Prakhar Bansal
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Research Interests

My research interests lie mainly in the domain of Cosmology and Astrophysics. I'm interested in working in all aspects theory, simulations as well as observations. A few particular topics about which I'm quite curious are Particle Physics of Early Universe, Reionization and CMB anisotropies. I am also looking forward to start working in Gravitational Waves. I have taken three advanced Physics Courses this semester: Gravitaional Wave Astronomy, Quantum Mechanics II (Perturbative Quantum Theory) and Quantum Mechanics III (Relativistic QM and Introductory QFT).

Education

Year	Program	CGPA/%	Institute
2024(ongoing)	B. Tech Major: Electrical Engineering Minor: Physics	9.29 10	IIT Bombay
2020	Intermediate/+2	97%	CBSE, India
2018	Matriculation	97%	CBSE, India

Research Internship

National Centre for Radio Astrophysics(NCRA), Pune
Resolved Star Formation using MaNGA survey
Prof. Yogesh Wadadekar | NCRA-TIFR Pune *June 2022-Present*

- Studied several aspects of extragalactic astronomy like **Galaxy Morphology and Evolution, Galaxy Clusters and High Redshift Galaxies** from Peter Schneider's book Extragalactic Astronomy and Cosmology
- Currently reading about various Galaxy surveys like **MaNGA** Survey, and **GALEX-SDSS-WISE** Catalog (GSWC) and familiarising with integral field spectroscopy analysis pipelines like **Pipe3D**
- Aiming to study resolved star formation in odd galaxies like **Blue Ellipticals, Red Spirals** etc. using above datasets
- Attended introductory Radio Astronomy Lectures on **Pulsars, AGNs, Interferometry** and visited Giant Meterwave Radio Telescope (**GMRT**) Observatory located in Pune

Key Projects

Optimal Parameter Constraints for Dark Energy Models
Github Repo Link
Prof. Bharat Ratra |Major Professor | Kansas State University *March 2022-Present*

- Read about various Cosmological Neoclassical Tests including **Gravitational Lensing, Bolometric Distance Modulus, Galaxy Count**. Studied three dark energy models: Λ**CDM** (Λ Cold Dark Matter), **XCDM** and ϕ**CDM**
- Applied Markov Chain Monte Carlo (**MCMC**) simulations using **emcee** library to obtain constraints on model parameters $\Omega_b h^2$, $\Omega_c h^2$, Ω_Λ, H_o, ω_x for Λ**CDM** and **XCDM** models using **H(z)** and **BAO** data
- Aiming to extend the parameter constraints analysis using **Supernova IA, Quasar Angular Size and H II starburst galaxy** data for ϕCDM model by employing **MontePython** and **CLASS** code

Detecting Dark Matter in Cosmological 21cm Signals
In Semester Undergraduate Research Programme |Prof. V. Rentala | IIT Bombay *December 2021-Present*

- Learnt about applications of **Boltzmann equation** in tracking abundance of various particle constituents like **Baryons**, Cold Dark Matter (**CDM**) Particles, **Neutrinos** and **Photons** of the universe
- Studied about **inhomogeneities in matter, growth of structure** in the universe in the linear regime and the **inflation theory**. Currently reading about **anisotropies** in the Cosmic Microwave Background (**CMB**)
- Familiarising with the 21cm cosmology field through **Pritchard and Leob's 2011 review article**. Aiming to investigate **21cm** signals from the epoch of cosmic dawn for **dark matter detection**

Mutant Peptide Analysis in Covid-19 Affected Indian Patients
Github Repo Link
Prof. Sanjeeva Srivastava | Dept. of Biosciences and Bioengineering, IIT Bombay *May 2021 - Feb 2022*

- 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, Skyline and Proteome Discoverer
- 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

Scholastic Achievements

- Secured **All India Rank 240** in **JEE Advanced** out of 240 thousand eligible candidates *(2020)*
- Achieved **All India Rank 150** in **JEE Main** out of 1.13 million candidates *(2020)*
- Selected for **National Initiative for Undergraduate Science(NIUS 2021), Physics**, conducted by HBCSE-TIFR, along with 80 other students from all over India *(2021)*
- Bagged All India Rank **27** and received the **Kishore Vaigyanik Protsahan Yojana** Fellowship *(2018)*
- Selected for OCSC camp for **International Chemistry Olympiad** along with 45 other students in India *(2020)*
- Qualified for **Indian National Astronomy Olympiad** conducted by HBCSE *(2018,2019)*

Technical Skills

Languages	Mathematica, C++, Python, VHDL, LaTeX, R
Software	Quartus, Git, MATLAB
Libraries	Emcee, Numpy, Scipy, Astropy, Biopython, Tensorflow, Keras, Pandas, Matplotlib

