

Rehmat Singh Chawla

4th-Year Physics Undergraduate

EDUCATION

- **B.Tech., Engineering Physics**, Indian Institute of Technology Bombay ('20 - '24)
GPA: 8.53/10.00, pursuing **Honors in Physics** and **Minor in Mathematics**

INTERESTS

I enjoy theoretical and computational Physics, and am interested in quantum field theories and their applications. I have experience working in Medical Imaging, Theoretical High Energy Physics, and Gravitational Wave Astronomy.

RESEARCH

Optimisation of Coincidence Selection for Energy Calibration | Codes | Report (Jun '23 - Aug '23)
Guide : Prof. Pawel Moskal, Marian Smoluchowski Institute of Physics, Jagiellonian University

- Optimized calibration of Time-over-Threshold (ToT) in JPET setup, improving photon energy estimation
- Invented and compared algorithms across varied parameters and resolutions for 3- and 4-multiplet coincidences
- Developed user-friendly Python-based pipeline controlling simulations, data processing, and algorithm accuracy analysis
- Implemented chunked processing and selective reading to reduce memory usage and decrease runtime by **90%**

Coincidence Discrimination in PET | Codes | Report (Jul '22 - Present)
Guide : Prof. Pragya Das, Department of Physics, IIT Bombay

- Adapting single-scatter reconstruction algorithm to energy-blind systems using time-of-flight relations and machine learning
- Incorporating polarisation to improve PET scan quality via coincident-pair discrimination for compton-scattered photons
- Modeled medical imaging processes using GATE, reconstructed images to compare source localisation techniques

DFT Simulations for Optical Materials (Nov '22 - Jun '23)
Guide : Prof. Anshuman Kumar, Department of Physics, IIT Bombay

- Investigating optical behaviour and exciton physics of **Transition Metal Dichalcogenide** monolayers under strain
- Implementing **Density Functional Theory** simulations using **Quantum Espresso** on the SpaceTime computing cluster

Topological Quantum Field Theories | Bachelor's Thesis | Report (Jun '23 - Present)
Guide : Prof. Pichai Ramadevi, Department of Physics, IIT Bombay

- Studied Chern-Simons theory and its applications in condensed matter physics and topological quantum computing
- Calculating the Vassiliev knot invariants using expansions of Wilson loop VEVs in Mathematica
- Examining resurgence techniques like Borel resummation to extract non-perturbative terms from asymptotic series

PROJECTS

Asymptotic Symmetries in GR | Course Project (Aug '23 - Present)
Advanced General Relativity, Guide: Prof. Vikram Rantala, Department of Physics, IIT Bombay

- Studying asymptotic structure of gauge theories, symmetries arising from boundary conditions, and the infrared triangle
- Deriving supertranslations and superrotations in the Bondi gauge for 4D GR in asymptotically flat and (A)dS spacetimes

RR Lyrae Analysis with Growth India Telescope | Course Project | Codes | Report (Feb '23 - May '23)
Astrophysics, Guide : Prof. Varun Bhalerao, Department of Physics, IIT Bombay

- Automated **photometric analysis** using astropy, sextractor, and APT to study an RR-Lyrae variable across spectral bands
- Measured lightcurve periods via **template matching**, researched period relations and estimated stellar characteristics

Momentum of Light in Linear Media | Course Project | Report (Feb '23 - May '23)
Electromagnetic Theory, Guide : Prof. Anshuman Kumar, Department of Physics

- Resolved Abraham-Minkowski controversy of stress tensor by demonstrating equivalence up to a localisation transform
- Derived the Belinfante-Rosenfeld stress tensor and balance equations field-theoretically for open and close systems
- Presented lecture on lagrangian formalism for deriving Maxwell's equations in a medium

Non-linear Optics using Single Atoms | Course Project | Report (Sep '22 - Nov '22)
Photonics, Guide : Prof. Anshuman Kumar, Department of Physics

- Studied light-matter interaction via a quantized electric field, and formulated the **Quantum Rabi Hamiltonian**
- Derived the effective coupling strength of light matter interaction via **Time-Dependent Perturbation Theory**

- Optimised for and simulated up-conversion analogues using **QuTiP** and reviewed their experimental feasibility

True Random Number Generator | Course Project | [Codes](#) | [Report](#) (Sep '22 - Nov '22)

