Utkarsh

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Indian Institute of Technology Bombay

Research Publications and Conference Proceedings

1. Singh, A. K., **Utkarsh** et al. (2024). Interplay of plasmonics and strain for hexagonal boron nitride emission engineering. arXiv: 2401.11428 [physics.optics]
2. **Utkarsh**, Singh, A. K., & Kumar, A. (2024). Interplay of plasmonics and strain on room-temperature SPEs in few-layer hBN. In *SPIE Photonics West 2024 oral presentation*. (in press), San Francisco, California, U.S.
3. **Utkarsh**, Singh, A. K., & Kumar, A. (2023). Plasmonic enhancement of strain-activated room-temperature SPEs in hBN monolayer. In *XXII International Workshop on Physics of Semiconductor Devices 2023*, IIT Madras, India.
4. 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.
5. 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.

Education

2019 – Present **Indian Institute of Technology Bombay** 8.63/10 GPA

B. Tech. – M. Tech. Dual Degree, Engineering Physics with a specialization in Nanoscience

Research Experience

Monolithic hBN Quantum Emitter - Cavity System *(Feb '24 - Present)*

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

- Studied possible cavity structures fabricated in monolithic hBN and methods to generate quantum emitters, further optimised oxygen plasma-induced defect generation in hBN multilayers
- Performed **FDTD simulations** and **mode analysis** to optimise the hBN ring resonator parameters
- Optimised ring resonator fabrication recipe in a Ga^+ **FIB**, successfully fabricating $O(\mu m)$ sized rings with observable **whispering gallery modes** in visible spectra confirmed with μ- PL measurements
- Set up an **automated confocal setup** for $\mathbf{g^2}(\tau)$ and **photoluminescence** mapping perfoRming photoluminescence and autocorrelation mapping and spectrum analysis for the cavity and quantum emitters

Plasmonic Nanoantennas for Strain Engineering of SPEs in 2D hBN *(Jul '22 - Dec '23)*

Guide: Prof. Anshuman Kumar *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**
- Performed **FDTD** simulations for plasmonic nanoantennas on Si substrate with and without hBN

Pulsed Echo Measurements for the Quantum Spin Liquid phase in $\mathbf{1T-TaS_2}$ *(May '23 - Aug '23)*

Guide: Prof. Kimberly Modic *TQM, IST Autria*

- Studied the **theoretical signatures of QSL** phase relevant to Pulsed Echo measurements in 1T-TaS_2
- Implemented the **Plasma Focused Ion Beam** technique to structure $\mathbf{O(10\mu m)}$ 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 reciever 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_2 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**

Arbitrary Waveform Generation for Si-Quantum Dot Qubit Control *(May '22 - Jan '23)*
Guide: Prof. Suddhasatta Mahapatra *Q-Si Lab, Department of Physics, IIT Bombay*

- Lead a team of three, 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 control of quantum dots based spin qubits in silicon heterostructures

Josephson Effects and Topological Superconductors: Simulations & 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

Entanglement Entropy in Coupled Harmonic Oscillator Systems *(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**

Quantum Many-Body simulations with Machine Learning *(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

Scholastic Achievements

2024 Awarded the **Chanakya Postgraduate Fellowship** for pursuing Master's research by I-HUB QTF

2023 Sanctioned a **grant** of **INR 220,000 (∼ 2,600 $)** for presenting at SPIE Photonics West 2024

Selected for the **ISTernship Summer Program** at **IST Austria** among **40 awardees worldwide**

Selected for the **MITACS Globalink Research Internship** among **1100 awardees worldwide**

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

Projects

Optical Investigation of Shape and Size-controlled Silver Nanoparticles *(Jan '23 - Present)*
Guide: Prof. Mohd. Aslam *Department of Physics, IIT Bombay*

- Prepared **Ag nanoparticles** using the **Polyol method** for better control on the particle size
- Characterised the **surface plasmon absorption** in Ag NPs using **UV-Vis spectroscopy**
- Learnt **PVD**, **AFM** and **SEM** for further extension of the project and characterization of the sample

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**

Higher moments of transverse momentum in p-p collisions *(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** via higher moments of transverse momentum for various multiplicities

