

Archana Purushothaman

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Professional Summary

Astrophysicist with a Master's in Astrophysics and Cosmology from the University of Bologna, with research experience in high-energy astrophysics, stellar evolution, and multi-wavelength data analysis. Proficient in statistical modelling, and Python-based pipelines and a strong background in independent, collaborative research across international institutes. Currently seeking a PhD position to further research in high-energy astrophysics, star formation, and feedback processes.

Publications

Purushothaman, et al.: 'Stochasticity in Stellar Yields Reflected in Theoretical Dust Masses Estimates Across all Type II Supernova Progenitors', arXiv:2508.12933, **Submitted to ApJ**, August 2025.

Peron, Morlino, Gabici, Amato, **Purushothaman**, and Brusa: "*On the correlation between young massive star clusters and gamma-ray unassociated sources*", **Published in ApJ Letters**, August 2024.

Education

Masters in Astrophysics and Cosmology

Sept 2021 - Dec 2023

Alma Mater Studiorum - Università di Bologna, Bologna, Italy

Grade: 86/110 | Credits: 120 | Thesis: Star clusters Gamma-ray emitters

Bachelor of Science in Physics

June 2017 - Mar 2020

University of Kerala, Thiruvananthapuram, India

Grade: 7.747/10 | Credits: 120 | Thesis: A study on the acoustic levitation of liquid droplets to simulate micro-gravity environments and influencing factors on the size of the droplet.

Technical Skills

- **Programming Languages:** Python, C++, FORTRAN, R, MATLAB, Java, Bash, SQL
- **Scientific Computing:** Jupyter, LaTeX, Wolfram Notebook, Shell scripting, Git
- **Astrophysics Libraries & Tools:** FermiPy, GammaPy, Astropy, CASA, XSPEC, DS9, IRAF, CARTA, HEASOFT, TOPCAT
- **Statistical & Data Analysis:** NumPy, SciPy, Pandas, Scikit-Learn, Monte Carlo methods, Bayesian Inference (rstanarm), Regression Analysis, EDA, Time Series Analysis
- **Machine Learning:** TensorFlow, PyTorch, PySpark, NLP, Deep Learning (Autoencoders)
- **Visualization:** Tableau, Power BI, Matplotlib, Seaborn, Plotly, Dash, Bokeh, Streamlit, Gnuplot, TOPCAT
- **Signal & Image Processing:** Spectroscopy, PSF-fitting Photometry, Interferometry, Astrometry, Statistical Modeling
- **Soft Skills:** Communication, Team Collaboration, Adaptability, Time Management, Analytical Thinking, Problem-Solving

Experience

Research Intern, Sep 2024 – June 2025

Supervisor(s): Dr. Arkaprabha Sarangi

Indian Institute of Astrophysics, Bangalore, India

- Analyzed dust formation in core-collapse supernovae (CCSNe) using progenitor models spanning 8–120 M_{\odot} to investigate the upper limits of post-explosion dust yields.
- Utilized statistical data analysis methods to visualize and study the trend of major dust masses across progenitor masses.

Research Intern, Mar 2023 – July 2023 Supervisor(s): Dr. Stefano Gabici, Dr. Giada Peron, Dr. Marcella Brusa
Laboratoire Astroparticule et Cosmologie (APC) – Université Paris Cité, Paris, France

- Developed scripts to analyze positional coincidences between available star cluster and HII region catalogs (Gaia, WISE) and gamma-ray emitters (Fermi-LAT) to investigate their potential as gamma-ray sources.
- Performed statistical analysis and generated synthetic catalogs using Monte Carlo methods to assess the significance of positional coincidences.

Research Intern, Feb 2023 - Mar 2023

Supervisor(s): Dr. Bruno Marano, Dr. Giuseppe Lete

INAF- Osservatorio Astrofisico di Catania, Sicily, Italy

- Assisted in data collection, calibration, and post-processing of observations from the Crab Nebula using the ASTRI-Horn prototype for the SST-2M telescope of the CTAO.
- Performed the application of statistical methods to quantify noise levels, evaluate signal-to-noise ratios, and refine calibration thresholds for gamma-ray data analysis.

