Shubhit **Sardana**

Pulsar Timing Arrays · Gravitational waves · Exoplanets

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Education

Integrated Bachelor and Master of Science in Physics — MP, India

Indian Institute of Science Education and Research (IISER) - Bhopal — Dec. 2021 - May 2026

Current CPI (Cumulative Point Index): 8.26 (from a maximum of 10)

Publications

(In-prep: 2, published: 1, under review: 1, Total Citations: 11, MY ADS LIBRARY)

Ensemble noise properties of the European Pulsar Timing Array. — 2nd Author

Published: Monthly Notices of the Royal Astronomical Society (MNRAS) — Feb. 2025

Goncharov, B., & **Sardana, S.** (2025). Ensemble noise properties of the European Pulsar Timing Array. Monthly Notices of the Royal Astronomical Society, staf190.

Fewer supermassive binary black holes in pulsar timing array observations. — 2nd Author

Review completed, final files submitted: Nature Communications — Nov. 2024

Goncharov, B., **Sardana, S.**, Sesana, A., Tomson, S. M., Antoniadis, J., Chalumeau, A., ... & Valtolina, S. (2024). Fewer supermassive binary black holes in pulsar timing array observations. arXiv preprint arXiv:2409.03627.

Research Experiences

Master's Thesis, Indian Institute of Science Education and Research (IISER) - Bhopal — MP, India

Thesis Supervisor: Dr. Mayuresh Surnis — June 2025 - Present

Topic: Heliospheric Density Mapping Using IPS for Correcting DM Excess in Pulsar

The Ooty Radio Telescope (ORT) regularly observes interplanetary scintillation (IPS) of compact radio sources, enabling measurements of plasma density fluctuations in the inner heliosphere—the region between the Earth and the Sun. Pulsars located near the ecliptic plane exhibit annual variations in their dispersion measure (DM) due to excess electron density along the line of sight caused by the heliosphere. My thesis focuses on correlating these IPS-based heliospheric density measurements with DM variations observed in the open-access IPTA DR2 pulsar timing data set. The goal is to improve our understanding of heliospheric contributions to pulsar timing noise, which is crucial for enhancing the sensitivity of Pulsar Timing Arrays (PTAs) in the search for nanohertz-frequency gravitational waves.

Research Project, Indian Pulsar Timing Array (InPTA) — InPTA Project

Noise Analysis Group, InPTA — Feb. 2025 - June 2025

Topic: Incorporating Solar Wind Gaussian Process in Pulsar Noise Modeling

As part of the DR2 Noise Analysis project within the InPTA Noise Analysis Group, I focused on incorporating the effects of the solar wind into the noise modeling framework for pulsars located near the ecliptic plane. My work involved developing and refining Python-based analysis pipelines, implementing a Gaussian Process model to account for solar wind contributions, and systematically testing it across multiple pulsars. In addition to the technical work, I actively participated in weekly group meetings, where I presented updates, discussed challenges, and engaged with collaborators on methodological improvements.

Research Intern, Max Planck Institute for Gravitational Physics (AEI Hannover) **Hannover, Germany**
Supervisor: Dr. Boris Goncharov **May 2024 - July 2024**
Topic: Ensemble noise properties of the European Pulsar Timing Array

Implemented a new procedure based on prior reweighting developed by Dr. Boris Goncharov to marginalise over uncertainties in the pulsar noise priors on EPTA data. Performed hierarchical Bayesian inference to infer the noise parameters of pulsars in the data. Accounting for the new prior distributions increases evidence for the Gravitational-wave background (GWB) as it makes inferred GWB parameters more consistent with theory while eliminating the systematic error from the measurement.
As a product of this internship, we got two research papers. The first one, "Ensemble noise properties of the European Pulsar Timing Array" (MNRAS) and the second one "Fewer supermassive binary black holes in pulsar timing array observations" (under review in Nature Communications).

Research Intern, Ludwig Maximilian University of Munich (LMU Munich) **Remote**
Supervisor: Dr. Karan Molaverdikhani **Dec. 2023 - Apr. 2024**
Topic: Analysis of Data from EVLA for Exoplanet Host Star Radio Emissions

Analyzed TRAPPIST-1, a well-known exoplanet host star, to investigate potential star-planet interactions in the radio spectrum using EVLA archival data. Utilized CASA and the VLA pipeline to process roughly 300 GB of the archival data, to perform detailed calibration, imaging, and visualization of the data products. Despite thorough analysis, no conclusive radio emission was detected from the system, which is likely due to the sensitivity limitations of the radio telescopes today. Such detections may become feasible with future instruments like the ng-VLA (next-generation Very Large Array) or SKA-mid (Square Kilometre Array).

