensional quantum kicked rotator.
 - Reproduced results of continuous-time quantum walks on graphs, developed a correspondence between quantum walks and the quantum-kicked rotor model, and analytically demonstrated quadratic advantage of quantum walks over classical walks using the first hitting time distribution.
 - Developed a formalism to test the first-hitting time distributions for the resonant quantum kicked rotor experimentally using neutral atoms and probe coherence times in quantum systems.
- May 2021–Aug 2021 **Research Intern at Brown University, RI**
 PI: Brad Marston, and Stephen Carr
 Topic: NMR spin-echos as phase-probes for 2D strongly-correlated materials ([paper](#))
- Reviewed literature on Hahn echos in magnetic resonance, developed [NMR-ML](#), a general-purpose python package to read, preprocess, extract, and interpret important features from spin-echo simulations.
 - Implemented unsupervised learning methods (PCA, K-Means, t-SNE, VAE) to identify clusters in spin-echo responses and discovered them to be based on the electronic correlations of the material.
 - Evaluated and optimized the performance of multiple machine learning models on time-series classification, and multi-parameter regression.
- Jan 2020–Oct 2021 **iGEM Software Team and Curem Biotech Lead at IISER Pune**
 PI: Sanjeev Galande
 Topic: Molecular dynamics simulations and development of AI-based disease diagnostics.'
- Identified novel protein-peptide interactions, engineered a library of peptide drugs against falciparum Malaria, and performed equilibrium molecular dynamics simulations with an insilico efficacy of >95%.
 - Designed, programmed and deployed [DeleMa-Detect](#), an open-source deep learning application for real-time Malaria diagnosis based on Mobilenetv2 transfer learning with an accuracy of 96%.
 - Spearheaded the IISER Pune team at the International Genetically Engineered Machine (iGEM) bioengineering competition at MIT, Boston.
 - Co-founded a startup, contributed to 5+ research grants and design of the Minimum Viable Product that was awarded the >\$50,000 grant by the National Biotechnology ignition grant and the \$10,000 cash prize at the iGEM 2021 Startup showcase competition.

Presentations/Talks

- Autonomous virtualization of quantum dot devices. Joint JQI-QuICS Seminar. 2024 Nov 22; *College Park, MD*
- Automated real-time gate virtualization of a 10 quantum dot array. Silicon Quantum Electronics. 2024 Sept 4-5; *Davos, Switzerland*
- Autonomous virtualization of quantum dot devices. 2024 Aug 28-Sept 2; *TU Delft, Netherlands*
- Learning phases from NMR spin-echoes. Conference on Nonlinear Systems and Dynamics (CNSD). 2022 Dec 15-18; *Pune, India*

Open Source Projects

- [QuantChaos](#): Tools to study quantum chaos and localization with the quantum kicked rotor
- [ComPhys](#): Repository of numerical recipes in Fortran to solve physics problems numerically.
- [QCompiler](#): A quantum simulator based on unitary dynamics.
- [ProgProtPy](#): Tools to learn bioinformatics (sequence alignments, hidden markov models).
- [PACMal](#): Peptides Against Cerebral Malaria - an open source solution

Graduate Coursework

Physics Classical mechanics, Statistical mechanics, Quantum mechanics I-III, Quantum information and quantum computation, Condensed matter theory I-II, Quantum field theory.

Technical Skills – Python, Julia, BASH, Fortran, R, MATLAB, C++. *Packages* – NumPy, Scipy, Pandas, Matplotlib, Scikit-learn, Seaborn, QuTiP, PyTorch, ITensor. *Quantum computing frameworks* – Qiskit, Cirq, PennyLane, Mitiq. *Tools* – Linux, Git, LATEX, Vim, GIMP, MS-Office

Awards and Achievements

- Dean's Fellowship (2024), Department of Physics, University of Maryland
- Qiskit Challenge (2021-23) : Top performer at the hackathon focussing on quantum algorithms, machine learnign and simulations.
- Chanakya Postgraduate Fellowship (2022) : Among 34 scholars from 1000+ applicants to receive the fellowship by Govt. of India to pursue research in quantum information science.
- iGEM's Startup Showcase (2021) : Won the Benchling and Hummingbird VC prize (cash award of \$10,000)
- National Graduate Physics Examination (2021) : 2th in the State of Maharashtra, Top 50 in the country.
- Mitacs Globalink Research Fellowship (2021) : Selected for the competitive fully-funded summer program at Universtiy of Waterloo on loss characterization of superconducting resonators; cancelled due to the pandemic.
- iGEM Gold Medal and iGEMer's award (2020) : Best project amongst 250+ teams from 40+ countries.
- Kishore Vaigyanik Protsahan Yojana (KVPY) (2018 - Present) : Placed among top 0.05the KVPY examinations; awarded a competitive scholarship by the Department of Science and Technology.
- Indian National Physics Olympiad(INPhO) (2017) : Selected to the state team.

Mentoring and Volunerring

- Physics department representative at the Graduate Student Council (2024), University of Maryland
- Physics department representative at the College of Mathematical and Natural Sciences (CMNS) Council (2024), University of Maryland
- Teaching assistant for CMSC858V (Quantum control, metrology and algorithm deployment) and PHYS485 (Electronic circuits) at the University of Maryland. 2023-2024
- TowardsDataScience (2021-2023) : Technical Writer on data science and open-source software.
- JuliaDynamics (2021) : Open source software contributor (Dynamical component analysis)
- Karavaan Annual Fest (2019, 2020) : IISER Pune's annual socio-cultural event; Student co-ordinator of Corporate relations department (2020); Research and Analysis Department (2019)
- Mimamsa Annual Fest (2020) : Supervised and managed India's largest UG science quiz in the state of Goa.
- Disha (Spread the smile) (2018-2023) : IISER Pune's social outreach program; Raising social awareness and inculcating scientific temper among bright young minds through planned workshops and activities.
- IISER Pune Quiz Club (2018-2023) : Conducting quiz programs for university and school audiences; (Elementary 2019, Karavaan (2018, 2019), various quizzes at IISER Pune)
- IISER Pune Astronomy Club (2018-19) : Participated in sky-watching workshops and communicated developments in astronomy and cosmology research through Dhruva, the annual student-led magazine.
- Bangalore Cricket Team (2014-6) : Represented Bangalore Urban and school cricket captain.
- School Head Boy (2015) : Elected school president.