Aarya Patil

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Research Interests

My research lies at the intersection of astrophysics, statistics, and computer science. I develop novel data-driven tools to guide models of the Milky Way galaxy. My goal is to use these models to understand how galaxies form and evolve.

Education

2023 **University of Toronto**, Direct-Entry PhD in Astronomy & Astrophysics — Canada
Thesis title: Order in Chaos - Decoding the age-metallicity structure of the Milky Way disk
Supervisors: Jo Bovy & Gwendolyn Eadie

2018 **S. P. Pune University**, BEng in Computer Engineering (CGPA: 9.45/10) — India

Professional Appointments

2023 - Present **LSST Discovery Alliance (LSST-DA) Catalyst Fellow**, MPIA
Mentors: Hans-Walter Rix & Ivelina Momcheva

Summer 2017 **Developer**, Google Summer of Code (GSoC) Participant with OpenAstronomy/Astropy
Mentors: T. Aldcroft (Harvard-Smithsonian), M. van Kerkwijk (U. of Toronto) & H. M. Günther (MIT)

Publications

Refereed

Published:

2023 **Patil, A. A.**; Bovy, J.; Jaimungal, S.; Frankel, N.; & Leung, H. W. "Decoding the age-chemical structure of the Milky Way disc: an application of copulas and elicitable maps". Monthly Notices of the Royal Astronomical Society, Volume 526, Issue 2, pp.1997-2016 [arXiv/2306.09319]

2022 **Patil, A. A.**; Bovy, J.; Eadie, G.; & Jaimungal, S. "Functional Data Analysis for Extracting the Intrinsic Dimensionality of Spectra: Application to Chemical Homogeneity in the Open Cluster M67". The Astrophysical Journal, Volume 926, Issue 1, article id. 51, 24pp. [arXiv/2109.10891] [4 citations]

2022 The Astropy Collaboration, Price-Whelan, A. M.; Lim, P. L.; Earl, N.; Starkman, N.; Bradley, L.; Shupe, D. L.; **Patil, A. A.** et al. "The Astropy Project: Sustaining and Growing a Community-oriented Open-source Project and the Latest Major Release (v5.0) of the Core Package". The Astrophysical Journal, Volume 935, Issue 2, article id 167, 20pp. [arXiv/2206.14220] [1014 citations]

2018 The Astropy Collaboration et al. incl. **Patil, A. A.**. "The Astropy Project: Building an Open-science Project and Status of the v2.0 Core Package". The Astronomical Journal, Volume 156, Issue 3, article id. 123, 19pp. [arXiv/1801.02634] [5906 citations]

Submitted:

Patil, A. A.; Eadie, G.; Speagle, J.; & Thomson, D. "Improving Power Spectrum Estimation using Multitapering I: Efficient asteroseismic analyses for understanding stars, the Milky Way, and beyond". Submitted to The Astronomical Journal, 32 pp. [arXiv/2209.15027][2 citations]

In preparation:

Patil, A. A.; Eadie, G.; Speagle, J.; & Thomson, D. "Improving Power Spectrum Estimation using Multitapering II: Precise mode parameter estimation using the F-test". To be submitted to The Astronomical Journal in February 2024.

Sun, J.[*]; **Patil, A. A.**; Li, Y.; Guo, J.; & Zhou, S. "How to Sustain a Scientific Open-Source Software Ecosystem: Learning from the Astropy Project". To be submitted to the IEEE/ACM International Conference on Software Engineering in March 2024. [*]mentee

Non-refereed

Conference Proceedings:

2020 **Patil, A.**; Bovy, J.; & Eadie G. "Likelihood-free Inference of Chemical Homogeneity in Open Clusters". Joint Statistical Meetings Proceedings, ASA, pp 1838-1844.