Microprocessors Lab, Guide : Prof. Pradeep Sarin, Department of Physics

- Implemented a True Random Number Generator on an Arduino, taking advantage of the **Thermal Jitter** in the in-built RC oscillators and **Avalanche effect** in a Zener diode, in **200+** lines of code and achieved a bitrate of **800 bps**
- Generated **2.2 million+** bits clearing **20** statistical & visual **NIST**-recommended tests implemented in **500+** lines of code

Gravitational Waves in High-Frequency Regime | Course Project | [Presentation](#) (Oct '22 - Dec '22)

- Used the **WKB approximation** to study high-frequency gravitational waves modelled as metric perturbations
- Drew analogies in propagation, amplitude and polarisation between high-frequency waves and geometrical optics limit

Generating Gravitational Waveforms | Krittika Summer Project | [Codes](#) | [Report](#) (Jun '22 - Oct '22)

Simulating gravitational waves in a mentored project organised by Astronomy Club of IIT Bombay

- Derived gravitational wave radiation reaction up to **2.5 Post-Newtonian** terms, inferred luminosity formula
- Reviewed literature to understand dynamics of **compact binary coalescence** and wave frequency characteristics
- Simulating coalescence waveforms using **Numerical Relativity** and **Post-Newtonian Approximations**, and performing **comparitive analysis** with LIGO data to understand how source parameters affect signals

Analysis of Proton-Proton Collisions using ROOT (CERN) | Course Project (Oct '21 - Nov '21)

Data Analysis and Interpretation, Guide : Prof. Sadhana Dash, Department of Physics

- Studied high energy proton-proton collisions by analysing moments of the **net charge** against collision **multiplicities**
- Created plots using **ROOT (CERN)** with focus on visual clarity from 2 million data points obtained from the **Pythia-8** Monte Carlo event generator, and compared the results to similar analyses for heavy ion collisions

PhysicC | Summer of Code - Web and Coding Club, IITB (Oct '21 - Aug '22)

Designed a physics engine module for the game engine Light, in a team of 8

- Implemented 3D **Collision Detection** and Contact Resolution modules using C++ template functions
- Took design decisions with a focus on **optimisation**, **extendability** and **user API** while respecting existing design principles

Reading Projects

Lattice Field Theory (Fall '23)

Supersymmetry and Gauge Theories (Summer '23)

Quantum Information and Computing (Winter '22)

Elementary Particle Physics (Summer '22)

Special and General Relativity (Summer '21)

Project PyRated | Summer of Code - Web and Coding Club, IITB (Mar '21 - Jul '21)

Developed a plagiarism detector as part of a 6-member team

- Used **3 layers** and 6 tests of **attribute-counting**, **structure** and **program-logic** based comparison to create an efficient detector that **minimises false positives** without sacrificing accuracy in plagiarism detection
- Achieved an accuracy of **88.89%** for plagiarised and **100%** for non-plagiarised file pairs from a coding assignment dataset

WORKSHOPS

Astrophysics Workshop | Techfest, IITB (Dec '20)

A 3-day workshop organised by Astronomy Club of IITB as part of Techfest

- Participated in **4+ hours** of lectures on **transients**, **gravitational waves**, and their electromagnetic counterparts
- Cleaned and analysed time series data using **noise models** for gravitational wave signatures in hands-on sessions

SYMPHY 2023, 2021 | Annual symposium, Department of Physics, IITB (Jan '23, Dec '21)

- Attended lectures on **Quantum Information**, **High Energy Physics**, **Photonics & Cosmology**

Winter in Data Science Bootcamp | Analytics Club, IITB (Nov '21 - Dec '21)

A 4-week course on Data Science and Analysis and Machine Learning

- Completed **2** assignments performing **Exploratory Data Analysis** and implementing machine learning models using **sklearn**

SCHOLASTIC ACHIEVEMENTS

- Secured **99.37** percentile in the **IIT-JEE Advanced** examination out of **0.16+ million** candidates ('20)
- Achieved **99.92** percentile in the **IIT-JEE Mains** examination out of **1+ million** candidates ('20)
- Awarded the **National Fellowship in Basic Sciences** (KVPY) by Department of Science, Govt of India ('19 - '20)
- **National winner** of the Scholarship Program for Awareness, Reasoning and Knowledge (**SPARK**), among 300 out of **300,000+ candidates**; conducted by **Times of India** and Bennett Coleman & Co Ltd ('17)

