Matthew Ho

Postdoctoral Research Fellow

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Highlights

- Authored 22 papers in leading astrophysics, machine learning, and physics journals.
- Mentored 12 students (11 undergraduate, 1 Master's), with five currently in top Ph.D. programs.
- Core collaborator on major research grants, securing over $7 million in total funding.
- Leader of the Implicit Likelihood Inference group (Learning the Universe Collaboration) and an active member of the Euclid, the LSST Dark Energy Science, and the Aquila consortia.
- Extensive teaching experience as an instructor, teaching assistant (10+ courses), and guest lecturer for university courses and summer schools.

Experience

Institut d'Astrophysique de Paris & Columbia University *Paris, FR & New York City, NY*

Postdoctoral Research Fellow *September 2022 - August 2026*

Joint 2+2 year position within the Simons Collaboration on Learning the Universe developing accelerated emulators and inference models for cosmological analysis.
Advisor: Benjamin Wandelt, Guilhem Lavaux, Greg Bryan

Education

Carnegie Mellon University *Pittsburgh, PA*

Ph.D., M.S. Physics *August 2017 - August 2022*

Thesis: Deep Learning for Dynamical Mass Estimation of Galaxy Clusters
Advisor: Hy Trac
GPA: 3.97

Carnegie Mellon University *Pittsburgh, PA*

M.S. Machine Learning *August 2021 - May 2022*

Research Interests: Deep Learning, Bayesian Modeling, Approximate Inference, Generative Models
GPA: 4.0

University of Illinois at Urbana-Champaign *Urbana, IL*

B.S. Engineering Physics *August 2014 - May 2017*

Minor in Mathematics
Research advisors: Lucas Wagner, Guy Garnett

Publications

∗ Highlighted works

Published

Sommovigo, L., Cochrane, R. K., …, **Ho, M.**, et al. 2025, "Learning the Universe: physically-motivated priors for dust attenuation curves" *The Astrophysical Journal*, 990, 114

∗**Ho, M.**, Zhao, X., and Wandelt, B. 2025, "Ordered Embeddings and Intrinsic Dimensionalities with Information-Ordered Bottlenecks" *Machine Learning: Science and Technology* Volume 6, Issue 3

Lue, A., Genel, S., …, **Ho, M.**, et al. 2025, "Cosmology with One Galaxy: Auto-Encoding the Galaxy Properties Manifold" *The Astrophysical Journal*, Volume 986, Issue 2

Ricketts, B. J., Huppenkothen, D., …, **Ho, M.**, et al. 2025, "RTFAST-Spectra: Emulation of X-ray reverberation mapping for active galactic nuclei" *MNRAS*, 538, 2

Bartlett, D., **Ho, M.**, and Wandelt, B. 2024, "Bye bye, LIMD bias: the statistics of the halo field are poorly determined by the local mass density" *The Astrophysical Journal Letters*, 977, 2

Modi, C., Pandey, M., **Ho, M.**, et al. 2023, "Sensitivity Analysis of Simulation-Based Inference for Galaxy Clustering" *MNRAS*, 536, 1

Bourdin, A., Legin, R., **Ho, M.** et al. 2024, "Inpainting Galaxy Counts onto N-Body Simulations over Multiple Cosmologies and Astrophysics" *ICML 2024 - AI4Science Workshop*

Kim, C., Ostriker, E., …, **Ho, M.** et al. 2024, "Metallicity Dependence of Pressure-regulated Feedback-modulated Star Formation in the TIGRESS-NCR Simulation Suite" *The Astrophysical Journal*, 972, 1

∗**Ho, M.**, Bartlett, D., Chartier, N. et al. 2024, "LtU-ILI: An All-in-One Framework for Implicit Inference in Astrophysics and Cosmology" *Open Journal of Astrophysics*, 7

Legin, R., **Ho, M.**, Lemos, P., et al. 2024, "Posterior sampling of the initial conditions of the universe from non-linear large scale structures using score-based generative models" *MNRAS*, 527, 1

