Aditya Saran

Third year Undergraduate
B.Tech in Engineering Physics, Minor in Data Science
Indian Institute of Technology Bombay

✉ aditya.saran@iitb.ac.in
in adityasaran
☎ +91 91134 54521

RESEARCH INTERESTS

Condensed Matter Physics - Josephson Junction Gates; Quantum Transport; Superconducting Qubits; Transport in SNS junctions
Quantum Computing - Applications of Parameterised Quantum Circuits; Quantum Algorithms; Quantum Machine Learning; Quantum Diffusion Models; Graph Transformers

EDUCATION

Indian Institute of Technology, Bombay   *2022–26*
Bachelor of Technology in Engineering Physics
Minor in Data Science

RESEARCH PROJECTS

Optimization of LTC Recurrent Neural Networks through Quantum Machine Learning   *2024*
Mentors: Prof. Vaneet Aggarwal and Dr. Debanjan Konar | Purdue University, USA

- Conducted an in-depth examination of the fundamental principles of **Liquid Time Constant Networks**, a recurrent neural network (RNN) inspired by the dynamics of spiking neurons in the brain
- Gained comprehensive expertise in the implementation of **Quantum Recurrent Neural Networks (QRNNs)**
- Investigated the feasibility of employing **differentiable quantum circuits** to implement **LTC Networks**, focusing on identifying limitations in classical LTC networks and evaluating potential improvements through quantum algorithms
- Developed a **Quantum ODE Solver** that effectively solves any ODE/ PDE using **Parameterized Quantum Circuits** based on a research paper
- Enhanced the efficiency of the ODE solver by integrating stochastic gradient descent and the **Tree-structured Parzen Estimator** (TPE) algorithm
- Conducted a literature survey on **Fourier Neural Operators** and looking into making a quantum model for making quantum PDE solvers using **Quantum Diffusion Models** and **Graph Transformer Neural Operator**

Application of Quantum Transport in semiconductor-superconductor devices   *2024*
Mentor: Prof. Bhaskaran Muralidharan | Dept. of Electrical Engineering, Indian Institute of Technology Bombay

- Developed a comprehensive understanding of **quantum coherent transport** phenomena, with a strong focus on **transmission formalism** using Landauer formula
- Studied the **non-equilibrium Green's function** (NEGF) technique with specialized applications to nanoscale device modeling, focusing on **superconductivity** and the emergence of **Majorana fermions**
- Simulated **Bogoliubov–de Gennes (BdG) Hamiltonian** in **Superconductor-Normal-Supercon- ductor (SNS)** junctions to study the transport of Josephson junctions
- Currently studying subgap states in semiconductor-superconductor devices, focusing on '**Poor Man's Majorana**' states

Analytical and Numerical Study of Stochastic Gene Expression with Cell Division   *2024*
Mentor: Prof. Dibyendu Das | Dept. of Physics, Indian Institute of Technology Bombay

- Conducted an in-depth examination of **analytical distributions of stochastic gene expressions** in bursty processes and **exact distribution of the quantal content in synaptic transmission**
- Exploring the possiblities to get an analytical distribution of stochastic gene expression involving **cell division**
- Used the technique **Kinetic Monte Carlo (Gillespie algorithm)** to numerically simulate different the PDFs
- Used **Mathematica** to get the analytical forms of generating functions and matched it with the numerical results

Exploring Superconductivity: Insights into Josephson-Junction Gates   *2023*
Mentor: Prof. Soumya Bera | Dept. of Physics, Indian Institute of Technology Bombay

- Conducted an in-depth examination of the fundamental principles of **Superconductivity**
- Attained a solid understanding of key theories explaining superconductivity, including the **microscopic BCS theory** and the macroscopic **Ginzburg-Landau theory**, highlighting strong theoretical knowledge
- Attained comprehensive expertise in **Josephson-Junction** gates through detailed study using the **RCSJ model**.
- Studied the concise nature of **short Josephson Junctions** and explored the formation of **Fraunhofer patterns** depicted in the maximum current versus flux graph
- Examined **Hysteresis** in Current-Voltage Characteristics of **Josephson Junction Arrays**

SCHOLASTIC ACHIEVEMENTS

('24)

- Secured a **99.59** All India Percentile in the **JEE Mains** exam among **1.2 million** candidates *('22)*
- Achieved an All India Rank of **1148** in **JEE Advanced** exam among **0.2 million** candidates *('22)*
- Secured a qualification for the prestigious **Indian National Mathematical Olympiad (INMO)**, ranking among the **top 300 students** across the nation *('20)*

OTHER PROJECTS

Quantum Computing, Information and Technologies | Summer of Science [*Report link*] *2023*

Maths and Physics Club, IIT Bombay | Mentor: Aneesh Kamat

- Proficiently **simulated** quantum gates and circuits using **Qiskit**, gaining insight into their practical applications
- Acquired a comprehensive understanding of a range of **quantum computing algorithms**, encompassing the Deutsch-Jotza Algorithm, Grover's Algorithm, Shor's Algorithm, and quantum teleportation
- Acquired a foundational understanding of **physical realisation of qubits** using **Superconducting qubits**

Chaos based Encryption using Arduino [*Report link*] *2024*

Course Project in Digital Electronics | Instructor: Prof. Maniraj Mahalingam

- Designed a delta modulator using Arduino to convert analog signals into into digital for easy transmission.
- Applied a chaos based logistic map to generate a binary key for encrypting the data.
- Implemented a **feedback based mechanism** to synchronise two arduino's for error free transmission of signal
- Used an analog electronic based delta-modulator to convert the binary string to a analog waveform