TECHNICAL SKILLS

Languages: Python, C++, Bash, MATLAB, Mathematica
Software: GATE, Quantum Espresso, LTspice
Libraries: ROOT, Geant4, QisKit, QuTiP, Sklearn, Pandas, Numpy, Scipy, Sympy, Astropy, Matplotlib, Seaborn

MENTORING AND ORGANISATIONAL EXPERIENCE

Teaching Assistant (TA) | Department of Physics, IITB (Mar '22 - Jul '22, Mar '23 - May '23)
Courses : Basics of Electricity & Magnetism | Classical Physics and Special Relativity

- Guided **problem-solving** sessions, held weekly quizzes for **40+** students, evaluated answer books, conducted review sessions.

Department Academic Mentor | Department of Physics, IITB (May '22 - Present)
Part of a 12-member team selected out of 30+ applicants after extensive interviews and peer reviews

- Mentoring 6 Physics sophomores by providing **academic guidance** and general counselling throughout the year
- Organised the Sophomore-101 session for **1200+** students to disseminate information about course planning
- Interviewed 10+ alumni and seniors about internship and research experiences to provide peers clarity on career paths

Literary Arts Convener | Institute Cultural Council, IITB (Jun '21 - Jun '22)
Part of a 7-member council responsible for organising Literary Arts events for 10,000+ students

- Executed Literarium, an annual Literary Arts festival, consisting of **8 events** garnering **60+ submissions** over 3 days
- Organised "**Literati Poetry Writing Month**", which garnered **80+** poetry submissions for **30+** prompts
- Redesigned the institute's quizzing blog and posted **100+ questions**, increasing engagement by **400% y-o-y**
- Created content for **50+ social media campaigns**, increasing the club's online engagement by **150%**

RELEVANT COURSES

Physics : **Advanced General Relativity**^{*†}, **Elementary Particle Physics**, Special Topics in Particle Physics, Astrophysics, Gravitational Wave Astronomy[†], General Theory of Relativity, **Relativistic Quantum Mechanics**, Quantum Information Theory, Condensed Matter Physics, Statistical Mechanics, Electromagnetic Theory, Photonics, Atomic and Molecular Physics*, Nuclear and Particle Physics*

Mathematics : General Topology, Basic Algebra, Group Theory Methods, **Fourier Analysis**, Real Analysis, Complex Analysis, Ordinary and Partial Differential Equations, Numerical Analysis, Linear Algebra

Miscellaneous : Data Analysis, Optics and Spectroscopy Lab*, Nuclear Physics Lab, Digital Systems, Electronics Lab I (Basic circuits), II (Op amp circuits), III (Digital Electronics) & IV (Microprocessors), Programming Lab

*Courses to be completed by November 2023, [†]Sit-through courses

[‡]Officially named "Current Trends in Physics"

REFERENCES

Prof. Pragya Das
Department of Physics
Indian Institute of Technology Bombay
pragya@phy.iitb.ac.in

Prof. Pichai Ramadevi
Department of Physics
Indian Institute of Technology Bombay
ramadevi@phy.iitb.ac.in

Prof. dr hab. Paweł Moskal
Faculty of Physics, Astronomy and
Applied Computer Science
Jagiellonian University, Krakow, Poland
ufmoskal@googlemail.com

EXTRACURRICULAR ACTIVITIES

- Scripted and recorded 7 videos of experiments exploring basic sciences under the NSS Online Laboratory initiative
- Published a **10,000+** word story in an anthology compiled by the **Chandigarh Literary Society** after attending their 2-day creative writing workshop in 2016; took part in IITB's inter-hostel English Creative Writing competitions in '21 and '22
- Bagged 4th of 50+ teams in the inter-hostel quizzing championship, represented IITB at the Inter-IIT Culturals for Quizzing
- Played **finals** as part of IITB's 16-member contingent for **Inter-IIT Scrabble League 2021**
- Qualified for the final round of **World Scholar's Cup**, an international multi-subject writing, quizzing, & debate tournament in a team of 3. Obtained **5th** place in History out of **1500+** students, and **83rd** place out of **500+** teams overall