

Matt L. Sampson

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Education

Princeton University Princeton, USA
Doctor of Philosophy 2022-Present

- **Specialization:** Machine learning, computational astrophysics

Princeton University Princeton, USA
Masters of Science 2022-2023

Australian National University Canberra, Australia
Honours (First class) 2021

- **Thesis:** “Simulating large scale cosmic ray propagation through compressible magnetohydrodynamic turbulence”

Queensland University of Technology Brisbane, Australia
Bachelor of Science 2017-2020

- **Major:** Physics

Queensland University of Technology Brisbane, Australia
Bachelor of Mathematics 2017-2020

- **Major:** Applied and Computational Mathematics
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Research Interests

- **Representation learning and optimization:** how and why do neural networks learn the representations they do, is there a way to understand the training dynamics in deep learning?
- **Dynamical systems and world models:** How can we best represent/capture complex dynamical systems we observe within deep neural networks. Can we build informative world models of these systems?
- **Machine learning for science:** Machine learning models show incredible predictive power, can we harness the learned representations to increase our own understanding of the physical systems we model?

Long-term Vision: To build models that robustly learn representations of complex dynamical systems — enabling both deeper scientific understanding and the development of autonomous agents capable of reasoning within these physical environments.

Professional Service

Referee Activity

- NeurIPS 2024 (Main conference)
- NeurIPS 2023,2024 (Machine learning for the physical sciences)
- ICML 2023 (Machine learning for astrophysics)

- The Astrophysical Journal
 - Monthly Notices of the Royal Astronomical Society
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Publications (citations: 266, h-index: 5) J=Journal, C=Conference/workshop, R=Submitted/In review

- [J, R] **Sampson, M. L.**, et al., (2025) "Two-moment cosmic ray fluid - plasma coupling in isothermal, supersonic, magnetized turbulence relevant to the interstellar medium"
The Astrophysical Journal, <https://arxiv.org/abs/2506.03768>
- [J] Ward, C., Melchior, P., **Sampson, M.L.**, et al., (2025). "Disentangling transients and their host galaxies with scarlet2: A framework to forward model multi-epoch imaging." *Astronomy and Computing*, 100930
Citations: 3
- [J] **Sampson, M. L.**, Melchior, P., (2024). "Path-minimised latent ODEs as inference models" *Machine Learning: Science and Technology*, 6, 025047
Citations: 1
- [J] **Sampson, M. L.**, Melchior, P., Ward, C., & Birmingham, S. (2024). "Score-matching neural networks for improved multi-band source separation" *Astronomy and Computing*, 49, 100875
Citations: 8
- [C] **Sampson, M. L.**, Melchior, P. (2023) "Spotting Hallucinations in Inverse Problems with Data-Driven Priors" *ICML ML4 Astro Spotlight talk*, [arXiv:2306.13272](https://arxiv.org/abs/2306.13272)
Citations: 2
- [J] **Sampson, M. L.**, Beattie, J. R., Krumholz, M. R., et al. (2023) "The turbulent diffusion of streaming cosmic rays through compressible, partially ionised plasma." *Monthly Notices of the Royal Astronomical Society* 519 (1), 1503-1525
Citations: 28
- [J] Krumholz, M. R., Crocker, R. M., **Sampson, M. L.**, (2022) "Cosmic Ray Interstellar Propagation Tool using Itô Calculus (CRIPTIC): software for simultaneous calculation of cosmic ray transport and observational signatures." *Monthly Notices of the Royal Astronomical Society* 517 (1), 1355-1380
Citations: 16
- [J] Beattie, J. R., Krumholz, M. R., Federrath, C., **Sampson, M. L.**, Crocker, R. M. (2022). "Ion Alfvén velocity fluctuations and implications for the diffusion of streaming cosmic rays" *Frontiers in Astronomy and Space Sciences*
Citations: 19
- [J] Stevenson, S., **Sampson, M. L.**, Powell, J., et al. (2019). "The impact of pair-instability mass loss on the binary black hole mass distribution." *The Astrophysical Journal*, 882(2), 121.
Citations: 189
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Teaching Experience

Teaching philosophy: I believe that education is one of the most important and impactful components of ones life, and a high quality education should be available to all regardless of background.

