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: 9, 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: MAKING IPS DENSITY MAPS OF THE HELIOSPHERE TO CORRECT THE DM EXCESS IN PULSARS

   The Ooty Radio Telescope makes observations of interplanetary scintillation of radio sources at regular intervals. This will help in measuring the plasma density fluctuations in the inner heliosphere, i.e, space between the Earth and the Sun. The pulsars at low ecliptic latitudes show an annual variation of the dispersion measure due to the extra delay added by the heliospheric plasma density. Connecting these two independent measurements and understanding their effects is important in understanding and modelling the pulsar noise analysis for Gravitational Wave detection. I will be handling the IPS data obtained from ORT for getting the heliospheric density maps and use the open access IPTA DR2 data set.

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

TEAM: NOISE ANALYSIS GROUP, InPTA   Feb. 2025 - June 2025

TOPIC: NOISE ANALYSIS OF DR2 BY INCORPORATING THE EFFECTS OF SOLAR WIND ON PULSE PROPERTIES

   I developed python scripts to assess the solar wind processes in the pulsars at low ecliptic latitudes, as part of the "Noise Analysis of DR2" project within the Noise Analysis Group of InPTA. The work involves script building, testing and data processing to determine the optimal models for each pulsar. I understood the correlations between solar wind parameters, electron column density, and their impact in pulsar timing. I also attend weekly group meetings for the updates.

Research Intern, Max Planck Institute for Gravitational Physics (AEI Hannover)

Hannover, Germany
May 2024 - July 2024

SUPERVISOR: DR. BORIS GONCHAROV
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
Dec. 2023 - Apr. 2024

SUPERVISOR: DR. KARAN MOLAVERDIKHANI
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
Dec. 2023 - Dec. 2023

SUPERVISOR: DR. MAYURESH SURNIS
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
May 2023 - July 2023

SUPERVISOR: DR. MAYURESH SURNIS
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

Introduction to Astronomy and Astrophysics, Cosmology 1, Cosmology 2, Nuclear and Particle Physics, Statistical Mechanics.

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.