



## Research Publications and Conference Proceedings

- 1 Prasad, A., Prajapati, S., **Utkarsh**, & Badhe, V. (2023). *Design and development of a sentence construction game for deaf and hard of hearing (dhh) users: A qualitative usability study*. (in press), Matsue, Shimane, JAPAN.
- 2 Singh\*, A. K., **Utkarsh\***, & Kumar, A. (2023). *Strain induced deterministic single photon emitters in hexagonal boron nitride<sup>†</sup>*.
- 3 Katla, V., **Utkarsh** et al. (2020). An approach to star tracker design for nano-satellite applications. In *National conference on small satellite technology and applications*, Trivandrum, India. <sup>†</sup> Manuscript in Progress

## Education

2019 – Present    🏛 **Indian Institute of Technology Bombay**    8.48/10 GPA  
B. Tech. – M. Tech. Dual Degree, Engineering Physics with a specialization in Nanoscience

## Research Experience

- 🏛 **Pulsed Echo Measurements for the Quantum Spin Liquid phase in 1T – TaS<sub>2</sub>** (May '23 - Present)  
Guide: Prof. Kimberly Modic    TQM, IST Autria
  - Studied the **theoretical signatures of QSL** phase relevant to Pulsed Echo measurements in 1T-TaS<sub>2</sub>
  - Implemented the **Plasma Focused Ion Beam** technique to structure O(10μm) size lamellae in Si
  - Successfully simulated and verified the propagation of RF sound waves in a cubic Si crystal implementing a single ZnO transducer as the transmitter and receiver and producing associated electrical signals
  - Worked towards realising **shear wave ZnO transducers** deploying **RF magnetron sputtering**
  - Deployed and optimised **polishing** and **tape-exfoliation** techniques on 1T-TaS<sub>2</sub> to obtain smooth crystal surfaces for high quality sputtering of **ZnO transducers**
  - Learnt and performed **Laue diffraction** to devise the crystallographic planes for polishing, and also learnt about high frequency **RF probes** for **low temperature - high field measurements**
- 🏛 **Topological Control of SPE emission in the strong coupling regime** (Jul '23 - Present)  
Guide: Prof. Anshuman Kumar    LOQM Lab, Department of Physics, IIT Bombay
  - Reviewed the existing literature on the **strong coupling** of SPEs to BIC cavities, their topological nature, and the induced fluorescence enhancement to optimise BIC cavity structure for the visible spectrum
  - Optimising parameters for **ion implantation** to induce **visible** and **IR quantum emitters** in pristine hBN multilayers, also implementing chemical activation by **polar solvents** developing on previous works
  - Performing numerical simulations in **COMSOL** to study a variety of BIC structures and their corresponding resonances, further developing the coupling of SPEs to study the variations in fluorescence
  - Optimising a **Ga<sup>+</sup>-FIB** system to fabricate O(10<sup>2</sup>) nm BIC arrays in hBN crystals to achieve O(eV) tunability in the BIC resonance energies and minimum (~ 10 nm) variance in structure design
  - Setting up an **automated confocal setup** for g<sup>2</sup>(τ) and **Photoluminescence** mapping
- 🏛 **Josephson Effects and Topological Superconductors: NEGF Simulations and Review**(Jan '23 - May '23)  
Guide: Prof. Bhaskaran Muralidharan    CNQT, IIT Bombay
  - Studied the **BCS formalism** of superconductivity to understand the **AC and DC Josephson effects**
  - Reviewed the literature on **Majorana Zero Modes** and the **Kitaev model**, ultimately studying the implementation of MZMs on a **Rashba Nanowire** in proximity to an s-wave superconductor with a B-field
  - Studied **quantum transport** and applied the formalism of **NEGF** to simulate S-N-S and S-I-S Josephson Junctions and thus understanding the **2π and 4π Josephson effects** in relation to topological superconductors

- **Arbitrary Waveform Generation for Si-Quantum Dot based Qubit Control**  
Guide: Prof. Suddhasatta Mahapatra

(May '22 - Present)  
Q-Si Lab, Department of Physics, IIT Bombay

  - Lead a team of 3, developed **QCoDeS** drivers to control an **Arbitrary Waveform Generator**, a **Vector Signal Generator**, and associated equipment to engineer **RF pulses** for quantum control of spin qubits
  - Performed I-V measurements on **Si-MOSFET Hall probes** for quality check of dopant implantation, oxide integrity, ohmic contacts, etc. in the fabricated heterostructures
  - Studied 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
  
- **Plasmonic Nanoantennas for Strain Engineering of SPEs in 2D hBN**  
Guide: Prof. Anshuman Kumar

(Jul '22 - Present)  
LOQM Lab, Department of Physics, IIT Bombay

  - Performed literature review of the properties and theoretical understanding of SPEs in hBN.
  - Prepared **monolayer samples** of hBN with **tape exfoliation** and integrated them with **EBL fabricated plasmonic nanostructures** via a PDMS assisted **dry transfer method**
  - Analysed hBN samples via **Raman Spectroscopy** confirming the presence of monolayers. Analysed the **PL map** of monolayer hBN over the nanostructures and studied the surface topography with **AFM**
  - Contributed to setup **in-house PL mapping**, imaging, and  $g^{(2)}$  and **lifetime measurements**
  - Performed **FDTD** simulations for plasmonic nanoantennas on Si substrate with and without hBN
  
