

## RESEARCH INTERESTS

To a large extent, my interests revolve around two broad fields; Quantum Computing and Cosmology. I find the experimental side of Quantum Computing, especially **Quantum Control and Measurement**, extremely intriguing. So far, my experience in the field of Quantum Computing has been inclined towards instrumentation involved in measurement and data acquisition.

I am also interested in General Relativity and Cosmology, especially **Inflationary Cosmology** and how Quantum Effects during this period of exponential expansion led to the universe we see today.

## EDUCATION

- **Indian Institute of Technology, Bombay** (Nov'20-Present)
  - Major: Bachelor of Technology in **Engineering Physics** with Honors **GPA: 9.42/10**

## PROJECTS

### RF Pulse Engineering (Jun'22-Present)

Guide: [Prof. Suddhasatta Mahapatra](#), Department of Physics, IIT Bombay

**QCoDeS** is an open source Python-based data acquisition framework developed by the **Copenhagen/ Delft/ Sydney/ Microsoft quantum computing** consortium, made to facilitate measurements in nanoelectronics.

- Developing drivers using QCoDeS to control an Arbitrary Waveform Generator, a Vector Signal Generator, and associated equipment to engineer **Radio Frequency pulses** for quantum control of **spin qubits**.
- Studied sensing and measurement techniques used for quantum control of spin qubits in **Quantum-Dots** fabricated in Silicon hetero-structures at the Silicon Quantum Computing (QSi) lab at IIT Bombay.
- Built an Analog circuit using Op-Amps that mimics the current  $\{I_{SD}(V_{G1}, V_{G2})\}$  map through a **Single Electron Transistor** capacitively coupled to two plunger gates on a larger voltage scale.
- The reports summarizing the QCoDeS related work done during the summers (Jun'22 to Jul'22) are linked [here](#).

### Models of Inflation | Research Project (Nov'21-Present)

Guide: [Prof. Vikram Rentala](#), Department of Physics, IIT Bombay

- Research project studying the different **Models of Inflation** which explain how **quantum fluctuations** in the very early, near homogeneous universe grew to form the large scale structure we see today.
- Current focus of the project is on studying Cosmological Inflation and re-deriving results from the **T.A.S.I.** (Theoretical Advanced Study Institute) **lectures on Cosmology** by Daniel Baumann (Jul 2009) linked [here](#).
- Read up on all relevant topics in **General Relativity** and **Physical Cosmology** with *Spacetime and Geometry* (by Sean Carroll) and *Modern Cosmology* (by Scott Dodelson) as the primary reference books.

### Data Analysis of High Energy p-p Collisions | Course Project [Report and Codes] (Sep'21-Nov'21)

[Prof. Sadhana Dash](#), IIT Bombay | PH219: Data Analysis and Interpretation

- Analyzed and interpreted data consisting of 4 million observations of high energy (Center of Mass Energy  $\sim 13\text{ TeV}$ ) proton-proton collisions generated using **PYTHIA 8 Monte Carlo** event generator.
- Studied the relationship between net-charge fluctuation and multiplicity by analyzing and plotting statistical parameters (like mean, std. deviation, etc) related to net-charge fluctuations using **ROOT - Cern** data analysis software.

## Nonlinear Dynamics in Biological Co-evolution | Course Project [\[Report and Codes\]](#)

(Sep'21-Nov'21)

Prof. Amitabha Nandi, IIT Bombay | PH567: Nonlinear Dynamics

- Analyzed, interpreted, and recreated results of a [paper](#) on the application of the **Replicator Equations** in studying nonlinear behaviour and **Bifurcation Theory** for biological co-evolution of three species.
- Simulated the nonlinear **Phase Space** behaviour of the three co-evolving species populations using numerical methods to solve the replicator equations (differential equations) and plotted it using **Python**.
- The project report and presentation summarizing the analysis and conclusions can be found [here](#).

## The Gaia Theory | Course Project [\[Report\]](#)

(Aug'21-Sep'21)

Prof. Kiran Kondabagil, IIT Bombay | BB647: Introduction to Evolutionary Biology

- Studied the modern version of the **Gaia Theory** and topics from **System Sciences** which are crucial to understand a planet's atmospheric and surface phenomenon, especially those affecting Earth ecosystems.
- Reviewed scientific papers on theories suggesting possible bottlenecks faced for evolution of life on a planet, focusing on the novel [Gaia Bottleneck Hypothesis](#), seeking the answer to Fermi's Paradox.