I have experience teaching the following units at Princeton University and the Queensland University of Technology where my role ranged from the delivery of lectures, leading tutorials, grading work, and engaging students with new content such as programming languages and higher level statistics for the first time.

- AST205 Planets and the Universe (1 Semester)
- SEB104 Grand Challenges in Science (3 Semesters)
- SEB113 Quantitative Analysis (3 Semesters)
- SEB115 Experimental Science (2 Semesters)
- PVB101 Physics of the Very Large (2 Semesters)
- BVB204 Ecology - Statistics Component (2 Semesters)

Mentorship

Undergraduate Summer Research Program

- Co-mentor with Prof. Charlotte Ward and Prof. Peter Melchior for Sufia Birmingham

Research Tutor

- Mentor in computational astrophysics research for Harry Van Der Ark (new at Columbia University)

Technical Skills

Languages: Python (JAX, PyTorch, diffrax, equinox), C++, R, MATLAB, FORTRAN (*ordered by proficiency*)

Mathematical: advanced calculus and linear algebra, ODEs/PDEs, statistics and probability, Bayesian inference, computational statistics

Dev/Databases/Other: Git, bash, remote/cluster computing, high-performance computing, SQL

Outreach and Community Service

Mercer Community College Astrophysics club

- I am passionate about the importance of education for all, with a strong focus on improving access to education from those with traditionally disadvantaged backgrounds
- I lead a series of yearly workshops teaching local community college students programming and machine learning skills
- Students from this have gone on to participate in both internship opportunities and transfer offers at 4-year institutions such as Princeton University and others

Princeton Thursday Lunch Seminar Series

- Event host/organizer

QUT Astrophysics Society

- Club president
- Led Python for Astrophysics workshop

Talks

Select list of invited, and contributed talks

- “Machine Learning for Astrophysics”. *Princeton Undergraduate Research School*, Princeton 2025.
 - “Latent ODEs for time series modelling and inference”. *Ciela Institute’s Astromerique student talk series*, (virtual) 2024.
 - “Score-based diffusion models with uncertainty quantification”. *Data Science X Astro seminar*, 2024.
 - “Spotting hallucinations in inverse problems with data-driven priors”. *ICML ML4Astro workshop*, Hawaii, 2023.
 - “Score-based diffusion models for galaxy separation”. *Cosmic Connections Symposium*, Flatiron Institute, NY, 2023.
 - “Turbulent diffusion of streaming cosmic rays”. *ACAMAR Meeting on Astroparticle Physics*, Perth, 2022.
 - *et. al.*, “Simulating large scale cosmic ray propagation through compressible magnetohydrodynamic turbulence”. *Australian Institute of Physics Summer Conference*, Brisbane, 2021.
 - *et. al.*, “Rapid and Effective Population Calibration with modified MCMC”. *Australian National University Student Conference*, Canberra, 2020 (best science talk prize).
 - *et. al.*, “The impact of pair-instability mass loss on the binary black hole mass distribution”. *Australian National Institute for Theoretical Astrophysics*
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Awards and Honors

- 2022 [Princeton Graduate Program First Year Fellowship in Natural Sciences](#)
- 2021 [Bok Honours Scholarship](#) in Astrophysics at the RSAA
- 2020 Deans List of Commendation for academic excellence
- 2020 Equal first place prize for best science talk at ANU RSAA student conference
- 2019 Accepted into the Deans Scholars Program QUT for high achieving students
- 2019 [ICRAR-Pawsey Centre Vacation Scholar](#)
- 2019 Deans List of Commendation for academic excellence
- 2018 [Swinburne Centre for Astrophysics and Supercomputing Summer Vacation Scholarship](#)
- 2018 Deans List of Commendation for academic excellence
- 2017 Accepted into QUT’s College of Excellence for high achieving students
- 2017 Deans List of Commendation for academic excellence