

Ramanuj Raman

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Current Positions

Indian Institute of Science Education and Research, Mohali

5th year-BSMS student

December, 2021 - Present

Peter Grünberg Institute - Quantum Control (PGI-8)

Master's Thesis student

May, 2025 - Present

Relevant Courses

- PHY302 & PHY306: Quantum Mechanics & Adv Quantum Mechanics
- PHY304: Statistical Mechanics
- PHY301: Classical Mechanics
- PHY660: Nonlinear Optics
- PHY665: Quantum Phases of Matter and Phase Transitions
- PHY640: Non-Equilibrium Statistical Mechanics
- IDC402: Nonlinear Dynamics, Chaos and Complex Systems
- PHY631: Quantum Computation and Quantum Information
- PHY424: Relativistic Quantum Mechanics and Quantum Field Theory
- PHY644: Foundation of Quantum Mechanics
- PHY638: Physics of Fluids

Education

Indian Institute of Science Education and Research

Mohali, India

BS-MS in Physics major

Dec. 2021 - June, 2026

* **CPI:** 9.0/10.0

* **SPI:** 10.0/10.0

Kendriya Vidyalaya Bangana (CBSE)

Una, India

High School Education

Mar. 2021

* **Percentage:** 95.8%

* **Class Rank:** 2nd

Master's Thesis

Error Budget in Dispersive Readout

under the supervision of Dr. Francisco Cárdenas López and Prof. Dr. Felix Motzoi at PGI-8, FZ Jülich

- Readout in superconducting qubits turns out to be the bottleneck leading for Quantum Error Correction. Earlier works suggested a readout fidelity of 99.99% for enabling on chip execution of quantum error correction

codes. In this project, we are exploring the different sources of error and characterize them as coherent error, due to controls causing drive induced state transitions, and incoherent errors, due to the resonator decay coupled to the qubit via photon dependent and independent terms. In the dispersive readout of a transmon we can define different coupling regimes using n_{crit} and this also define different limits to Schrieffer Wolf Perturbation Theory and explains the strength of different effects in control and dissipator.

Another challenge for dispersive readout is resonator reset and recent works suggest new pulse engineering technique called DRACHMA which can do active resonator reset leading to faster operations on a superconducting chip. We are also exploring the effect of these pulses on the QNDness of the readout.

Projects

Analytical and Numerical Investigation of Fully Quantized Light-Matter Interaction in Few-Level Systems

Prof. Dr. Torsten Meier and supervised by Dr. Hendrik Rose at Institute for Photonic Quantum Systems, Paderborn University, Germany

- In this project, we extended the original 2-level JCM for a 3-level system and attempted to study the excitation dynamics of the system. We have also studied the excitation dynamics of the system under different quantum statistics of light, like coherent states, squeezed vacuum states, thermal light, etc. In this project, we have attempted to solve the 3-level JCM using both analytical and numerical methods. For numerical methods, we have mainly used the Python library qutip. This project was completed in online mode.

Electromagnetically Induced Transparency and Ground State Cooling

Semester Project for PHY660: Nonlinear Optics

- In this project, we made an attempt to understand electromagnetically induced transparency in a 3-level system and also tried to understand how ground state cooling happens in the atoms. Many methods have been earlier shown for laser cooling, and in this project, we have explored ground state cooling based on the principles of EIT.

Bose Hubbard Model and Superfluidity : A Numerical and Analytical study

Semester Project for PHY665: Quantum Phases of Matter and Phase Transitions

- In this project, we made an attempt to understand the phase diagram and the superfluidity in the Bose-Hubbard model. We explored the model in various limits and tried to study the properties of the system using the Ginzburg-Landau theory of phase transitions, mean-field theory, and an incomplete attempt using the Gutzwiller variational ansatz.

Dynamics of Slip-Bond and Slip-Catch-Slip Bond Cluster Under Applied Force

Dr. Anil Kumar Dasanna at IISER Mohali

- In this project, we made an attempt to study the dynamics of slip bonds under applied force on the cluster and tried to find the quantities like critical force, variation of time of dissociation with applied force, and time evolution of number of closed bonds under given applied force. Another failed attempt has been made to study the dynamics of slip-catch-slip bond cluster under applied force and to find similar quantities for this model. We found an equation giving bond dissociation as function of applied force. The models have been studied by solving mean field equations using RK-4 method in Python and all Stochastic Simulations have been done using Gillespie Algorithm in C++.

Reading Project on Fourier Optics

Dr. Sandeep Kumar Goyal, IISER Mohali

- We worked together to understand the interference and diffraction patterns formed by slits of different shapes to then get a general expression for any random shape. This project included learning scalar diffraction theory and finally deriving the Kirchhoff-Fresnel diffraction formula.