- **Entanglement Entropy in Coupled Harmonic Oscillator Systems**  
Guide: Prof. Shankaranarayanan S

(Aug '21 - Apr '22)  
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**
  
- **Quantum Many-Body simulations with Machine Learning**  
Guide: Prof. Nilmani Mathur

(May '21 - Feb '22)  
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

## Projects

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- **Optical Investigation of Shape and Size-controlled Silver Nanoparticles**  
Guide: Prof. Mohd. Aslam

(Jan '23 - Present)  
Department of Physics, IIT Bombay


  - Preparation of **Ag nanoparticles** using the **Polyol method** for better control on the particle size
  - The **surface plasmon absorption** in Ag NPs will be characterized using **UV-Vis spectroscopy**
  - Learning **PVD**, **AFM** and **SEM** for further extension of the project and characterization of the sample
  
- **Gamma-ray Spectroscopy | Instrumentation Subsystem | GLEE | IITBSSP**  
*A global mission that aims to conduct science and test technology on the surface of the moon using chipsats*

(Feb '21 - Nov '21)

  - Conducted extensive literature survey on the **Lunar radiation environment** and related missions
  - Analysed possibilities for onboard detection of **alpha particles**, **neutrons** and **X/ $\gamma$ -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  $5 \times 5 \text{ cm}^2$  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**  
*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**

(Feb '20 - July '20)
-  **Higher moments of transverse momentum in p-p collisions**  
*Guide: Prof. Sadhana Dash*


  - 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

(Oct '20 - Dec '20)

*Department of Physics, IIT Bombay*
-  **Transverse Spinning of Unpolarised Light**  
*Guide: Prof. Anshuman Kumar*


  - 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

(Jan '21 - Apr '21)

*Department of Physics, IIT Bombay*
-  **Coherent State Representation of Photons**  
*Guide: Prof. Urjit Yajnik*

  - 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

(May '22)

*Department of Physics, IIT Bombay*
-  **Piano Man : Portable Piano on a Glove**  
*Guide: Prof. Varun Bhalerao*

  - 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



(Sep '21 - Oct '21)




*Department of Physics, IIT Bombay*

## Scholastic Achievements

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- 2023


-  Selected for **ISTernship Summer Program** funded by **OeAD** for pursuing a research internship at **IST Austria** among a total of **40 awardees worldwide**
  -  Selected among the **top 1100 applicants globally** who were offered funded summer research internship under the **MITACS Globalink scholarship**
- 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

## Positions of Responsibility

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- May - Nov '21

-  **Subsystem Head | Instrumentation Subsystem**
    - Guided a **14-member inter-system team** towards best instrument 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
- Aut '23 & '20

-  **Teaching Assistant | Department of Physics, IIT Bombay**  
**Analog Electronics Lab**
    - Responsible for assisting students with weekly assignments, clearing conceptual doubts, debugging circuits and grading lab assignments.
  -  **Quantum Physics and Applications**
    - Conducted tutorial and doubt clearing sessions, weekly tests, and graded answer books of 40+ undergraduate freshmen

## Skills

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<b>Programming</b>	C++, Matlab, Python - (PILPython, QCoDeS, NumPy, Matplotlib, pandas), VHDL, Arduino IDE
<b>Software</b>	Mathematica, COMSOL, Ansys- Lumerical FDTD, ROOT, Qiskit, LTSpice, OriginLab, Quartus
<b>Experimental</b>	Xe and Ga Plasma Focused Ion Beam and SEM, Laue diffraction, Dillution Refrigerator
<b>Experience</b>	Photoluminescence spectroscopy, Photon Correlation Study, Laser alignment, Raman Spectroscopy, Atomic Force Microscopy, Scanning Electron Microscopy, Physical Vapor Deposition, UV-Vis Spectroscopy







## Courses

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<b>Physics</b>	Quantum Mechanics I and II, Quantum Transport, Semiconductor Physics, Quantum Information and Computing, Quantum Optics, Methods in Material Characterisation, Nanoscience: Introduction to Fabrication, Atomic and Molecular Physics, Statistical Physics, Electromagnetic Theory, Photonics, Introduction to Condensed Matter Physics
<b>Mathematics</b>	Calculus, Linear Algebra, Real Analysis, Introduction to Numerical Analysis, Complex Analysis, Differential Equations
<b>Labs</b>	Nanoscience Characterisation Techniques, Solid State and Nuclear Physics, Optics and Spectroscopy, Analog Circuits, Op-amp Circuits, Digital Electronics, Microprocessors

## Extracurricular

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Social service	 Received a <b>special mention</b> for exemplary volunteering work under the department of <b>Sustainable Social Development, NSS, IIT Bombay</b> completing <b>80+</b> hours of social work
	 Visited <b>SNJB College, Nashik</b> representing <b>Department of Sustainable Social Development, NSS</b> and interacted with the students and professors and demonstrated experiments to school students
Workshops	 Completed <b>Quantum Computing Workshop</b> organised by MnP Club IIT Bombay
	 Completed <b>Astrophysics Workshop</b> organised by Krittika: The Astronomy Club and Techfest
	 Completed Learner's Space's <b>Scientific Computation and Mathematical Modelling</b> boot-camp organised by Maths and Physics club IIT Bombay as a part of the Technical Summer School
Miscellaneous	 Submitted a <b>conference proceeding</b> in the <b>International Conference on Advanced Learning Technologies</b> presenting a <b>game-based approach</b> to address difficulty in sentence construction for <b>DHH students</b>