Transverse Spinning of Unpolarised Light *(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 *(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 quantum field

Piano Man : Portable Piano on a Glove *(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

Positions of Responsibility

Teaching Assistant, Department of Physics, IIT Bombay

Spring '24 — **General Physics Lab**

- Responsible for assisting students with the **Fresnel's biprism experiment**, clearing conceptual doubts, testing their understanding and grading lab reports

Autumn '23 — **Analog Electronics Lab**

- Responsible for assisting students with weekly assignments, clearing conceptual doubts, debugging circuits and grading lab assignments

Autumn '20 — **Quantum Physics and Applications**

- Conducted tutorial and doubt clearing sessions, weekly tests, and graded answer books of 40+ undergraduate freshmen

Student Satellite Team, IIT Bombay

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** from **50+ applicants** by evaluating their technical ability, practical approach and teamwork

Skills

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

Courses

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

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

References

- **Prof. Anshuman Kumar**
  Laboratory of Optics of Quantum Materials (LOQM)
  Indian Institute of Technology Bombay
- **Prof. Kimberly Modic**
  Thermodynamics of Quantum Materials (TQM)
  Institute of Science and Technology Austria
- **Prof. Suddhasatta Mahapatra**
  Silicon Quantum Computing Lab (Q-Si Lab)
  Indian Institute of Technology Bombay

भारतीय प्रौद्योगिकी संस्थान मुंबई
INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
पवई / Powai, मुंबई / Mumbai 400 076

Official Transcript

Date of Issue : 11-January-2024 , liable to change since student has not yet graduated

Roll Number: 190260044
Name of the Student: Utkarsh
Programme: Dual Degree (Dual Degree Programme)
Academic Unit: Engineering Physics
Discipline/Specialization: Nanoscience
Joining Month & Year: July 2019

Code	Name	Credits	Tag	Grade/ Marks	Code	Name	Credits	Tag	Grade/ Marks
Academic Year: 2019 - 2020, Term: Semester Autumn									
CH 105	Organic & Inorganic Chemistry	4.0	MA	BB	ME 113	Workshop Practice	4.0	MA	AA
CH 107	Physical Chemistry	4.0	MA	AA	NOCS01	NCC/NSS/NSO	0.0	MA	PP
CS 101	Computer Programming and Utilization	6.0	MA	BB	PH 107	Quantum Physics and Application	6.0	MA	AB
MA 105	Calculus	8.0	MA	BB	PH 117	Physics Lab	3.0	MA	BB
SPI= 8.63/10					CPI= 8.63/10				
Academic Year: 2019 - 2020, Term: Semester Spring									
BB 101	Biology	6.0	MA	BB	ME 119	Engineering Graphics & Drawing	5.0	MA	AB
CH 117	Chemistry Lab	3.0	MA	AA	NOCS02	NCC/NSS/NSO	0.0	MA	PP
EE 112	Introduction to Electronics	6.0	MA	AB	PH 108	Basics of Electricity & Magnetism	6.0	MA	BB
MA 106	Linear Algebra	4.0	MA	BB					
SPI= 8.57/10					CPI= 8.60/10				
Academic Year: 2020 - 2021, Term: Semester Autumn									
EE 224	Digital Systems	6.0	MA	AB	MA 403	Real Analysis	8.0	AL	BC
ENT201	Introduction to Entrepreneurship	6.0	MA	AB	PH 207	Introduction to Special Theory of Relativity	3.0	MA	AB
HS 101	Economics	6.0	MA	AB	PH 215	Thermal Physics	3.0	MA	BB
MA 205	Complex Analysis	4.0	MA	AB	PH 217	Classical Mechanics	6.0	MA	BB
MA 207	Differential Equations II	4.0	MA	BC	PH 219	Data Analysis and Interpretation	6.0	MA	AB
SPI= 8.61/10					CPI= 8.61/10				
Academic Year: 2020 - 2021, Term: Semester Spring									
MA 214	Introduction to Numerical Analysis	8.0	MA	BC	PH 232	Physics Laboratory I (General Physics Lab)	3.0	MA	AB
PH 202	Waves & Oscillations & Optics	6.0	MA	BB	PH 233	Electronics Lab II (Op amp circuits)	3.0	MA	AA
PH 204	Quantum Mechanics I	8.0	MA	AB	PH 544	General Theory of Relativity	6.0	MA	AB
PH 231	Electronics Lab I (Basic circuits)	3.0	MA	AA					
SPI= 8.57/10					CPI= 8.60/10				
Academic Year: 2021 - 2022, Term: Semester Autumn									
HS 305	Reading Literature	6.0	MA	BB	PH 423	Quantum Mechanics II	6.0	MA	BB
PH 230	Electronics Lab III (Digital Electronics)	5.0	MA	AA	PH 435	Electronics Lab IV (Microprocessors)	5.0	MA	AA
PH 303	Supervised Learning	6.0	MA	AA	PH 523	Quantum Mechanics III	6.0	AL	CC
PH 421	Photonics	6.0	MA	DD					
SPI= 8.24/10					CPI= 8.53/10				
Academic Year: 2021 - 2022, Term: Semester Spring									
PH 436	Introduction to Condensed Matter Physics	6.0	MA	BB	PH 534	Quantum Information and Computing	6.0	MA	AB
PH 438	Statistical Physics	6.0	MA	BC	PH 540	Elementary Particle Physics	6.0	AL	CC
PH 444	Electromagnetic Theory	6.0	MA	CC	PH 572	Special Topics in Elementary Particle Physics	6.0	MA	AA
PH 446	Physics Laboratory (Solid state and Nuclear Physics)	3.0	MA	AB					
SPI= 8.09/10					CPI= 8.46/10				