Reading Project on Quantum Machine Learning and Quantum Deep Learning

Dr. Kuntal Roy at IISER Bhopal

- We worked together to understand the basics of Quantum Computing starting off with learning basic algorithms such as quantum teleportation, Deutsch-Jozsa algorithm, Bernstein-Vazirani algorithm, and Simon's

algorithm. Then we moved toward learning a few of the more advanced algorithms such as the HHL algorithm and tried to understand the foundations of quantum machine learning and quantum deep learning by studying the training of deep restricted Quantum Boltzmann's machine using quantum algorithms GEQS and GEQAE

Second Quantisation, Ising Model, Kitaev Chain: A literature survey

Prof. N.S. Vidhyadhiraja at JNCASR Bangalore

- Our objective during this project was to understand the dynamics of lattice vibrations for different crystal systems in 1D using both classical and quantum treatment. We also explored the statistical properties of classical Ising Model using analytical techniques in both 1D and 2D, as an extension to the classical Ising Model, we also explored Kitaev chain in open boundary conditions and observation of Majorana particles as edge modes. I also gave a talk on Introduction to Quantum Computing Using Qiskit, exploring basics and different quantum algorithms and protocols as teleportation, Quantum Fourier transform and variational algorithm.

Solving Quantum Hisenberg Chain Model using Quantum Computer

Prof. N.S. Vidhyadhiraja at JNCASR Bangalore

- Our objective during this project was to try to solve the Heisenberg Chain Model using a quantum computer simulator and to find eigenvalues using Quantum Phase Estimation. The time evolution circuit for the Heisenberg Chain Model has been implemented using Qiskit on a simulator.

Skills

Mathematical Techniques: Langevin Equations, Mean Field Theory, Schrieffer Wolf Transformation, Lindblad Master Equation, Fokker Planck Equation

Programming Languages: Mathematica(Beginner), Julia(Intermediate level), Python(Intermediate level), C++(Intermediate level)

Specific Libraries and Packages: Numpy, Scipy, SymPy, Pandas, Matplotlib, Qutip, Qiskit, QuantumCumulant.jl, ModelingToolkit.jl

Miscellaneous: Latex, Typst, Sleep.ai

Honors and Achievements

- Selected for conducting help sessions for undergraduates by the Department of Physical Science, IISER Mohali and awarded honorarium by the Dean of Students for recognition of my services.
- Awarded Quantum Excellence Badge in 2024 Quantum Global Summer School: Path to Utility
- Cleared NEET-UG exam and got admission into MBBS at RPGMC Tanda.
- Cleared JEE-Mains and got admission in BTech (Electronics and Communications Engineering) at National Institute of Technology, Hamirpur.
- **All India Rank-367** in IISER Aptitude Test
- Passed NTSE stage-1, national talent search exam conducted across India.
- Twice VVM, India's largest online talent search exam, Himachal Pradesh State Champion.

Workshops and Seminars

- Physics of Life 2024-9th Annual Monsoon School at Simons Centre at NCBS, Bangalore (July 1-10, 2024)
- Participated in NEXT Epoch 2024, the deep learning workshop at Harvard Medical School, aimed at applications of deep learning on Biochemistry and secondary structure prediction.
- Participated in Qiskit Global Summer School-2024: Path to Utility

Teaching Experience

- Conducted help sessions for undergraduate students on PHY101: Mechanics, recognized by the Department of Physics and Dean of Students at IISER Mohali.
- Conducted help sessions for undergraduate students on PHY102: Electromagnetism, recognized by the Department of Physics and Dean of Students at IISER Mohali.
- Conducted help sessions for undergraduate students on PHY204: Modern Physics, recognized by the Department of Physics and Dean of Students at IISER Mohali.

Volunteer Experience

- Worked with the Prayatana Organization at IISER Mohali to help underprivileged kids in the locality of IISER Mohali. We conducted evening classes for underprivileged kids and also provided them with food and clothings. We also ran fundraising events at IISER Mohali and arranged events for kids to visit IISER Mohali.

Talks and Presentation

- Talk at Vidhyadhiraja Group, JNCASR Bengaluru on "An Introduction to Qiskit and Quantum Computing" in May, 2023
- Presentation at 9th-Physics of Life Monsoon School at NCBS Bengaluru on "Dynamics of slip-bond cluster" on 09 August, 2024
- Lecture on "Vectors, Tensors and Electromagnetism" at Phi Club IISER Mohali
- Presented lecture on "Postulates of Quantum Mechanics" at IISER Mohali
- Presented a paper on Quantum Heat Engines with Carnot Efficiency at Maximum Power, for my course on seminar delivery.
- Presented my work on Analytical and Numerical Investigation of Fully Quantized Light-Matter Interaction in few-level systems, for my course on seminar delivery.