Software:

2022 **Patil. A.** "aaryapatil/tapify: v0.1.0". Zenodo. doi.org/10.5281/zenodo.7312220

2022 Cruz, K.; Günther, H. M.; **Patil, A.**; Swinbank, J.; & Tollerud, E. "Astropy Proposal for Enhancement 19: Distributing Astropy Project Funding (APE19)". Technical Report, Zenodo. doi.org/10.5281/zenodo.6312048

2021 Robitaille, T. et al. incl. **Patil, A.** "astropy/astropy: v4.2.1", Zenodo. doi.org/10.5281/zenodo.4670729

Major Fellowships & Awards

2024 **Best Astrostatistics Student Paper Finalist** (one of 5 finalists) finals in August
American Statistical Association (ASA)/Astrostatistics Interest Group, award for Patil et al. (2023)

2026 - 2027 **MPIA Postdoctoral Fellowship**
MPIA, catalyst fellowship extension

2023 - 2026 **LSST-DA Catalyst Fellowship** USD 72,100/year
LSST Discovery Alliance, independent fellowship with USD 15k research budget/year

2022 - 2023 **Data Sciences Institute Doctoral Student Fellowship** CAD 25,000/year
Data Sciences Institute, University of Toronto (UofT), up to 3 years of funding

2022 **Best Astrostatistics Student Paper Finalist** (one of 5 finalists) USD 1,100
ASA/Astrostatistics Interest Group, award for Patil et al. (2022)

2021 - 2022 **International Graduate Student Doctoral Fellowship** CAD 3,000
D. A. D. Dept. of Astronomy & Astrophysics (DADDAA), UofT

2021 **Delta Kappa Gamma World Fellowship Runner-up**
International World Fellowship Committee, Delta Kappa Gamma

2018 - 2023 **University of Toronto Fellowships** CAD 80,000

2018 - 2021 **Massey College UofT Junior Fellowship** CAD 11,000

2017 **ABU ROBOCON 2017 - All India Rank 10** out of 125 teams
Programming Head, Pune Institute of Computer Technology Robotics Team

Major Grants

2022 - 2023 **Astropy Cycle III Funding Grant** USD 20,220
Co-Investigator (Co-I): "Python/Astropy Training School in Bulgaria" ($8,670)
Lead: "Pan-African School for Emerging Astronomers (PASEA) 2022 in Zambia" ($11,550)

2022 - 2023 **Dunlap Institute (UofT) Seed Funding Grants** CAD 35,968
Co-I: "PASEA 2022 in Zambia" ($29,100)
Co-I: "Intertwining Dunlap/UofT & Sustainable Open-Source Software via Astropy" ($6,868)

Presentations

Invited

2024 **Königstuhl Colloquium**, Feb. 16 Heidelberg, Germany
"Understanding the formation history of the Milky Way galaxy using astrostatistics"

2024 **243rd meeting of the American Astronomical Society**, Jan. 8 New Orleans, USA
Expert panelist: "Building on 25 Years of Community Organization in Astro Software Development"

2023 **Toronto AstrophysicS Talks, Y'all (TASTY)**, Nov. 2023 Toronto, Canada
"Building a unified model of the Milky Way galaxy"

2023 **LSST Discovery Alliance Catalyst Symposium**, Oct. 23 Tucson, USA
"Building a unified model of the Milky Way galaxy using Rubin/LSST"

2023 **NRC Herzberg Astronomy and Astrophysics**, March 1 Victoria, Canada
"Building a unified model of the Milky Way galaxy"

2022 **Good Vibrations Seminar**, Oct. 26
"Multitaper Spectral Analysis: Precise asteroseismic modeling of stars, exoplanets, and beyond" (virtual)

2022 **Astronomical Software Development Workshop**, May 20 New York, USA
"Project Governance & Management" Session Lead (cancelled due to COVID-19)

2021 **Women of Aeronautics and Astronautics (WoAA), India**, Dec. 4
Around the World Speaker Series: "From Computer Engineering to Astrophysics" (virtual)

2021 **Statistical Challenges in Modern Astronomy VII Conference**, June 10
Bayesian Breakout: "Likelihood-free Inference of Chemical Homogeneity in Open Clusters" (virtual)

2020 **Joint Conf. for Sch. & Uni. students on Natural & Math. Sciences, Ukraine**, Dec. 3
"How did the Milky Way Galaxy Form and Evolve?" (virtual)

2020 **International CHASC AstroStatistics Centre, Harvard University**, Nov. 17
"Likelihood-free Inference of Chemical Homogeneity in Open Clusters" (virtual)

Conferences/Seminars

2024 **243rd meeting of the American Astronomical Society**, Jan. 8 New Orleans, USA
"Decoding the age-chemical structure of the Milky Way disk: An application of Copulas and Elicitable Maps"

2023 **Astrostatistics in Canada and Beyond**, Nov. 2 Banff, Canada
"Decoding the age-metallicity structure of the Milky Way disk using Copulas & Elicitable Maps"