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Official Transcript

Name of the Student: Utkarsh — Roll Number : 190260044

Code	Name	Credits	Tag	Grade/ Marks
Academic Year: 2022 - 2023, Term: Semester Autumn				
ENT606	Developing a Proof of Concept- Basic	6.0	MA	AA
ET 613	Human-Computer Interaction for Educational Technology	6.0	MA	AA
GC 101	Gender in the workplace	0.0	MA	PP
PH 447	Physics Lab (Optics and Spectroscopy)	3.0	MA	AA
PH 505	Introduction to Nuclear & Particle Physics	6.0	MA	BC
SPI=8.13/10				
PH 515	Introduction to Atomic and Molecular Physics	6.0	MA	CD
PH 517	Methods in Analytical Techniques	6.0	MA	CD
PH 575	Nanoscience: Fundamentals to Fabrication	6.0	MA	AB
PH 587	B.Tech Project I	6.0	MA	AA
CPI=8.40/10				
Academic Year: 2022 - 2023, Term: Semester Spring				
DE 403	Studio Project I	6.0	AL	BB
EE 691	R & D Project	6.0	MA	AB
EE 755	Quantum Transport in Nanoscale Devices	6.0	AL	BB
ES 200	Environmental Studies: Science and Engineering	3.0	MA	AB
HS 200	Environmental Studies	3.0	MA	AA
SPI=9.10/10				
PH 570	Advanced Laboratory Techniques in Nanosience	6.0	AL	BB
PH 574	Physics of Semiconductor Devices	6.0	MA	BB
PH 576	Nanoscale Quantum Transport	6.0	MA	AB
PH 588	B.Tech. Project II	6.0	MA	AA
TA 101	Teaching Assistant Skill Enhancement & Training (TASET)	0.0	MA	PP
CPI=8.48/10				
Academic Year: 2023 - 2024, Term: Semester Project*				
PH 591	Dual Degree Project I	30.0	PR	AA
Academic Year: 2023 - 2024, Term: Semester Autumn				
PH 569	Applied Solid State Physics	6.0	MA	AB
SPI=9.00/10				
CPI=8.63/10				

Mandatory Course Credits (MA+HO)	**= 324.0**	**CPI (Courses)**	**= 8.49/10**
Project Credits (PR)	**= 30.0**		
Net Mandatory Credits (MA+PR)	**= 324.0**	**CPI (Overall)**	**= 8.63/10**
Overall Completed Credits	**= 294**		
Overall Grade Points	**= 2495**		