Ho, M., Soltis, J., Farahi, A., et al. 2023, "Benchmarks and Explanations for Deep Learning Estimates of X-ray Galaxy Cluster Masses" *MNRAS*, 524, 3

Soltis, J., ..., **Ho, M.**, et al. 2022, "A Machine Learning Approach to Enhancing eROSITA Observations" *The Astrophysical Journal*, 940, 60S

∗**Ho, M.**, Ntampaka, M., Rau, M. M., et al. 2022, "The Dynamical Mass of the Coma Cluster from Deep Learning" *Nature Astronomy*, 6 (8), 936-941

Aguena, M., Avestruz, C., …, **Ho, M.**, et al. 2021, "CLMM: a LSST-DESC Cluster weak Lensing Mass Modeling library for cosmology" *MNRAS*, 508, 6092

Ho, M., Farahi, A., Rau, M. M., Trac, H. 2021, "Approximate Bayesian Uncertainties on Deep Learning Dynamical Mass Estimates of Galaxy Clusters" *The Astrophysical Journal*, 908, 204H

Farahi, A., **Ho, M.**, & Trac, H. 2020 "Aging Halos: Implications of the Magnitude Gap on Conditional Statistics of Stellar and Gas Properties of Massive Halos" *MNRAS*, 493, 1, 1361-1374

Ho, M., Rau, M. M., Ntampaka, M., et al. 2019, "A Robust and Efficient Deep Learning Method for Dynamical Mass Measurements of Galaxy Clusters" *The Astrophysical Journal*, 887, 1

In Press

Lovell, C., Starkenburg, T., **Ho, M.**, et al. 2025, "Learning the Universe: Cosmological and Astrophysical Parameter Inference with Galaxy Luminosity Functions and Colours" Accepted in *MNRAS*

In Review

Macias, O., Mason, Z., **Ho, M.**, et al. 2024, "Simulation-Based Inference for Direction Reconstruction of Ultra-High-Energy Cosmic Rays with Radio Arrays" Submitted to *Physical Review D*

Hsu, A., **Ho, M.**, Lin, J., et al. 2024, "Reconstructing Galaxy Cluster Mass Maps using Score-based Generative Modeling" Submitted to *The Astrophysical Journal*

Pandey, S., Modi, C., …, **Ho, M.** et al. 2024, "CHARM: Creating Halos with Auto-Regressive Multi-stage networks" Submitted to *MNRAS*

Huppenkothen, D., Ntampaka, M., **Ho, M.**, et al. 2023, "Constructing impactful machine learning research for astronomy: Best practices for researchers and reviewers" Submitted to *BAAS*

Grants & Fellowships

2025-2028	**Simons Collaboration**, Simons Foundation Collaborator on a renewal grant for the Learning the Universe Simons Collaboration, securing $6M in total funding ($700K allocated to Columbia University) to advance research on machine learning analysis of cosmological and galaxy formation models. The grant emphasizes applications to next-generation observatories, including JWST, DESI, *Euclid*, and the Simons Observatory.	*$6,000,000*
2024-2025	**NSF ACCESS Maximize Computing Grant**, National Science Foundation Collaborator on a computing grant awarding 42 million CPU hours and 20 GPU-years to run advanced dark matter and hydrodynamical simulations, and to develop machine learning emulators for the Learning the Universe project.	*$438,732*
2023-2025	**ANR Appel à projets générique**, Agence nationale de la recherche (French National Research Agency) Collaborator on an ANR AAPG grant (INFOCW) awarded to use state-of-the-art simulations and machine learning inference to analyze large-scale structure maps, with the aim of inferring the universe's cosmological parameters and initial conditions.	*€304,261*
2022-2025	**NSF Astronomy and Astrophysics Research Grant**, National Science Foundation Collaborator on a NSF grant (AST 2206055) awarding to develop new multiwavelength machine learning models to probe halo environments and galaxy formation in cluster- and group-scale systems.	*$538,957*
2021	**John Peoples, Jr. Research Fellowship in Physics**, Department of Physics, CMU Recipient of full tuition and stipend, awarded annually to one outstanding physics graduate student.	*$40,000*
2020	**McWilliams-PSC Research Seed Grant**, McWilliams Center for Cosmology Recipient of full tuition and stipend for pursuing innovative, high-impact scientific research.	*$40,000*