2023 **Joint Statistical Meetings (JSM) Conference**, Aug. 8 Toronto, Canada
"Improving Power Spectral Estimation using Multitapering: Precise modelling of stars, exoplanets, and beyond"

2023 **TASC7/KASC14 Workshop**, July 21 Honolulu, USA
"Multitaper Spectral Analysis: Precise asteroseismic modeling of stars, exoplanets, and beyond"

2023 **Canadian Astronomical Society (CASCA) Meeting**, June 14 Penticton, Canada
"Building a unified model of the Milky Way galaxy"

2023 **Wide-Field Spectroscopy vs Galaxy Formation Theory**, March 29 Tucson, USA
"Decoding the age-metallicity structure of the Milky Way disk: An application of Copulas and Elicitable Maps"

2022 **JSM Conference**, Aug. 11 D.C., USA
ASA/AIG Finals: "Functional Data Analysis for Extracting the Intrinsic Dimensionality of Spectra"

2022 **TASC6/KASC13 Workshop**, July 11
Pitch:"Asteroseismology with Multitaper Methods: Improvements for Stars, Planets & the Milky Way" (virtual)

2022 **Multitaper Spectral Analysis Workshop**, June 26
"Asteroseismology with Multitaper Methods" (virtual)

2021 **Statistics & MachIne LEarning (SMILE) Journal Club, UofT**, Nov. 19
"Multitaper Spectral Estimation for Asteroseismology" (virtual)

2021 **HRMOS Science Workshop**, October 21
"Functional Data Analysis for Extracting the Intrinsic Dimensionality of Spectra" (virtual)

2021 **Sloan Digital Sky Survey (SDSS) Meeting**, August 11
"Functional Data Analysis for Extracting the Intrinsic Dimensionality of Spectra" (virtual)

2021 **JSM Conference**, August 10
"Modeling the Chemical Structure of Stars: Functional Data Analysis & Bayesian Inference" (virtual)

2021 **GALactic Archaeology with HERMES Science Meeting**, June 24
"Functional Data Analysis for extracting the Intrinsic Dimensionality of Spectra" (virtual)

2021 **SCMA VII Conference**, June 7
Poster: "Functional Data Analysis for extracting the Intrinsic Dimensionality of Spectra" (virtual)

2021 **Stellar Stats Workshop, UofT**, May 28
"Functional Principal Component Analysis (FPCA) in Stellar Spectroscopy" (virtual)

2020 **SMILE, UofT**, October 16
"Introduction to Neural Networks" (virtual)

2020 **JSM Conference**, August 4, **SDSS Meeting**, June 24
"Likelihood-free Inference of Chemical Homogeneity in Open Clusters" (virtual)

2019 **Canadian Astronomical Society (CASCA) Conference**, June 17 Montreal, Canada
Poster: "CHIME/Pulsar Evolution of PSR B1508+55: Potential Echoes from the Interstellar Medium"

2018 **Global Radio Scintillometry Astrophysics Conference**, October 20 Shanghai, China
Poster: "CHIME Monitoring of Pulsars & the Interstellar Medium towards them"

2018 **Python in Astronomy Conference**, April 30 New York, USA
"GSoC 2017 with Astropy"

Mentoring and Teaching

Graduate Student Mentor

2024 - Present **Jenny Su** (Astronomy & Astrophysics, UofT) with Gwendolyn Eadie (UofT)
AST 1501 project: "Estimating the periodicities of RR Lyrae stars using the multitaper F-test"

2022 - Present **Jiayi Sun** (Computer Eng., UofT) with Shurui Zhou (UofT) and Jin Guo (McGill)
PhD project: "Improving collaboration efficiency of open-source scientific software teams"

2021 **Suyog Garg** (Physics, University of Tokyo) with Hans Moritz Guenther (MIT)
GSoC project: "Implementing the MRT/CDS table standards in Astropy"

Instructor

2023 **The Astropy training school** Sofia, Bulgaria
Co-designed & taught a week-long (40 hrs) intensive Astropy course for students/scientists from Eastern Europe

2022 **Pan-African School for Emerging Astronomers (PASEA)** Livingstone, Zambia
Co-designed & taught a week-long (40 hrs) intensive Python/Astropy course for postgraduate students from Africa