Teaching and Mentorship

Summer of Science 2022 Mentor| Cosmology and Dark Matter

Maths n Physics Club | IIT Bombay *May 2022-July 2022*

- 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

Teaching Assistant|PH 108: Basics of Electricity Magnetism

Prof Alok Shukla |Dept. of Physics, IIT Bombay *March 2022-July 2022*

- Discussed **weekly problem sets**, oversaw the logistics of conducting tutorial quizzes on SAFE platform

Teaching Assistant|PH 107: Quantum Physics and Application

Prof S. Shankaranarayanan |Dept. of Physics, IIT Bombay *December 2021-March 2022*

- Responsible for mentoring a batch of **38** students, discussing weekly **problem sets** and grading exam papers

Other Projects

Elementary Particle Physics

Summer of Science |MnP Club, IIT Bombay *May 2021 - July 2021*

- Studied the properties of various elementary particles, their classification schemes and investigated the several types of interactions with the help of **Feynman Diagrams** and the **Conservation Laws** that govern these interactions
- Learnt about Noether's theorem and some fundamentals of group theory focussing mainly on **Lie Groups** and explored properties of certain lie groups like **SU(n), SO(n) and SL(n,$\mathbb{C}$)**
- 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 bound states of two quark mesons and three quark baryons

Correcting Stellar Aberration Using Curve Fitting

Github Repo Link

Krittika Summer Project 2.0 |Krittika ,The Astronomy Club, IIT Bombay *August 2021*

- Used relativistic velocity addition to determine the relation between **Apparent Ecliptic Coordinates** of a star in terms of its **True Ecliptic Coordinates**
- Computed the true position of star using **Curve-Fitting**, given its apparent position over a period of an year

n3URL

Github Repo Link

Institute Technical Summer Project(ITSP) | Institute Technical Council, IIT Bombay *March 2021 - July 2021*

- Implemented a **Convolutional Neural Network** using Tensorflow and trained it on **Electroencephalogram data** in order to classify EEG signals based on whether the user is thinking about left or right movement
- Used simulated EEG signals to control movement in the **Breakout** game with **75 % accuracy** in predicting direction
- Were selected as one of the **top 6** teams among **50** teams that participated in the competition

Convolutional Neural Networks and Its Applications

Github Repo Link

Seasons of Code | WnCC, IIT Bombay *March 2021 - July 2021*

- Implemented the **ResNet50** architecture along with **transfer learning** from the Imagenet project using Tensorflow and used it for the multilabel classification problem of classifying movie posters based on their genres
- Achieved **18% accuracy** for predicting all genres correct and maximum **80% accuracy** for predicting a single genre
- Learnt about various types of Convolutional Neural Networks and how to implement them in Python using **Tensorflow**

Course Projects

IITB-RISC Microprocessor Design

Github Repo Link

Course Project | *EE 309: Microprocessors* | *Prof. Virendra Singh* — *Apri 2022 - May 2022*

- Designed a **16-bit, 8 register Computer System** using Multicycle based implementation capable of performing **17 different types** of instructions, based on the given ISA
- Designed the **flowcharts, datapaths** and the **control logic**, and implemented the processor using **VHDL**
- Facilitated in the designing of the **Pipeline based Implementation** of the processor for better performance

The Lasso Game

Course Project | *CS101: Computer Programming and Utilization* | *Prof. Bhaskaran Raman* — *February 2021*

- Enhanced a basic GUI based coin catching game written in C++ using **SimpleCpp Graphics** library
- Increased the difficulty level of game by adding a bomb feature using **Object Oriented Programming**
- Added the **Leaderboard** feature which keeps a record of highest scorers and their respective scores

Key Courses Undertaken

Physics	Gravitational Wave Physics and Astronomy*, Quantum Mechanics III*, Quantum Mechanics II*, General Relativity, Statistical Physics, Classical Mechanics, Basics of Electricity and Magnetism, Quantum Physics and Application
Electrical Engineering	Microprocessors, Control Systems, Power Engineering 2, Electronic Devices and Circuits, Power Engineering 1, Digital Systems, Analog Circuits, Probability & Random Processes, Signal Processing
Mathematics	Linear Algebra, Complex Analysis, Multi-variable Calculus, Ordinary Differential Equations, Partial Differential Equations

** To be completed by November, 2022*

Extra-Curriculars & Other Interests

- Among the top 8 performers of the institute to perform in Annual Standup Showcase for a crowd of 500 members *2022*
- 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 *2021*
- Received **Special Mention** in **Laughter Riots** conducted by Comedy Cons, IIT Bombay *2021*
- Participated in RascionX conducted by Chemistry Club, IIT Bombay and cleared the Prelims Round *2021*