Presentations

Invited

August 2025. *Learning the Universe: Building a Scalable, Verifiable Emulation Pipeline for Astronomical Survey Science*. NSF IAIFI Summer Workshop, Harvard University, Cambridge, MA

April 2025. *Learning the Universe: Building an Accelerated Modeling Pipeline for Cosmological Surveys*. Yale Data Science and Physics Seminar, Yale University, New Haven, CT

March 2025. *Science or Serendipity? Validation Tests with Explanations*. Chesapeake ML-Astro Group, Space Telescope Science Institute, Baltimore, MD

March 2024. *Introduction to the LtU-ILI Inference Pipeline*. Simulation Based Inference for Galaxy Evolution, University of Bristol, Bristol, UK

November 2022. *Observational Inference with Machine Learning: Investigations in Galaxy Cluster Mass Estimation*. Institut d'Astrophysique de Paris Univers Seminar, Institut d'Astrophysique de Paris, Paris, FR

March 2022. *Observational Inference in the Era of Machine Learning*. Yale Data Science X Astronomy & Astrophysics Seminar, New Haven, CT

March 2022. *Observational Inference in the Era of Machine Learning*. Cosmic Physics Center, Fermilab, Batavia, IL

February 2021. *Galaxy Cluster Mass Estimation Using Deep Learning*. NSF AI Planning Institute for Physics of the Future, Carnegie Mellon University, Pittsburgh, PA

December 2020. *Galaxy Cluster Mass Estimation Using Deep Learning*. Artificial Intelligence Interest Group, Dark Energy Science Initiative

June 2019. *Galaxy Cluster Mass Estimation Using Deep Learning*. Weak Lensing Seminar, Universitaets-Sternwarte der Ludwig-Maximilians-Universitaet, Munich, Germany

Contributed

September 2025. *Learning the Universe: Building a Scalable, Verifiable Emulation Pipeline for Astronomical Survey Science*. Open SkAI, NSF-Simons AI Institute for the Sky, Chicago, IL

May 2025. *Scientific Discovery from Ordered Information Decomposition*. Cosmic Horizons Conference, University of Texas at Austin, Austin, TX

December 2024. *Practical Simulation-Based Cosmological Inference with Learning the Universe*. Cosmology and Galaxy Astrophysics with Simulations and Machine Learning 2024, Center for Computational Astrophysics, New York City, NY

May 2024. *Scientific Discovery from Ordered Information Decomposition*. European AI For Fundamental Physics Conference, Amsterdam, NL

November 2023. *Scientific Discovery from Ordered Information Decomposition*. Debating the Potential of Machine Learning in Astronomical Surveys, Institut d'Astrophysique de Paris, Paris, FR

April 2022. *Galaxy Cluster Mass Estimation Using Deep Learning*. Galaxy Clusters 2022: Challenging Our Cosmological Perspectives, Space Telescope Science Institute, Baltimore, MD

September 2021. *Galaxy Cluster Masses from Approximate Bayesian Deep Learning*. A Multi-Wavlength View of Galaxy Clusters: Deriving Masses in the Era of Wide-Field Surveys, European Space Agency

June 2020. *Galaxy Cluster Mass Estimation Using Deep Learning*. Astrostatistics Interest Group 2020 Student Paper Finalists, Joint Statistical Meeting, Philadelphia, PA

June 2019. *A Robust and Efficient Deep Learning Method for Dynamical Mass Measurements of Galaxy Clusters*. Artificial Intelligence Methods in Cosmology Workshop, Ascona, Switzerland.