2022 **PASEA Alumni Research Program (Virtual)**
Co-designed & taught a Python online course on Astronomical Data Analysis to PASEA alumni

Teaching Assistant (TA)

2021, 2022 **Head TA**, AST 201: The Sun and its Neighbours, UofT
2020, 2021 **TA**, AST 221: Stars and Planets, UofT
2019, 2020 **TA**, AST 201: The Sun and its Neighbours, UofT

2018, 2019 **TA**, AST 101: Stars and Galaxies, UofT

Workshops

2024 **Introduction to Statistics 101** MPIA, Germany
Designed and taught a hands-on statistics workshop over 6 hours

Training & Certification

2021 - 2022 Teaching Fundamentals Certificate, Teaching Assistants' Training Program, UofT
2020 Advanced Training in Academic Writing and Speaking, GCAC, UofT

Active Scientific Collaborations

2024 **Euclid consortium**: Member working on some of the first images/spectra
2023 **LSST Discovery Alliance**: One of the Rubin community ambassadors as a catalyst fellow
2020 **Kepler Asteroseismic Science Consortium**: Member working on Kepler time-series analysis
2019 **Sloan Digital Sky Survey-IV**: Member working on APOGEE spectral analysis
2017 **The Astropy Collaboration**: Core team member developing software and managing finances

Software Skills

Programming Languages

Advanced	Python, C/ C++, Shell Script
Intermediate	R, Java, JavaScript

Open-Source Packages

Lead	`tapify`
Contributor	`astropy` (#33), `sewpy` (major), `numpy` (minor)
Example Codes	`specdims`, `mtls`, `XOdia`, `Assembly`
Competitive Coding	CodeChef
Frameworks/Tools	Git, Emacs, TensorFlow/PyTorch/Keras, CUDA, MATLAB, Raspberry Pi

Selected Professional Activities & Services

Workshops & Schools

2023 **Scientific Organizing Committee Member**, Python/AstroPy training school
2022 - Present **Organizer, Postgraduate Stream Instructor**, PASEA, Africa
2022 **Scientific Organizing Committee Member**, Gaia Hike Workshop
Co-developed the talk/tutorial schedule and led the unconference session programming

Organizations

2021 - Present **Finance Committee Member, Voting Member**, The Astropy Project
Helped raise/manage ∼1.6 million USD for the project, Ranked 32nd in code contributions

2021 - Present **International Member**, WoAA, India
Supporting women, gender minorities, LGBTQI+ people in aeronautics, astronautics, STEM

University of Toronto

2022 - Present **Organizing Committee Member**, SMILE Journal Club
Inviting local/external speakers in astrostatistics and astroinformatics; organizing talks

2021 - Present **Learn Astropy Project Local Representative**, Dunlap Institute
Improving the computing skills of the Institute and developing educational resources for Astropy

2021 - 2022 **Anti-Racism Meetings Organizing Member**, DADDAA
Running weekly meetings to learn and to take action against racism in the workplace

2021 - 2022 **Undergraduate/Graduate Mentor** (Student Life), Astronomy & Astrophysics

2020 - Present **Governing Board Risk Committee Member**, Massey College
First Elected Student on the Governing Board; helped develop the COVID-19 risk plan

2019 - Present **MasseyScope Committee Co-founder**, Massey College
Organizing astronomy outreach with a focus on underprivileged communities

2018 - 2020 **Anti-Racism and Diversity Committee Co-chair**, Massey College

2019 - 2020 **Lionel Massey Fund Co-chair, Treasurer** (Student Life), Massey College

2018 - 2021 **Mental Health, Health & Safety, Course Committee Member**, Grad. Astronomy

Other Outreach

2018 - 2022 AstroTours Toronto Outreach Volunteer
2018 - 2020 Astronomy on Tap Toronto Volunteer
2020 National Society of Black Physicists Booth Volunteer
2019 Planet Party Toronto Volunteer
2019 Science Rendezvous Toronto Volunteer

MEDIA

2021 **Massey Dialogues**: "The Stars are Aligned, the Future of Astrophysics", UofT
A publicly-streamed conversation with CITA Director Juna Kollmeier and Martine Lokken

Languages

English Near-native reading, speaking, oral comprehension, and writing
German Intermediate reading; beginner speaking, oral comprehension, and writing
Hindi Native Speaker
Marathi Native Speaker