Praneeth Avasarala *M.Tech, B.Tech*

Graduate Research Student in Cosmology

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I am currently pursuing a Master's degree in Astronomy, with my thesis work's primary focus on Cosmology. My academic journey saw a transition from a Mechanical Engineering background to the realm of Physics, a change driven by my deep passion for the subject. This shift has been personally fulfilling, igniting my dedication to further explore the mysteries of the universe and contribute to its ever-expanding knowledge.

Education

Indian Institute of Technology (IIT), Indore — July 2022 – Present

Master of Science in Astronomy. Performance – 8.34/10 CPI (two semesters) — *Indore, India*

Department of Astronomy, Astrophysics and Space Engineering (DAASE)

Indian Institute of Technology (IIT), Madras — August 2017 – June 2022

Dual Degree - B.Tech in Mechanical Engineering & — *Chennai, India*

M.Tech in Thermal Engineering. Performance – First Class

Department of Mechanical Engineering

Research Experience

Studying the impact of different reionization source models on simulated HI 21-cm images using Wavelet Scattering Transform (WST) – Detailed Report — May 2023 – Present

A year-long Masters thesis project under the guidance of Dr. Suman Majumdar – DAASE, IIT Indore — *Indore, India*

- Applied WST on simple 2D images with various known morphological features – circles, ellipses, Gaussian random fields, distribution of circles of different sizes etc., to understand how WST extracts features from input images
- Studied the physics incorporated in the different EoR source models considered and the simulation techniques used to generate the 21-cm coeval cubes
- Performed WST analysis on simulated 21-cm images of UV, Soft Xray and Hard Xray photon-dominated reionization source models
- Generated lightcones for our models from the simulated coeval cubes and examined the evolution with WST coefficients
- Our work on coeval cubes shows that 2D WST outperforms 3D power spectrum with its ability to extract non-Gaussian information from the fields. 2D WST is also more sensitive to non-Gaussianities than 3D Bispectrum in some of our source models
- » Skills developed: EoR Cosmology, Fourier & Wavelet Analysis, Handling Big Data, Parallel Processing, Statistical Inference

Particle-Mesh N-body Simulation — March 2023 – June 2023

Project as part of Computational Methods in Astrophysics course under the guidance of — *Indore, India*

Dr. Suman Majumdar

- Simulated Dark matter (DM) density fields using N-body simulation code
- Generated DM halo catalogues and DM halo maps from the DM density fields using friends-of-friends (FoF) halo finder algorithm
- Calculated Power Spectrum and Halo mass function of the simulated DM density maps and the halo catalogue respectively
- » Skills developed: Cosmology - Cosmological parameters, equations of motion, Zeldovich Approximation, Programming - C

Markov Chain Monte Carlo Simulation (Metropolis-Hastings and Hamiltonian Monte Carlo) — April 2023

Project part of Astrostatistics course taken by Dr. Suman Majumdar — *Indore, India*

- Used the Markov Chain Monte Carlo (MCMC) and Hamiltonian Monte Carlo (HMC) random walk algorithms to estimate cosmological parameters from supernova Ia data
- MCMC and HMC simulations were used to analyze data from the photographic plates from Eddington's 1919 eclipse expedition to confirm Einstein's General Theory of Relativity
- » Skills developed: Probability, Bayesian statistics & random walk simulations to find and fine-tune the parameters for given conditions

Computational Fluid Dynamics (CFD) - Numerically solving PDEs using finite difference and finite volume methods — Februay 2023

Project as part of Computational Methods in Astrophysics course taken by — *Indore, India*

Dr. Bhargav Vaidya – DAASE, IIT Indore

- Solved Advection equation using FTCS, Upwind, Lax Method, MacCormack method & Lax-Wandroff Schemes
- Flux Limiters – Solved Isothermal Shock Tube problem using Total Variation Diminising (TVD) slope limiters & flux limiters schemes
- » Skills Developed: Numerical methods for solving PDEs

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Time Series Analysis & Fourier Analysis September 2022 - November 2022

Project as part of Astronomy Programming course taken by Dr. Amit Shukla – DAASE, IIT Indore *Indore, India*

- Applied Time Series Analysis techniques to transform a non-stationary time series into a stationary one using COVID-19 data
- Improved the quality of time series data using data cleaning, smoothing, and seasonal decomposition. These Pre-Processing techniques helped to generate more valuable insights from the analysis
- Performed fourier analysis to determine the time period of a pulsar using pulsar flux data and time information
- Skills developed – Curve fitting, Hypothesis testing (chi-square test), Forecasting methods from time series and Fourier signal analysis to reveal periodicities and patterns hidden in the data

Implementing selection of reactions & Quasi steady state assumptions on simulated combustion reactions using DRGEP Method August 2021 – June 2022

A year-long Masters thesis project under the guidance of *Chennai, India*

Dr. Kritika Narayanaswami (Department of Mechanical Engineering, IIT Madras)

- Designing an error propagation algorithm to calculate the impact of removal of desired reactant species on the combustion products using Directed Relation Graph with Error Propagation (DRGEP) approach
- Skills developed – Thermodynamics of Combustion, Reaction Mechanisms, Error Propagation techniques used in Combustion simulations

Plotting Geodesics on a Toroidal surface Sep 2020 – Nov 2020

Undergraduate project as part of Classical Mechanics course taken by *Chennai, India*

Dr. Kasi Swaminathan (Department of Physics, IIT Madras)

- Numerically solving the geodesic equation on Toroidal surface passing through any two given initial points using Runge-Kutta methods
- 3D Visualisation of the geodesic lines on a toroidal surface
- Skills developed – General Relativity - Geodesic Equations, Numerical Methods for solving differential equations, MATLAB

Teaching Experience

Teaching Assistant for "Engineering Mechanics - Statics and Dynamics" course as part of National Programme on Technology Enhanced Learning (NPTEL) Jan 2019 – April 2019

under the guidance of Dr. Mahesh Panchagnula – Dept of Mechanical Engineering & Dean of Alumni and Corporate Relations (ACR), IIT Madras *Chennai, India*

- Conducted bi-weekly doubt clarification sessions
- Helped with the preparation of weekly assignments, mid-term and end-term question papers

Skills

Computational Astrophysics : N-Body simulations, FoF Halo finder, Numerical methods for solving PDEs

Statistical Inference : Probability & Statistics, Bayesian Inference using MCMC Analysis, Time Series Analysis, Fourier & Wavelet Analysis

Computer Languages : Python - Astropy, Tools21cm, Kymatio, Matplotlib, Numpy, Pytorch, Tensorflow; Linux; MATLAB; LaTeX; Web Development - HTML, CSS

Soft Skills : Creative Problem Solving, Effective Communication of ideas, Collaborative Teamwork, Adaptability, Curiosity-driven discussions

Other Interests

Reading Books : I like to learn about Neuroscience, Psychology, Biology and Philosophy through non-fiction books written by leading researchers from the relevant fields

Visual Storytelling : I like the art of combining story telling with cinematography & and the imagination that goes into the process.

Music : I like collecting good music from all over the world. I also plan to learn how to play violin & piano in the future

Science Communication : I like interacting with curious and passionate researchers. I enjoy learning about their field as well as sharing exiting things about my field

Teaching : I'm good at breaking down complex topics and communicating them by stacking simpler ideas. I like to teach Math and Physics to curious people willing to learn

Strategy-based Games : I like to play board games like chess, card games like Bridge, Go Fish etc ; PC games like FIFA, Age of Empires etc.

Sports & Fitness : I like to play badminton, football & cricket. I also like to go to the Gym