May 2018. *Improving Mass Measurements of Galaxy Clusters through Applications of Machine Learning*. Machine Learning in Science and Engineering Conference, Carnegie Mellon University, Pittsburgh, PA

April 2015. *Dynamic Particle Control and Simulation*, NCSA Students Pushing Innovation Seminar, National Center for Supercomputing Applications, Urbana, IL

December 2014. *Gestural Recognition of Human Expression*, NCSA Students Pushing Innovation Seminar, National Center for Supercomputing Applications, Urbana, IL

Teaching Experience

Fall 2025	**IMPRS Heidelberg Summer School on AI for Astronomy**, Lecturer	*Heidelberg*
Fall 2024	**Frontiers of Astrophysics**, Guest Lecturer	*Columbia*
Summer II 2021	**Introduction to Astronomy**, Instructor	*CMU*
Spring 2021	**Advanced Computational Physics**, Teaching Assistant	*CMU*
Fall 2019	**Matter & Interactions I**, Teaching Assistant	*CMU*
Summer II 2019	**Physics I for Engineering Students**, Teaching Assistant	*CMU*
Summer II 2019	**Physics for Future Presidents**, Teaching Assistant	*CMU*
Summer I 2019	**Physics II for Engineering and Physics Students**, Teaching Assistant	*CMU*
Spring 2019	**Physics II for Engineering and Physics Students**, Teaching Assistant	*CMU*
Fall 2018	**Matter & Interactions I**, Teaching Assistant	*CMU*
Spring 2018	**Physics II for Engineering and Physics Students**, Teaching Assistant	*CMU*
Fall 2017	**Matter & Interactions I**, Teaching Assistant	*CMU*

Mentoring

2025-	**Ariyana Bonab**, City University of New York	*Masters*
2024-	**Chaipat Tirapongprasert**, Columbia University	*Undergrad*
2024-2025	**Thais Velazquez**, Barnard College	*Undergrad*
2023-2025	**Antoine Bourdin**, Université de Montréal *Now Ph.D. at University of Chicago*	*Undergrad*
2023-2025	**Kalvyn Adams**, University of Colorado, Boulder *Now Ph.D. at University of California, Los Angeles*	*Undergrad*
2022-2024	**Alan Hsu**, Carnegie Mellon University *Now Ph.D. at Harvard University*	*Undergrad*
2023-2024	**Caleb Ogle**, University of Colorado, Boulder *Now Ph.D. at University of Wisconsin, Milwaukee*	*Undergrad*
2022-2023	**Joyce Lin**, Carnegie Mellon University *Now Ph.D. at University of Wisconsin, Madison*	*Undergrad*
2022-2023	**Kevin Hu**, Yale University	*Undergrad*
2021	**Bryant Dean**, Morehouse College	*Undergrad*
2020-2021	**Faith Ruehle**, Carnegie Mellon University	*Undergrad*
2019-2020	**Alexa Lansberry**, Carnegie Mellon University	*Undergrad*

Organized Conferences & Workshops

2025	**Simulation-Based Inference for Galaxy Evolution Workshop**, Scientific Organizing Committee	*Bristol, UK*
2024	**Cosmology and Galaxy Astrophysics with Simulations and Machine Learning Conference**, Scientific Organizing Committee	*New York City, NY*
2024	**Simulation-Based Inference for Galaxy Evolution Workshop**, Scientific Organizing Committee	*Bristol, UK*

Service & Outreach

2025	**Astronomy on Tap - Baltimore**, Presenter
2024-	**Aquila Consortium Contact Unit**, Committee Member
2023	**Learning Learning the Universe**, Organizer and Presenter
2022	**Astronomy on Tap - Pittsburgh**, Presenter
2021	**Carnegie Science Center**, Career Panelist
2020-2021	**McWilliams Software Seminar Series**, Organizer
2020-2021	**Vera Computing System Commissioning Committee**, Committee Member
2017-2021	**Department of Physics Industry Speaker Seminar Series**, Founder, Organizer
2019-2020	**CMU Data Science Club**, Project Lead

Peer Review

- The Astrophysical Journal
- Nature Astronomy
- Journal of Cosmology and Astrophysics
- Monthly Notices of the Royal Astronomical Society

Professional Memberships

- Simons Collaboration on Learning the Universe
- Euclid Consortium
- Aquila Consortium
- LSST-Dark Energy Science Collaboration
- American Statistical Association