Current Status
The academic requirements for the degree are yet to be completed.
Signature & Seal of Transcript Issuing Authority:

Offg. N Balasubramanian 11/01/24
Joint/Assistant Registrar (Academic), IIT Bombay
कृते सहायक कुलसचिव (शैक्षणिक)
Date: 11-January-2024
For Assistant Registrar (Academic)
Place: Mumbai
भारतीय प्रौद्योगिकी संस्थान, मुंबई
Indian Institute of Technology, Bomb
पवई मुंबई/Powai, Mumbai-400076

INDIAN INSTITUTE OF TECHNOLOGY POWAI MUMBAI 76.

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Verification Ticket Number: 1D BE98 8450 2706 6014

Official Transcript

Name of the Student: Utkarsh | Roll Number: 190260044

General Information

The medium of instruction at the Institute is English.

Course credits and grade: Each academic course is associated with a credit which is an indicator of its relative academic weight in calculating the academic performance. A two-letter grade is awarded to students on the basis of their performance in examinations and assignments of a specific course. The letter grades have numerical equivalents on a 0-10 scale as given below.

Letter Grade	AP	AA	AB	BB	BC	CC	CD	DD	FF	FR	W	DX	PP	NP	AU
Numerical Equivalent	10	10	9	8	7	6	5	4	0	0	-	-	-	-	-

FF: Fail, FR: Fail and repeat, W: Withdrawn, DX: Insufficient attendance, AU: Satisfactory performance in an audit course, PP: Pass, NP: Not Pass. The minimum passing grade in a course is DD. The grade AP is awarded to students with exceptional performance in core courses of a programme. Numerical equivalents of letter grades are referred to as grade points.

The numerical grade points are not convertible into marks or percentages.

Performance Indicators: The performance of a student in a semester is given by a number called the Semester Performance Index (SPI),which is the weighted average of the earned grade points in the courses during the semester.

If a student has courses with credits $C_1, C_2, \ldots, C_n$, with grade points of $G_1, G_2, \ldots, G_n$ respectively, then

Semester Credits = $C_1 + C_2 + \ldots + C_n$.	Semester Grade Points = $C_1G_1 + C_2G_2 + \ldots + C_nG_n$.	SPI = Semester Grade Points ÷ Semester Credits.

Cumulative Performance Index (CPI) is the weighted average of the grade points in the courses in all semesters. The indices SPI and CPI are calculated upto two decimal places.

*The project grades are included for calculation of overall CPI which is shown in the CPI (Overall).

Courses are tagged as MA: Mandatory (Core/Elective), MI: Minor, HO: Honours, AL: Additional Learning, AU: Audit

- Each degree programme has mandatory credits consisting of core courses, elective courses, and non credit courses. These courses are tagged as MA.
- For calculation of SPI and CPI, grades obtained only in mandatory courses (MA) are considered.
- Students can supplement the learning experience by crediting additional courses. Credits earned in these courses, when appropriate, can earn additional credentials either in the form of "Honours" (HO) in the chosen discipline or "Minor" (MI) in another discipline or both.
- "Honours" is not indicative of proficiency, and can be earned by completing the additional prescribed set of advanced core and elective courses in the chosen discipline. "Minor" can be earned by completing the prescribed set of courses in a discipline other than the chosen discipline. Additional courses that are not used for earning "Honours" or "Minor" are tagged as "Additional Learning" (AL).
- The AU is awarded based on satisfactory attendance and fulfilling the minimum requirements as set by the course instructor.It carries no grade points and does not figure in SPI or CPI calculations.
- PP or NP is awarded in some credit courses that are not earmarked with a letter grade. Correspondingly, PP/NP does not carry a grade point.
- O-IITB is/are the Course(s) completed by a student outside IIT Bombay (NPTEL/ Swayam). These course(s) contribute towards the completion of credits for a degree requirement. However, grades/marks earned for such course(s) is/are not considered for SPI / CPI calculation.

The Institute does not award any class or division. Notionally, the CPI may be multiplied by a factor of 10 to obtain a numerical percentage.

The veracity of this document can be ascertained by using the verification ticket number in the URL given at the bottom of this page.

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