Utkarsh

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Indian Institute of Technology

Scholastic Achievements

2019
- Secured **All India Rank 22** in **National Entrance Screening Test** among **60,000** candidates
- Achieved **99.10** percentile in **JEE Advanced** among 2,45,000 eligible candidates
- Achieved **99.74** percentile in **JEE Main** out of 1.2 million candidates

Education

2019 – Present — **Indian Institute of Technology Bombay** — 8.36/10 GPA
B. Tech. – M. Tech. Dual Degree Engineering Physics

2016 – 2018 — **GRM School, Bareilly** — 95%
Higher Secondary - Central Board of Secondary Education

2016 — **GRM School, Bareilly** — 10/10 GPA
Junior Secondary - Central Board of Secondary Education

Research Experience

Plasmonic Nanoantennas for Strain Engineering in 2D TMDCs *(Jul '22 - Present)*
Guide: Prof. Anshuman Kumar *LOQM Lab, Department of Physics, IIT Bombay*
- Studying the effect of external strain on the **band structure** in atomically thin two-dimensional TMDCs
- Performing **scotch-tape exfoliation** of **WSe2** and **hBN** to achieve monolayers, and performing **photolumiescence spectroscopy**, **Raman spectroscopy** and $g^{(2)}$ measurements
- Performing **FDTD** simulations for plasmonic nanoantennas on Si substrate in the presence of EM radiation

Arbitrary Waveform Generation for Si-Quantum Dot based Qubit Control *(May '22 - Present)*
Guide: Prof. Suddhasatta Mahapatra *Q-Si Lab, Department of Physics, IIT Bombay*
- 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
- Performing I-V measurements on **Si-MOSFET Hall probes** checking for issues in dopant implantation, oxide integrity, ohmic contacts, etc. in the fabricated heterostructures
- Studying the working of a **dry dilution refrigerator**, to be used for low-temperature experiments
- Studied sensing and measurement techniques used for **quantum control** of quantum dots based spin qubits in Silicon heterostructures

Quantum Many-Body simulations with Machine Learning [Report] *(May '21 – Feb '22)*
Guide: Prof. Nilmani Mathur *Department of Theoretical Physics, TIFR*
- Conducted literature survey on the applications of **Tensor Networks** and implementation of **MPS** and **PEPS** as numerical ansatz for approximating interesting quantum many-body wave-functions
- Implemented **importance sampling** in Monte Carlo for the **2-D Ising model** and **classical XY model** with the **Metropolis** and **Wolff cluster** algorithms and analysed the thermodynamic properties
- Implemented a **restricted Boltzmann machine** to generate Monte Carlo samples for the 2-D Ising model
- Learnt about the **inaccuracies in generative machine learning methods** for simulating the phase transitions of the Ising and the XY models

Entanglement Entropy in Coupled Harmonic Oscillator Systems [Report] *(Aug '21 - Apr '22)*
Guide: Prof. Shankaranarayanan S *Department of Physics, IIT Bombay*
- Studied the **zero-mode divergence** in entanglement entropy in a coupled harmonic oscillator and worked on understanding the contribution of high energy eigenstates to the divergence of entanglement entropy
- Studied the relation between zero-mode divergence and **space-time curvature** and the **EUP**

Projects

Gamma-ray Spectroscopy | Instrumentation Subsystem | GLEE | IITBSSP *(Feb '21 - Nov '21)*

A global mission that aims to conduct science and test technology on the surface of the moon using chipsats

- Conducted extensive literature survey on the **Lunar radiation environment** and related missions
- Analysed possibilities for onboard detection of **alpha particles**, **neutrons** and **X/γ-rays** using **PIN diodes**, **SDDs**, **SiPMs**, **CMOS** and **CCD** detectors given the stringent power and space requirements of LunaSats
- Designed a **small**, **low-powered gamma-ray spectroscopy system** for the $\mathbf{5 \times 5\ cm^2}$ chip with PIN diodes and devised the testing, simulation, and calibration plan, incorporating the various possible effects of radiation on the circuit and **guided two students** in the design and simulation phase

Lens Module | Instrumentation Subsystem | STADS | IITBSSP *(Feb '20 - July '20)*

A CubeSat-compatible Star Tracker-based Attitude Determination System to be tested onboard the PS4-OP

- Devised **requirements** for compatible lens systems based on **bench-marked performance criteria**
- Designed, simulated and analysed various **multiple and single-lens systems** in **Zemax OpticStudio**

