Matt L. Sampson

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Updated: September 30, 2025

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

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?

Long-term Vision: To design optimization methods that make it possible to build and train models with a deep understanding of complex dynamical systems — enabling new scientific discoveries and forming the foundations for increasingly general, physics-inspired intelligence.

Publications **(citations: 285, h-index: 5)** **J=Journal, C=Conference/workshop, R=Submitted/In review**

First author

[C, R] **Sampson, M. L.**, Melchior, P., (2025) "Dynamics of Learning: Generative Schedules from Latent ODEs" *https://arxiv.org/abs/2509.23052*

[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] **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: 10**

[C] **Sampson, M. L.**, Melchior, P. (2023) "Spotting Hallucinations in Inverse Problems with Data-Driven Priors" *ICML ML4 Astro Spotlight talk, arXiv: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: 33**

Second author/major contributions

[C] Yan, A., **Sampson, M. L.**, Melchior, P., (2025) "A novel approach to classification of ECG arrhythmia types with latent ODEs"
NeurIPS Time Series for Health Workshop

[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: 17**

[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: 199**

Co-author

[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] 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: 20**

Software

- Major contributor to Scarlet2, python based software for galactic source deblending. Contributed a score-based diffusion model to act as neural priors for galaxy morphology.
- Co-developer of CRIPTIC, C++ software for simulation of cosmic ray transport

Teaching Experience

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 Quantatative 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 (now 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

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

Outreach and Community Service

Mercer Community College Machine Learning 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

Selected 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.

Awards and Honors

- 2025 Google PhD Fellowship (Nominee)
  - One of four PhD students university-wide nominated by Princeton University for Google's North American PhD fellowship program
- 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