

# Prakhar Bansal

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📄 prakharbansal16

🌐 <http://prakharbansal16.github.io/>



## Education

2020 – 2023*	📌 <b>Indian Institute of Technology Bombay, India</b> B.Tech <i>Electrical Engineering</i> Minor in <i>Physics</i>	9.30 CPI 10 CPI
2018 – 2020	📌 <b>Yogiraj Public School, Kota, Rajasthan, India</b> Intermediate/+2	97%
2008 – 2018	📌 <b>St. Peter's Sr. Sec. School, Bharatpur, Rajasthan India</b> Matriculation	97%

## Research Interests: Cosmology and Astrophysics

- 📌 CMB Anisotropies and Polarization, Neutrino Cosmology, Primordial Gravitational Waves, Reionization, Dark Energy Models, Inflation, 21 cm Cosmology, Structure Formation, Weak Lensing

## Publications

- 2022 📌 **Detection of mutant peptides of SARS-CoV-2 variants by LC/MS in DDA approach using an in-house database:** Sakshi Rajoria, Ankit Halder, Ishita Tarnekar, Pracheta Pal, **Prakhar Bansal**, and Sanjeeva Srivastav  
Journal of Proteome Research 2023 22 (6), 1816-1827 | DOI: 10.1021/acs.jproteome.2c00819

## Research Experience

- 2023 📌 **New Degrees of Freedom using  $N_{\text{eff}}$  (Effective Neutrino Species) measurements of CMB**  
Guide: *Prof Adam Ritz | University of Victoria, BC, Canada*
  - Developed a **computational code** to calculate  $N_{\text{eff}}$  for analyzing various dark matter models. Successfully replicated results for a model involving **dark matter interacting with the SM via massive dark photons**
  - Currently, investigating a model incorporating **heavy sterile right-handed neutrinos**
  - Studied the contributions of **LO and NLO QED corrections** to Standard Model  $N_{\text{eff}}$  calculation
  - Reviewed CMB Anisotropy **Power Spectrum** and understood the effect of  $N_{\text{eff}}$  on **CMB Damping Tails**
  - Examined the role of **CMB-S4** in improving the precision of  $N_{\text{eff}}$  measurement and breaking the **degeneracy between  $Y_P$  (Helium Abundance) and  $N_{\text{eff}}$  using CMB polarization** observations
- 2022 📌 **Optimal Parameter Constraints for Dark Energy Models** 🔗 [Github Repo Link](#)  
Guide: *Prof Bharat Ratra | Kansas State University*
  - Applied Markov Chain Monte Carlo (**MCMC**) simulations to constrain model parameters like **Baryon, Dark Matter, Dark Energy density and  $H_o$**  for  $\Lambda$ CDM, XCDM and  $\phi$ CDM models using **H(z)** and **BAO** data
  - Aiming to extend the parameter constraints analysis to other datasets like **Supernova IA, Quasar Angular Size and H II starburst galaxy** data by employing **MontePython** and **CLASS** code
  - Read about various Cosmological Tests including **Gravitational Lensing, Bolometric Distance Modulus, Galaxy Count**
- 📌 **Detecting Dark Matter in Cosmological 21cm Signals** 🔗 [Cosmology Lecture Notes](#)  
Guide: *Prof. Vikram Rentala | IIT Bombay* 🔗 [Github Repo](#) | 🔗 [Google Drive\\*](#)
  - Working on deriving constraints for **millicharged dark matter** models using data from **SARAS 3** by developing a **code to track the temperature evolution** of baryons and dark matter particles
  - Gained proficiency in key concepts, including distinction b/w **Brightness and Spin Temperature**, in-depth exploration of **Radiative Transfer Equations**, and presented findings in a **seminar**
  - Completed the first nine chapters of **Scott Dodelson's cosmology text**, establishing a strong theoretical foundation covering topics such as **matter inhomogeneities, linear structure growth, and inflation**

\* Drive link contains the project report and the video presentation on 21 cm Physics

