YUVRAJ SHARMA

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ACADEMIC POSITION

Visiting Student *Aug 2023 - Jun 2024*
International Centre for Theoretical Sciences [ICTS] Bangalore
PI: Dr. Prayush Kumar, Astrophysical Relativity Group

EDUCATION

Indian Institute of Science Education and Research, Bhopal *Aug 2019 - June 2024*
BS-MS Natural Sciences (Majors in Physics)
CPI: 8.08/10

Reliance Foundation School, Surat *Apr 2017 - Mar 2019*
Higher Secondary Education
CBSE Examination - XII^{th} Percentage: 93.80/100

ACHIEVEMENTS

Long-Term Visiting Student Program Stipend, ICTS Bangalore *Aug 2023*
Winner Star Finder Competition - AstraX'20 AstroMeet Hosted by IIT Mandi *Mar 2020*
Winner Messier Marathon - Singularity Science Fest 2021, IISER Bhopal *Oct 2021*

RESEARCH EXPERIENCE

Rapid Identification and Classification of Eccentric Binary Black-Hole mergers using Machine Learning *Aug 2023 - Present*
Visiting Student with Dr. Prayush Kumar @ ICTS-TIFR, Bangalore

- Optimized a Separable-CNN architecture to identify Eccentric Binary Blackhole Mergers by injecting Simulated waveforms into Noise data from aLIGO detectors [H1, L1, V1]
- Developed data generation pipeline and a python module to generate datasets and automate training the CNN model
- Worked with HPC Cluster [Sonic] @ ICTS, used parrellel computing for intensive jobs
- Used Separable CNNs to obtain faster and lighter models, with the best achieved accuracy of 0.86 over 30 epochs
- Utilized both CPU and GPU nodes for training
- Presented my work at International and National conferences
- Completed this project as a part of my Master's Thesis

Simulating Gravitational Waveform fro Symmetric BBH mergers using PN approximations *Jun 2022 - Sep 2022*
Summer Internship

- Worked on deriving the waveform expression for Binary Black-hole mergers using Quadrupole and Post-Newtonian Approximations
- Applied linearized theory on distant weakly gravitating bodies and derived expressions for Post-Newtonian terms
- Determined frequency (period) for Innermost Stable Circular Orbit (ISCO) and Calculated time until merger using the derived relations
- Conducted analysis of relations for various source parameters

- Using the derived relation, simulated the inspiral phase and modeled the waveform for GW150914 merger and detected it using Match-filtering

IBAC Student Research Group *Sept 2021 - Aug 2023*
Core Member

- Data analysis and Image processing using the CCD data from the 14-inch Schmidt Cassegrain telescope present at IISER Bhopal
- Handling and demonstration of the telescope for observation sessions, also with an 8-inch Dobsonian telescope
- Hosted Night parties for the club with our 8" and 10" Dobsonian telescope, and held Astrophotography sessions

SEMESTER PROJECTS

Lattice Boltzmann Method (LBM) to Understand fluid flows *Mar 2024 - Apr 2024*
Course Project in Numerical Methods @ ICTS, Bangalore

- Completed project for Numerical Methods course to simulate fluid flows using Lattice Boltzmann Method under the guidance of Dr. Prayush Kumar
- Simulated fluid flows for a 2D lattice using the D2Q9 lattice model, for various obstacles within the fluid flow path
- Conducted quantitative and qualitative analysis for various obstacles, observed Kármán vortex streets as a result of introducing turbulence within the fluid, the repository with reports and videos can be found here
- The project showed potential for using LBM to conduct fluid analysis for complex systems

Studying the SEIRD Model to Simulate Epidemics *Jan 2023 - Apr 2023*
Course Project in Numerical Methods and Programming [NMP] @ IISER Bhopal

- Completed project for NMP course to solve coupled differential equations simulating the population rates during an epidemic under the guidance of Dr. Nirmal Ganguly.
- Defining parameters and solving the system of coupled differential equations using the RK4 [Runge-Kutta 4] method for the SEIRD model.
- Completed a parameter based analysis and compared the model with other models like SIR and SEIRS.

