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: 4.0/4.0)*
University of Maryland, College Park, MD
Anticipated graduation 05/28

2018–2023 **B.S-M.S** in Physics *(GPA: 8.9/10)*
Indian Institute of Science Education and Research, Pune, India

Publications and preprints

- S. Gandhari, **ASR**, M.J.Gullans. Compressive unitary learning of non-markovian interactions from randomized benchmarking. *(in preparation)*
- **ASR**, CD. White, S. Muleady, A. Sigilito, MJ. Gullans. Interacting electrons in silicon quantum interconnects: From Wigner Crystals to long-range capacitive coupling. (arxiv:2601.05306)
- **ASR**, B van Straaten, V John, CX. Yu, SD. Oosterhout, L Stehouwer, G Scappucci, M. D. Stewart Jr., M Veldhorst, F Borsoi, JP. Zwolak. Towards autonomous time-calibration of large quantum-dot devices: Detection, real-time feedback, and noise spectroscopy (arxiv:2512.24894)
- **ASR**, D Buterakos, B van Straaten, V John, CX. Yu, SD. Oosterhout, L Stehouwer, G Scappucci, M Veldhorst, F Borsoi, JP. Zwolak. Modular Autonomous Virtualization System for Two-Dimensional Semiconductor Quantum Dot Arrays. *(PRX 15.021034)*
- **ASR**, D Madan, A Ray, D Vinayagamurthy, MS Santhanam. Learning hard distributions with quantum-enhanced Variational Autoencoders. *arXiv:2305.01592*
- **ASR**, S Carr, C Snider, DE Feldman, C Ramanathan, VF Mitrović. Machine-learning-assisted determination of electronic correlations from magnetic resonance. *(PRR 5(4), 043098)*

Research Experience

Jan 2024 -*present* **Graduate Research Assistant**
PI: Michael Gullans, University of Maryland, College Park, MD

- Developing novel Quantum Error Correction (QEC) protocols, focusing on fault-tolerance overhead reduction in architectures with long-range connectivity.
- Studying a new proposal for capacitively coupled long-range two-qubit gates in spin-qubit devices.
- Developed a scalable framework using randomized benchmarking to characterize quantum hardware noise and quantify qubit leakage rates.
- Performed analytical calculations and tensor-network simulations to probe the ground state and disorder landscape of silicon interconnects for shuttling spins in semiconductor quantum devices.

PI: Justyna P. Zwolak, National Institute of Standards and Technology, Gaithersburg, MD

- Characterizing effects of two-level fluctuators on the T_1decay dynamics of superconducting qudits.
- Developed a physics-informed ensemble of U-Net convolutional neural networks for real-time device calibration and noise spectroscopy of quantum-dot devices.
- Developed a modular and scalable framework using an ensemble of U-net convolutional neural networks to construct virtual-gates for quantum dot devices and demonstrated it on the then-largest 2D quantum-dot device.

June 2022 – May 2023 **Master's Intern at IBM Research, India**
PI: Venkata Subramaniam and D. Vinayagamurthy
Topic: Variational quantum algorithms for generative learning (arXiv)

- 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 quantum processor 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 (Google Summer of Code)**
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%.
- Lead the IISER Pune team at the International Genetically Engineered Machine (iGEM) bioengineering competition at MIT, Boston, winning the first gold-medal and best project award.
- 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 price at the iGEM 2021 Startup showcase competition.

Posters (P) / Invited (IT) / Accepted Talks (AT)

- (*AT*) Interacting electrons in silicon quantum interconnects: From Wigner Crystals to long-range capacitive coupling. Silicon Quantum Electronics. 2025 Oct 7; *Los Angeles, CA*
- (*AT*) MAViS: Modular Automated gate-virtualization of two-dimensional semiconductor quantum dot arrays. APS Global Physics Meet. 2025 Mar 19; *Anaheim, CA*
- (P) Phase transitions in random circuits with dissipation. QIP 2025. 2025 Feb 27; *Rayleigh, NC*
- (P) Autonomous virtualization of quantum dot devices. ITI Science day. 2024 Nov 22; *Gaithersburg, MD*
- (*IT*) Autonomous virtualization of quantum dot devices. Laboratory of Physical Sciences. 2024 Dec 09; *College Park, MD*
- (*AT*) Autonomous virtualization of quantum dot devices. Joint JQI-QuICS Seminar. 2024 Nov 22; *College Park, MD*
- (*AT*) Automated real-time gate virtualization of a 10 quantum dot array. Silicon Quantum Electronics. 2024 Sept 4-5; *Davos, Switzerland*
- (*AT*) Autonomous virtualization of quantum dot devices. 2024 Aug 28-Sept 2; *TU Delft, Netherlands*
- (*P*) 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 I-II, Quantum mechanics I-III, Quantum Information Processing, Condensed matter field theory I-II, Quantum Algorithms, Error Correction and Fault Tolerance.

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

Awards and Achievements

- Dean's Fellowship (2024): Fellowship by Department of Physics, University of Maryland CP
- Qiskit Challenge (2021-23): Top performer at the hackathon focussing on quantum algorithms, machine learning 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): 2^{nd} in the State of Maharasthra, 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 among 250+ teams from 40+ countries.
- Kishore Vaigyanik Protsahan Yojana (KVPY) (2018 - 2023): Placed among top 0.05% candidates in the country; awarded a competitive scholarship by the Department of Science and Technology.

Mentoring and Volunterring

- Robust Quantum Simulation Graduate-Student Council (2025-), University of Maryland
- Physics department representative at the Graduate Student Council (2024-25), University of Maryland
- Physics department representative at the College of Mathematical and Natural Sciences (CMNS) Council (2024-25), 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.