Research Intern, Indian Institute of Science Education and Research (IISER) - Bhopal **MP, India**
Supervisor: Dr. Mayuresh Surnis **Dec. 2023 - Dec. 2023**
Topic: Pulsar Search Pipeline Improvement and Result Analysis

Improved the PRESTO-based pulsar search pipeline developed earlier for analyzing GMRT data by implementing more efficient de-dispersion methods. Minimized input-output operations by shifting frequency sub-bands to their expected positions instead of processing each frequency separately, maintaining data integrity while increasing efficiency. Analyzed the outcomes in discussion with Dr. Surnis, which strengthened understanding of pulsar signals and search techniques. The updated pipeline, complete with clear instructions, is available on my GitHub page.

Research Intern, Indian Institute of Science Education and Research (IISER) - Bhopal **MP, India**
Supervisor: Dr. Mayuresh Surnis **May 2023 - July 2023**
Topic: Pulsar Search and Analysis of GMRT Data

Analyzed radio data from the GMRT (Giant Metre-wave Radio Telescope) to search for pulsars. Extensively used PRESTO (Pulsar Exploration and Search Toolkit), developed by Dr. Scott Ransom, for the search. Used RFI Clean to remove radio frequency interference from atmospheric and other sources. Corrected signal dispersion caused by the interstellar medium and Earth's atmospheric via diffraction effects through the de-dispersing algorithm in PRESTO. Developed a Python pipeline to automate the process, streamlining the data cleaning, dispersion correction, and candidate filtering.

Reading projects

Research Intern, Indian Institute of Science Education and Research (IISER) - Bhopal — **MP, India**

Supervisor: Dr. Mayuresh Surnis — **Sept. 2024 - Oct. 2024**

Fundamental concepts in Radio Interferometry

Developing analysis scripts for modeling solar wind effects on pulsars located close to the solar disk, as part of the Noise Analysis of DR1 project within the Noise Analysis Group of InPTA. The work involves script building, testing and data processing to determine the optimal models corresponding to each pulsar. Working on understanding the correlations between solar wind parameters, electron column density, and their impact on pulsar timing precision. The part allocated to me is focused on determining the influence of solar wind plasma between earth and the sun on dm (dispersion measure) for the selected pulsars showing bias towards SWGP model. The script I built to determine the solar wind gaussian process effects is available on my github webpage.

Conference/Teleconference Presentations

InPTA-wide Telecon — **Teleconference**

Topic: (Research Paper) Exploring the time variability of the solar wind using LOFAR pulsar data. — **5th March 2025**

Presented in the InPTA's bi-weekly meeting focusing on the importance of including the effects of solar wind in the pulsar timing. Mentioned the importance of integrating the effects due to solar wind plasma and electron density on the dispersion measure (dm) of signals from pulsars which lie very close to the solar disk. Showed the results from the first version of the script I built to analyse this process.

Gravitational-wave Analysis Telecon — **Teleconference**

Topic: (Two Research Papers) Ensemble noise properties of pulsars in EPTA and implications for GWB. — **17th Oct. 2024**

Gave a presentation in the GWA's bi-weekly Teleconference. GWA is one of the several working groups in the IPTA. The presentation was focused on the key findings from the work done under the supervision of Dr. Boris Goncharov. This work has also been published in the form of two research papers.

EPTA-wide Telecon — **Teleconference**

Topic: (Research Paper) Ensemble noise properties of pulsars in EPTA. — **29th July 2024**

Presented in the EPTA-wide Telecon, a bi-weekly EPTA meeting. The presentation focused on the Ensemble noise properties of Pulsars, a research project that I did under the supervision of Dr. Boris Goncharov. This work has also been published as a research paper.

Skills

Programming Languages	Python (Matplotlib, NumPy, Pandas ...), C/C++
Statistical Techniques	Monte Carlo Markov Chain, Bayesian analysis
Web development	HTML5, CSS, JS
Other Tools	HPC, Linux (CLI, experience with Arch and Ubuntu based systems), PRESTO, a bit of CASA for processing and analyzing radio astronomical data and interferometry, Mathematica and a bit of MATLAB.

Related courses

Astronomy and Astrophysics, General Relativity, Cosmology, Special Relativity, Nuclear and Particle Physics, Statistical Mechanics, Wave and Optics, Electrodynamics, Non-Linear Dynamics and Chaos, Numerical Methods and Programming, Classical Mechanics, Quantum Mechanics, Advanced Quantum Mechanics, Atomic and Molecular Physics, Mathematical Methods - 1, Mathematical Methods - 2, Probability and Statistics, Signals and Systems.

Workshops and Certifications

- Attended a two-day Winter Conference on Condensed Matter Physics, Astrophysics & High Energy Physics Seventh Edition (2024) online, organized by The University of Tennessee, Knoxville, USA.
- Attended Sagan Summer Workshop 2023 online mode hosted by the NASA Exoplanet Science Institute, California Institute of Technology, Pasadena, CA, a 5-day workshop.
- Attended a 2-week workshop, Overview of Space Science (START Program) by the Indian Space Research Organisation (ISRO), held online.
- Studied the universe's evolution by taking a course by Dr. S. George Djorgovski at Caltech, where he taught The Evolving Universe on Coursera.