Analyzed Synchronization and Community Switching *2023*

Course Project in Non Linear Dynamics | Instructor: Prof. Punit Parmananda

- In a team of three, conducted simulations of the **Kuramoto model** involving **100 oscillators**, using **MATLAB**
- Investigated the community switching phenomenon in a **six-oscillator** network as a team, analyzing variations with changing connections and coupling strength, showcasing a collective grasp of network dynamics
- Analyzed community switching in a **three-oscillator model**, focusing on its dynamics and behavior, contributing collectively to a deeper understanding of **synchronization phenomena** in complex systems

Canoeing through the Stars on Gaia Telescope | Krittika Summer Project [*Report link*] *2023*

Krittika Summer Project

- Conducted detailed analysis of **open** and **globular clusters** using data obtained from the **Gaia telescope**
- Systematically constructed and carefully analyzed **Hertzsprung-Russell diagrams** for multiple clusters, utilizing data to **estimate age** and **metallicity** using multiple techniques
- Conducted comprehensive analysis of the **Large Magellanic Clouds** and **Small Magellanic Cloud**, contributing to the understanding of galactic structures in the field of astronomy

Cosmic Convergence | Krittika Summer Project [*Report link*] *2023-24*

Krittika Computational Astronomy Project

- Conducted an extensive analysis of cosmology, involving in-depth exploration of the **Friedmann equation**.
- Systematically studied **six** different cosmological models, including the **non-flat Lambda-CDM model**, to obtain constraints on dark energy dynamics.
- Utilized the **Monte Carlo Markov Chain method** on **Hubble parameter**, **baryon acoustic oscillation** data, and **Quasi-Stellar Object data** to optimize parameters for the models.

TEACHING AND MENTORSHIPS

Teaching Assistant for PH221 (Analog Electronics) *2024*

- Responsible for assisting students with weekly assignments, clearing doubts and grading lab reports

Mentor for Stellar Data Analysis with Gaia Project *2023-24*

Guiding groups of 6-10 undergraduate mentees on exploratory astronomy projects for 1-2 months

- Curated and created resources and code to assist learning of astronomical data using Gaia exploration
- Taught theory and coding for cluster dynamics and IMF, galaxy rotation and variable stars in weekly meetings

POSITIONS OF RESPONSIBILITY

Department Research Coordinator, Department of Physics IIT Bombay *2024-25*

- Coordinating programs like **SURP** and **WURP** by procuring projects from professors of physics department
- Organising events like **seminars, symposiums** and **lab open day** in the department to promote research enthusiasm
- Planning and executing an institute-wide industry meet focused on **Quantum Machine Learning**

Volunteer at Krittika, Astronomy Club of IITB *2023-24*

- Orchestrated Krittika's flagship event **"Astromania"**, attracting **150+** attendees. Collaborated with team members on quiz content and ensured seamless event execution.
- Skillfully guided and mentored **6+** enthusiastic students through an enthralling **month-long astronomy project** centered on **Gaia data analysis**, demonstrating exemplary mentoring prowess.
- Delivered hands on observation session & talk to **400+ underprivileged school students** as a joint initiative by Institute Technical Council & GNAANU foundation
- Trained to operate **Equatorial** and **Dobsonian** mount telescopes to conduct **stargazing sessions**, engaging extensively with attendees to enhance their experience

TECHNICAL SKILLS

Languages	Mathematica, LaTeX, C++, Python, Blender 3D, Java, HTML, JavaScript, CSS, Matlab, LT Spice, Arduino IDE, Julia
Libraries	Qiskit, Qadence, Scipy, NumPy, Torch, Pandas, Matplotlib, Astropy, Astroquery

COURSES UNDERTAKEN

Physics	Quantum Information and Computing, Quantum Physics I, II & III*, Intro to Condensed Matter Physics*, Advanced Statistical Mechanics*, Classical Mechanics, Statistical Physics, Electromagnetic Theory*, Numerical Analysis, Waves, Thermal Physics, Non-Linear Dynamics
Mathematics	Single and Multi-variable Calculus, Linear Algebra, Differential Equations, Complex Analysis
Others	Digital Image Processing*, Introduction to Machine Learning, Computer Programming and Utilization, Organic and Inorganic Chemistry, Physical Chemistry, Biology, Makerspace, Economics, Capitalism*

* to be completed by November 2024

EXTRACURRICULARS

- Proficiently solves the Rubik's Cube with remarkable speed and precision, consistently completing it in an impressive **sub-15-second** average time, showcasing a strong command of this complex puzzle
- Completed over **80+ hours** of rigorous training through the **National Cadet Corps (NCC)** program. Engaged in challenging events like the **Crossy GC** marathon and **training GC**, highlighting my readiness for challenges.
- Participated in the **XLR8** competition, leading the development, implementation, and fabrication of the **joystick-controlled bot** encompassing both mechanical and electrical design aspects.
- Elected class representative to address issues and establish faculty communication for 60+ students

REFERENCES

Prof. Bhaskaran Muralidharan
Professor, Department of Electrical Engineering
Indian Institute of Technology Bombay
Mumbai, India, 400076
bm@ee.iitb.ac.in

Prof. Vaneet Aggarwal
Professor, Department of IE, ECE, and CS
Purdue University
West Lafayette, IN 47907, United States
vaneet@purdue.edu

Prof. Dibyendu Das
Professor, Department of Physics
Indian Institute of Technology Bombay
Mumbai, India, 400076
dibyendu@iitb.ac.in

Prof. Soumya Bera
Associate Professor, Department of Physics
Indian Institute of Technology Bombay
Mumbai, India, 400076
soumya.bera@iitb.ac.in