Obtaining semi-major axis for exoplanets using Machine Learning *Jan 2022 - Apr 2022*
Course Project in Data Science and Machine Learning [DSML] @ IISER Bhopal

- Completed project for DSML course to solve a regression problem to Obtain semi-major axis radius of orbit for detected exoplanets using source parameters within the data from NASA Exoplanet Archive under the guidance of Dr. Tanmay Basu
- Achieved Mean-Squared Error [MSE] value of 0.03 (closer to 0 shows higher accuracy)
- Used various regression models such as linear/non-linear multivariate regression, decision trees, random forest, SVM analysis, and Artificial Neural Network [ANN]
- Demonstrated skills in analyzing and interpreting data, fitting it to models, and evaluating the performance of different machine learning algorithms
- Developed a novel algorithm that achieved the lowest MSE, used for accuracy measurement

Morphological classification of Galaxies using CNN *Aug 2021 - Nov 2021*
Course Project in Artifitial Intelligence @ IISER Bhopal

- Completed project for AI course to solve a classification problem to Classify Galaxies based on Hubble's Morphological classification model using Galaxy image data from SDSS 16 under the guidance of Dr. Vaibhav Kumar

- Used LeNet5 architecture for the CNN model and learned about data analysis tools such as NumPy, matplotlib, scipy, scikit-learn, and modeling libraries such as Keras and TensorFlow
- Trained and optimized the CNN model, achieving maximum accuracy of 89.83% during training and 70.66% during testing
- Demonstrated expertise in developing and evaluating machine learning models using CNNs and relevant tools and libraries

POSTERS AND PRESENTATIONS

A search technique to observe precessing compact binary mergers in the advanced detector era *Jan 2024*
Journal Club Presentation @ ICTS

- Presented the work of McIsaac et al. [paper] to the Astrophysical Relativity Group ICTS, presentation [link]
- Researched the proposed methods for the search technique
- Studied analytical formulation for GW signals from precessing binaries
- Studied spherical harmonic decomposition to model precessing binaries and an efficient method approximation to model the search for such binaries

42nd Meeting of the Astronomical Society of India 2024 *Feb 2024*
Poster

Rapid Identification and Classification of Eccentric Binary Black-hole Mergers using Machine Learning

International Conference on Gravitation and Cosmology [ICGC] 2023 *Dec 2023*
Poster

Rapid Identification and Classification of Eccentric Binary Black-hole Mergers using Machine Learning

WORKSHOPS & SCHOOLS

Workshop on Gravitational Waves and LIGO-India *Oct 2024*
BITS Pilani, Pilani

ZTF Summer School: AI in Time Domain Astronomy *July 2024*
University of Minnesota, Minneapolis

Workshop on Numerical and Analytical Relativity 2024, IIIT Allahbad *Mar 2024*
Online

IAGRG School on Gravitation and Cosmology *Oct 2023*
ICTS-TIFR, Bengaluru

Statistical Methods and Machine Learning in High Energy Physics *Aug 2023*
ICTS-TIFR, Bengaluru

Summer School on Gravitational Wave Astronomy *July 2023*
ICTS-TIFR, Bengaluru

Gravitational-Wave Open Data Workshop May 2023
Online

TECHNICAL SKILLS

Programming Languages	Python, SQL, Bash, C, 7C++, MATLAB
Python Packages	Keras, Tensorflow, PyCBC, Pandas, scikit-learn GWPy, gwosc, Matplotlib, Numpy, Scipy, h5py
Software & Tools	LaTeX, Mathematica, R-Programming, Git SpECTRE, NMMA, Blender, DaVinci, CorelDraw

COURSEWORK

Physics	Cosmology, Introduction to Astrophysics, Nuclear & Particle Physics, General Relativity, Quantum Field Theory, Quantum Information Theory, Electrodynamics, Condensed Matter Physics (Course + Lab), Classical Mechanics, Quantum Mechanics, Statistical Mechanics, Mathematical Methods, Waves and Optics, General Properties of Matter Electromagnetism, Physics through Computational Thinking General Physics Laboratory (Undergraduate Labs)
Data Science	Data Science and Machine Learning, Advance Programming in Python, Artificial Intelligence, Data Structures and Algorithms, Discrete Mathematics, Econometrics, Applied Optimization

EXTRA CURRICULAR

Department Representative - Mathematics Department	*Aug 2020 - Aug 2021*
Head of Production and Design - Enthuzia Cultural Fest 2022	*Aug 2021 - Apr 2022*
Core Member - IISER Bhopal Astronomy Club [IBAC]	*Mar 2021 - July 2023*
Head of Design - Chrysalis Science Magazine	*Mar 2021 - Apr 2022*
Event Coordinator - Singularity Science Fest 2019	*October 2019*
Club Coordinator - ComiX Club	*Feb 2021 - Oct 2022*

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