## Research Experience (continued)

- 2022 📌 **National Centre for Radio Astrophysics, Pune**  
**Photometric Properties of High Redshift Galaxies using JWST**  
*Guide: Prof Yogesh Wadadekar | NCRA-TIFR*
- Worked on preparing a catalog of properties like **Redshift, Mass, Star Formation Rate** of  $\sim 60,000$  high redshift galaxies using **Grizli** pipeline from **CEERS** (Cosmic Evolution Early Release Science Survey) data
  - Studied aspects of extragalactic astronomy like **Galaxy Morphology, Evolution, Clusters and the High Redshift Universe** from Peter Schneider's book Extragalactic Astronomy and Cosmology
  - Attended introductory Radio Astronomy Lectures on **Pulsars, AGNs, Interferometry** and visited the Giant Meterwave Radio Telescope (**GMRT**) Observatory located in Pune
- 2021 📌 **Mutant Peptide Analysis in Covid-19 Affected Indian Patients**  
*Guide: Prof. Sanjeeva Srivastava | IIT Bombay*
- Written python scripts to extract specific Sars-Cov-2 protein sequences and **identify correct frame** from a three frame translated proteomic data of Covid-19 affected Indian Patients
  - Completed the 21 day Proteomics Internship Orientation Program and learnt about various proteomics approaches like **gel based, label based** and **targeted proteomics**
  - Trained in various **Bioinformatics tools** like Maxquant, Reactome and Proteome Discoverer

## Course Projects

- 2023 📌 **Transformation Optics for Material Design** 🔗 [Google Drive Link\\*](#)  
*PH 444: Electromagnetic Theory | Instructor: Prof. Anshuman Kumar*
- Developed a theoretical understanding of the technique of **Space Transformation in Optics**
  - Explored the application of transformation optics to **enhance optical gradient forces in a system of coupled waveguides**
- 2022 📌 **Gravitational Waves from Freely Precessing Rigid Bodies** 🔗 [Google Drive Link\\*](#)  
*PH 821: Gravitational Waves Physics and Astronomy | Instructor: Prof. Archana Pai*
- Performed analytic calculations for the Gravitational Wave (**GW**) **amplitude** corresponding to plus (+) and cross (×) polarisation and **power radiated** in GWs from a rigid body precessing about its axis
  - Estimated the order of magnitude of Gravitational Waves emitted from **pulsars** and presented the work as a **seminar** for the course
- \* Drive link contains the project report and the video presentation*

## Scholastic Achievements

- 2020 📌 Secured **All India Rank 240** in **JEE Advanced** out of 240,000 eligible candidates
- 2020 📌 Achieved **All India Rank 150** in **JEE Main** out of 1.13 million candidates
- 2021 📌 Selected for **National Initiative for Undergraduate Science (NIUS 2021), Physics**, conducted by HBCSE-TIFR, among 80 other students from all over India
- 2022 📌 Awarded the **MITACS Globalink** fellowship for pursuing undergraduate research in Canada
- 2023 📌 Selected for the **DAAD-WISE** fellowship for pursuing summer research in Germany.
- 2018 📌 Bagged All India Rank **27** and recommended for the **Kishore Vaigyanik Protsahan Yojana** Fellowship
- 2020 📌 Selected for OCSC camp for **International Chemistry Olympiad** along with 45 other students
- 2018,19 📌 Qualified for **Indian National Astronomy Olympiad** conducted by HBCSE
- 2016 📌 Among the top **310** students selected for **Indian National Junior Science Olympiad (INJSO)**
- 2018 📌 Recipient of the **National Talent Search Examination (NTSE) Scholarship**, awarded by NCERT

## Technical Skills

- Programming Languages 📌 Matlab, Mathematica, C++, Python, VHDL,  $\LaTeX$ , R
- Software 📌 Git, Quartus, GNU Radio,
- Libraries 📌 Emcee, Scipy, Astropy, Biopython, Tensorflow, Keras, Pandas, Matplotlib

## Relevant Courses Undertaken

Physics	📖 <b>Elementary:</b> Classical Mechanics, Basics of Electricity and Magnetism, Quantum Physics and Application, Statistical Physics, Electromagnetic Theory, Quantum Mechanics II, General Relativity <b>Advanced:</b> Gravitational Wave Physics and Astronomy, Advanced Astrophysics, Quantum Mechanics III, Elementary Particle Physics, Special Topics in Elementary Particle Physics
Mathematics	📖 Linear Algebra, Complex Analysis, Multi-variable Calculus, Ordinary Differential Equations, Partial Differential Equations
Electrical Engineering	📖 Electrical Design Lab, Communication Systems, Electromagnetic Waves, Control Systems, Power Engineering 2, Electronic Devices and Circuits, Power Engineering 1, Digital Systems, Analog Circuits, Probability & Random Processes, Signal Processing