Projects

Characterizing jets from Protostars , JWST I-HOW 2025 Workshop, Supervisor(s): Dr. Łukasz Tychoniec
Processed JWST MIRI Medium Resolution Spectrometer (MRS) and NIRSpec data cubes of a Class I protostar L1448 IRS-1 in the Perseus molecular cloud. Developed custom Python workflows to create continuum-subtracted moment maps of jet-tracing spectral lines. Extracted spatially resolved spectra to investigate jet feedback and shock chemistry through emission line diagnostics and spatial morphology analysis.

Supernova Dust Formation as a Function of Progenitor Mass Supervisor(s): Dr. Arkaprabha Sarangi
Analyzed dust formation in core-collapse supernovae (CCSNe) using a comprehensive grid of progenitor models (8–120 M_{\odot}) to investigate the upper limits of dust yields post-explosion. Employed statistical methods to quantify and visualize the variation of major dust species (carbon, silicate, alumina) and CO mass across different progenitor masses.

Star Clusters as Gamma-ray Emitters Supervisor(s): Dr. Stefano Gabici, Dr. Giada Peron, Dr. Marcella Brusa
Conducted a multi-wavelength analysis to explore whether young massive star clusters can emit GeV gamma rays. Cross-matched unassociated Fermi-LAT sources with GAIA and WISE catalogs, performed Monte Carlo simulations to assess statistical significance, and found spatial and spectral evidence suggesting that clusters younger than 1–2 Myr may produce gamma rays through stellar wind activity alone.

A study on the acoustic levitation of liquid droplets to simulate micro-gravity environments and influencing factors on the size of the droplet. Supervisor(s): Dr. Bijini B. R.
Designed and built an Arduino-based acoustic levitation setup to simulate microgravity conditions for liquid droplets. Investigated how variables such as liquid density, droplet volume, and sound frequency affect stable levitation, demonstrating the system’s potential as a cost-effective platform for simulating space-like environments in laboratory settings.

Multiwavelength lab projects

Supervisor(s): Dr. Cristian Vignali, Dr. Alessio Mucciarelli, Dr. Myriam Gitti, Dr. Annalisa Bonafede, Dr. Fabrizio Brighenti, Dr. Robert Benton Metcalf

- **Radio Imaging of Galaxy Cluster Abell 3670 (JVLA):** Reduced interferometric data using CASA; calibrated, flagged, and imaged a wide-angle tail galaxy source using X-band data. Produced cleaned continuum images and characterized spatially extended radio emission.
- **Faraday Rotation Measure Mapping of 5C4.85 (Coma Cluster):** Computed RM from polarization images across 4 frequencies; corrected for $n\pi$ ambiguity and estimated the intracluster magnetic field using Felten’s formula assuming a β -model for electron density.
- **X-ray AGN Classification (Chandra 7Ms & Mosaic Catalogs):** Compared source catalogs, fitted AGN spectra using XSPEC, and derived hydrogen column densities, power-law indices, and luminosities. Analyzed trends across redshift and bandpass.
- **Hydrostatic equilibrium in a Galaxy Cluster and turbulent diffusion of metals in the hot gas:** Solved hydrostatic equilibrium numerically to compute gas density profiles with varying temperature gradients. Modeled turbulent diffusion of Fe in the ICM and compared results with Rebusco et al. 2006
- **SNR shock evolution:** Simulated SNR shock evolution using 1D hydrodynamical equations in polar and Cartesian coordinates. Incorporated artificial viscosity and modeled X-ray emission from shocked gas.
- **Photometry of NGC 2808 (SOFI):** Performed PSF photometry on J and K-band images of the globular cluster NGC 2808 using IRAF (DAOFIND, PHOT, ALLSTAR) and optimized stellar detection with Moffat25 profile.
- **Spectroscopic Reduction and Classification:** Reduced stellar spectra from SOFI by performing bias subtraction, extraction, and wavelength calibration using comparison lamp spectra. Identified the spectral type by matching observed lines with standard stellar features.

References

- **Dr. Arkaprabha Sarangi**
Assistant Professor, Indian Institute of Astrophysics, Bangalore, India , arkaprabha.sarangi@iiap.res.in
- **Dr. Marcella Brusa**
Full Professor, Department of Physics and Astronomy, University of Bologna, Italy, marcella.brusa3@unibo.it
- **Dr. Stefano Gabici**
Researcher, Laboratoire APC – Université Paris Cité- CNRS, France , gabici@apc.in2p3.fr
- **Dr. Giada Peron**
Research Fellow, INAF - Osservatorio Astrofisico di Arcetri, Florence, Italy, giada.peron@inaf.it