## Huffman Coding | Course Project [\[Report\]](#)

(Feb'22-Apr'22)

Prof. Maniraj Mahalingam, IIT Bombay | EE224: Digital Systems

Huffman coding is a **lossless data compression** algorithm that assigns variable length codes to different characters based on the frequency of occurrence as compared to constant length of conventional ASCII.

- Designed an easily extensible **digital circuit** using a collection of both **sequential and combinations** logic elements that can perform compression using Huffman coding for a message consisting of 3 letters.
- Used components like **logic-gates**, **flip-flops**, registers, counters, and memory elements working in sync with a system clock summarizing the final circuit design in the report linked [here](#).

## Electronics Projects | Lab Courses

(May'21-Present)

Physics Department, IIT Bombay

- Designed, Simulated and Physically implemented several circuits including Op-Amp based filters, Oscillators, Amplifiers and Finite State Machine Implementations.

## General Theory of Relativity | Reading Project [\[Report\]](#)

(May'21-July'21)

Maths and Physics club, IIT Bombay | Summer of Science

- Completed a reading project (and [report](#)) on Einstein's **General Theory of Relativity** studying the fundamentals of Riemannian Geometry, Tensor Algebra, Gravitation and exploring Inflationary Cosmology.

## TEACHING EXPERIENCE

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### Teaching Assistant | PH-108 | PH107

(Mar'21-Jul'22) | (Nov'21-Mar'22)

Physics Department, IIT Bombay

Conducted weekly tutorials to discuss problem sets, solved doubts and provided general course-work related guidance. Tutored a batch of 45 students for freshmen year courses:

- PH-108, [Basics of Electricity and Magnetism](#).
- PH-107, [Quantum Physics and Applications](#).

Notes I made for the tutorial sessions are linked [here](#)

## Summer of Science Mentor

(May'22-Jul'22)

Maths and Physics Club, IIT Bombay

- Guided students for the research based reading project on the topics of **Cosmology and Dark Matter**.
- Provided resources for learning basics of Cosmology and helped with topic related doubts whenever required and reviewed the final reports and video explanation about the project submitted by the students.

## TECHNICAL SKILLS

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**Programming:** C, C++, Python (incl. packages like scipy, einsteinpy, etc.), HTML, QCoDeS

**Technical Software:** MATLAB, Mathematica, ROOT-Cern,  $\text{\LaTeX}$ , Autocad, SolidWorks, Photoshop

**Spoken Languages:** English, Hindi, Gujarati, Marathi

## SCHOLASTIC ACHIEVEMENTS

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- Currently **Department rank 6** out of 66 students in Engineering Physics batch of 2024. (Jul'22)
- Secured **All India Rank 612** out of 250,000 candidates in **JEE-Advanced 2020**. (Oct'20)
- Secured **99.87 Percentile** out of 0.87 million candidates in **JEE-Main 2020**. (Sep'20)
- Selected for Kishore Vaigyanik Protsahan Yojana (**KVPY**) fellowship in SX category, provided by IISc, ranking in the **Top 1.36%** out of 0.97 million candidates. (Apr'20)

## KEY COURSES UNDERTAKEN

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- **Physics:** Quantum Physics and Applications; Basics of Electricity and Magnetism; Physics Lab; Classical Mechanics; Introduction to Special Theory of Relativity; Thermal Physics; Data Analysis and Interpretation; Quantum Mechanics I; Waves Oscillations and Optics; General Theory of Relativity, Quantum Mechanics II\*, III\*; Photonics\*; Group Theory\*.
- **Mathematics:** Calculus; Linear Algebra; Complex Analysis; Differential Equations I, II; Introduction to Numerical Analysis.
- **Electronics:** Digital Systems, Microprocessors Lab, Electronics Lab (Analog and Digital).
- **Miscellaneous:** Engineering Graphics & Drawing, Chemistry, Biology, Chemistry Lab, Gender in the Workplace, Computer Programming and Utilisation.

(\*) Courses to be completed by Nov'22

## EXTRACURRICULAR ACTIVITIES

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- Regularly play **Squash** and participated in NSO sports in my freshman year.
- Secured **2nd** position among multiple participating schools from all over Thane, in Inter School Quiz Competition conducted by **Rotary Club** of Thane Lake City (2017-18).
- Taekwondo **Poom Black Belt** certificate received from the **World Taekwondo federation**.
  - Participated in several Tournaments winning a Silver in state level S.F.A (2016), Bronze in the 4th Invitational Kudo Championship (2012) among others.
- Secured **A grade** in both the Elementary and Intermediate Examinations conducted by the Art Directorate of the Government of Maharashtra.