## Other Projects

- 2021 📖 **Elementary Particle Physics** [📄 Project Report](#)  
*Summer of Science | MnP Club, IIT Bombay*
- Studied the properties of elementary particles, their classification schemes and their interactions with the help of **Feynman Diagrams** and the **Conservation Laws** governing these interactions
  - Learnt about Noether's theorem and some fundamentals of group theory focusing mainly on **Lie Groups** and explored properties of certain lie groups like **SU(n), SO(n) and SL(n,C)**
  - Looked into **Flavor Symmetry** to understand **Quark Models** like baryon decuplets and meson nonets by studying the combinations of up, down and strange quarks to form mesons and baryons
- 📖 **Correcting Stellar Aberration Using Curve Fitting** [📄 Github Repo Link](#)  
*Krittika Summer Project 2.0 | Krittika, The Astronomy Club, IIT Bombay*
- Obtained the relation between **Apparent Ecliptic Coordinates** of a star and its **True Ecliptic Coordinates** using relativistic velocity addition
  - Computed the true position of a star using **Curve-Fitting**, given its apparent position over an year





## Teaching

- 2021-23 📖 Teaching Assistant at IIT Bombay for the following courses
- | Semester    | Course                                    |
|-------------|---|
| Fall 2021   | PH 107: Quantum Physics and Application   |
| Spring 2022 | PH 108: Basics of Electricity & Magnetism |
| Fall 2022   | PH 251: Classical Mechanics               |
| Spring 2023 | CH 107: Quantum Chemistry                 |
| Spring 2023 | PH 111: Introduction to Classical Physics |
- Teaching responsibilities included discussion of **weekly problem sets**, **grading** the exam papers, and conducting weekly tutorial quizzes









## Reading Projects

- 2021 📖 **Special Black Hole Geometries** [📄 Beamer Slides](#)  
*Guide: Prof. Vikram Rentala | IIT Bombay*
- Studied the **Reissner Nordström** Solution (Charged) and **Kerr** (Rotating) Blackhole Solutions
  - Learnt about the **Penrose diagrams, Penrose Process and Blackhole Thermodynamics**
- 2023 📖 **Black Hole Information Paradox** [📄 Google Drive Link\\*](#)  
*Guide: Prof. Urjit Yajnik | IIT Bombay*
- Covered Prof **Suvrat Raju's video lectures** on the Information Paradox and explored the application of Quantum Field Theory (**QFT**) in **curved spacetime**, including the **Unruh Effect**
  - Studied the derivation of **Hawking Radiation using correlators, the Page Curve** and the Eigen State Thermalization Hypothesis. Gained an understanding of the distinction between **the Old Information Paradox and the Modern Information Paradox** (AMPSS Paradox)
- \* Drive link contains the project report and the video presentation

## Mentorship and Outreach

- 2023  **Institute Student Mentor**  
*Student Mentorship Program | IIT Bombay*
- Part of a **143 member team selected from 386 applicants** to guide freshmen throughout the first year
- 2022  **Summer of Science 2022 Mentor | Cosmology and Dark Matter**  
*Maths n Physics Club | IIT Bombay*
- Mentored 4 students to complete a reading project covering a range of topics like Special and General Relativity, Basics of Cosmology and some theoretical ideas about Dark Matter
-  **Primary Presenter | Physics Group Discussion on Special Relativity**  
*Maths n Physics Club | IIT Bombay*
- Moderated the group discussion on Special Relativity and discussed the fundamental ideas like Time Dilation, Length Contraction, Simultaneity of the theory
-  **Volunteer | LIGO India (INDIGO)**  
*Techfest | IIT Bombay*
- Communicated the fundamental concepts of Gravitational Waves to the general public through engaging interactive games and a **stretch squeeze camera** and discussed the profound significance of the LIGO India Program

## Extracurriculars

- 2023  **Overall Coordinator | Annual Standup Showcase**
- Coordinated with a team of 50+ members to present a flagship for an audience of 1200+ people
  - Written and performed the Sketch; one of the main acts of the event
-  Mentor of the winning team of Laughter Riots, a standup comedy event for first year students
-  Runner-up in Astromania, the annual Astronomy quizzing event of IIT Bombay
- 2022  Among the top 8 performers of the institute to perform in Annual Standup Comedy Showcase
- 2021  Volunteering at **Vriskh NGO** for teaching **Chemistry** and **Physics** to high school students for various competitive examinations like JEE Main, JEE Advanced, KVPY and Olympiads
-  Received **Special Mention in Laughter Riots** conducted by Comedy Cons, IIT Bombay
-  Completed one year of **Dramatics** training under NSO, IIT Bombay
-  Participated in RascionX conducted by Chemistry Club, IIT Bombay and cleared the Prelims Round

## References



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