

# Vasu Dipakkumar Pipwala

Prospective PhD Student — Dark Matter, Galactic Dynamics & Stellar Streams

Computational Astrophysics | Probabilistic Modeling | Machine Learning Foundations

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**Astrophysics researcher** with 3+ years of research experience in Galactic and extragalactic astronomy, applying computational modeling, statistical inference, and astrophysical data analysis to stellar populations and dynamical systems.

- Key strengths and focus areas:

- Strong academic training in astrophysics, with a solid mathematical foundation in linear algebra, probability theory, statistics, and numerical methods.
- Research experience in stellar populations and variable stars (Classical Cepheids, Type-II Cepheids, RR Lyrae, etc.), with an emphasis on their use as probes of Galactic structure and evolution.
- Hands-on experience developing Python-based, reproducible analysis pipelines for large, noisy astronomical datasets.
- Applied probabilistic modeling, uncertainty quantification, and data-driven inference to astrophysical problems, with careful attention to physical interpretation.
- Growing research focus on Galactic dynamics and near-field cosmology, particularly the use of thin globular-cluster stellar streams to probe the Milky Way's dark matter halo.

Motivated to pursue PhD training in Galactic dynamics at DTU Space, with the goal of combining controlled numerical experiments, phase-space analysis, and modern computational methods to extract robust insights into the Milky Way's gravitational potential.

## Research Experience

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### Data-driven Astrophysics Researcher, Rome University, Italy

Nov 2023 – Oct 2025

- Conducted computational studies of RR Lyrae stars to investigate early Galactic chemical enrichment and the formation history of the Milky Way.
- Designed and implemented automated, reproducible Python pipelines for large-scale analysis of high-resolution spectroscopic data.
- Applied physically constrained NLTE synthetic spectral modeling to these F-type variable stars, directly incorporating stellar-atmosphere physics into the inference process.
- Utilized Non-negative Matrix Factorization (NMF) to decompose stellar spectra into physically interpretable components, enabling robust separation of continuum, line features, and noise-dominated structures.
- Performed systematic validation and consistency checks across heterogeneous spectroscopic datasets acquired from multiple instruments and observing campaigns.

### Master's Researcher, Heidelberg University, Germany

Sept 2022 – Sept 2023

- Developed robust Bayesian regression frameworks to calibrate Period–Luminosity (PL) and Period–Wesenheit (PW) relations for Type-II Cepheids in LMC, explicitly addressing outliers and heteroscedastic uncertainties beyond ordinary least-squares methods.
- Implemented classification and contamination-rejection schemes based on Bhattacharyya distances to isolate clean Type-II Cepheid samples in M31.
- Performed extensive uncertainty quantification and posterior validation, recovering accurate benchmark distances to the M31 and achieving >98% relative accuracy across multiple distance tracers, despite relying on archival ground-based photometry.
- Demonstrated that Type-II Cepheids are viable extragalactic distance indicators, particularly for galaxies lacking young stellar populations, with strong relevance for JWST, LSST, and ELT observations.

## Research Sample

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**Research project:** Unveiling the early chemical enrichment of the Milky Way using RR Lyrae stars. (in prep.)

**Master's thesis:** Using Type-II Cepheids as Extragalactic Standard Candles: Distances to M31. [\[link\]](#)

## Education

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**M.Sc. in Physics**, Heidelberg University, Germany Apr 2020 – Sep 2023

— Overall GPA: 1.5 (German scale)

— Specialization: Galactic & Extragalactic Astronomy, Cosmology

— Thesis: Distance to M31-Testing Type-II Cepheids as Standard Candles for the Extragalactic Distance Scale

— Supervisor: Prof. Eva K. Grebel

**B.Sc. Honors in Physics**, Baroda University, India 2016 – 2019

## Internships & Observational Training

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**Observing Student**, NEON Observing School, Observatoire de Haute-Provence, France Oct 2022

— Topic: Spectro-photometric analysis of extragalactic transients

**Summer Student**, ASTRON, Netherlands Jun 2022 – Aug 2022

— Topic: Radio continuum emission as a star-formation tracer in dwarf galaxies

## Important Talks & Presentations

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**The Milky Way and Andromeda: the odd couple!**, Sexten, Italy Jan 2025

— Chemical abundance analysis of Galactic RR Lyrae stars under NLTE

**EAS Conference 2023**, Kraków, Poland July 2023

— Distance to M31 using Type-II Cepheids

## Computational & Analytical Skills

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**Programming:** Python (scientific computing), Bash, SQL; working knowledge of C/C++/FORTRAN

**Statistical Modeling:** Bayesian inference, robust regression, uncertainty quantification, model validation

**Physics-Informed Analysis:** Physically constrained modeling, interpretable matrix factorization (NMF), clustering

**Scientific Computing:** Time-series analysis, numerical modeling

**Machine Learning:** scikit-learn; working knowledge of PyTorch

**Tools:** NumPy, SciPy, pandas, PyMC, Astropy, Jupyter, Git, TOPCAT, DS9, IRAF, iSpec, LaTeX

**Research Skills:** Scientific curiosity; Analytical problem-solving; Independent research drive; Clear scientific communication

## Academic Outreach & Service Activities

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— **Outreach Volunteer**, European Researcher's night, Rome University

— **Chair**, Galaxy Evolution Seminar, Heidelberg University

— **Teaching and lab supervisor**, Heidelberg University

— **Outreach Volunteer**, Indian Space Research Organisation (ISRO) exhibition, Baroda University

## Languages

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English (fluent) | Hindi (native) | Gujarati (native)