Piano Man : Portable Piano on a Glove [Presentation] *(Sep '21 - Oct '21)*

Guide: Prof. Varun Bhalerao *Department of Physics, IIT Bombay*

- Implemented a **position based note selection algorithm** on an **Arduino Uno** using an **U/S sensor**
- Integrated an **LCD** display, along with an **ROM** to **read-write** the sequence of notes being played

Higher moments of transverse momentum in p-p collisions [Report] *(Oct '20 - Dec '20)*

Guide: Prof. Sadhana Dash *Department of Physics, IIT Bombay*

- Applied the data analysis framework **ROOT** developed by **CERN** to analyse over **two million events** generated using **PYTHIA 8** for p-p collisions at 13 TeV center of mass energy
- Confirmed **positive skewness** for various multiplicities by calculating higher moments of transverse momentum

Transverse Spinning of Unpolarised Light [Report] *(Jan '21 - Apr '21)*

Guide: Prof. Anshuman Kumar *Department of Physics, IIT Bombay*

- Studied the formulation of **evanescent waves** and **Gaussian beams** generated by unpolarised sources
- Confirmed the existence of the transverse spin angular momentum from respective **coherency matrices**
- Reproduced the **spin angular momentum density plots** for a Gaussian beam

Coherent State Representation of Photons [Report] *(May '22)*

Guide: Prof. Urjit Yajnik *Department of Physics, IIT Bombay*

- Derived the coherent states for a harmonic oscillator and the **vacuum distribution** for a scalar field with the corresponding creation and annihilation operators
- Related the **plane-wave photon state** with the coherent state representation of the corresponding quantum field

Positions of Responsibility

Nov '20 - Mar '21 **Teaching Assistant | Quantum Physics and Applications**

- Managed a batch of **37 UG students** and conducted weekly tutorial sessions and quizzes
- Personally clarified doubts of academically weaker students to motivate them and boost their performance

May '21 - Nov '21 **Subsystem Head | Instrumentation Subsystem**

- Guided a **14-membered inter-system team** towards best sensor and optics integration practices
- Executed **three-step recruitment process** to short-list and mentor **8 students** for the subsystem from **50+ applicants** by evaluating their technical ability, practical approach and teamwork

Skills

Programming	C++, Python - (PIPython, QCoDeS, NumPy, Matplotlib, pandas, TensorFlow), VHDL, Arduino IDE
Software	Mathematica, Ansys- Lumerical FDTD, ROOT, Qiskit, LTSpice, OriginLab, Quartus
Experimental	Photoluminescence spectroscopy, Photon Correlation Study, Laser alignment, Raman Spectroscopy

Courses

Physics	Quantum Information and Computing, Quantum Optics, Methods in Spectroscopy and Microscopy, Nanoscience: Introduction to Fabrication, Atomic and Molecular Physics, Statistical Physics, Electromagnetic Theory, Introduction to Condensed Matter Physics
Mathematics	Calculus, Linear Algebra, Real Analysis, Introduction to Numerical Analysis, Complex Analysis, Differential Equations
Labs	Solid State and Nuclear Physics Lab, Optics and Spectroscopy Lab, Op-Amp and Digital Electronics lab, Microprocessors lab
Miscellaneous	Neural Networks and Deep Learning, Improving Deep Neural Networks, Structuring Machine Learning Projects - all by Deeplearning.ai

Extracurricular

Social service

- Received a **special mention** for exemplary volunteering work under the department of **Sustainable Social Development, NSS, IIT Bombay** completing 80+ hours of social work
- Visited **SNJB College, Nashik** representing **Department of Sustainable Social Development, NSS** and interacted with the students and professors and demonstrated experiments to school students

Workshops

- Completed **Quantum Computing Workshop** organised by MnP Club IIT Bombay
- Completed **Astrophysics Workshop** organised by Krittika: The Astronomy Club and Techfest
- Completed Learner's Space's **Scientific Computation and Mathematical Modelling** bootcamp organised by Maths and Physics club IIT Bombay as a part of the Technical Summer School

Culturals

- Secured 4^{th} position in **Dance Mania**, the annual inter-hostel group dance competition
- Designed various **typographical visuals** as a part of the Inktober challenge in a team of 10 for exhibition at **Vision** - The Design festival of IIT Bombay with a footfall of 8000+