RESUME

Michael W. Toomey, Ph.D.

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SUMMARY

Physicist with 10+ years of experience developing and deploying statistical and ML models for large-scale scientific data analysis. Expertise in Bayesian inference, deep learning (CNNs, transformers, normalizing flows, diffusion models), and high-dimensional statistical modeling. Published 25 peer-reviewed papers with 1,100+ citations. Proven track record leading cross-institutional research teams and mentoring 37+ students.

TECHNICAL SKILLS

Languages	Python, C, Cython, Shell
ML/AI	PyTorch, normalizing flows, diffusion models, CNNs, vision transformers, self-supervised learning, domain adaptation, anomaly detection, Bayesian inference, MCMC
Data & Computing	Monte Carlo simulation, high-performance computing, statistical modeling, image processing, large-scale data pipelines
Software & Tools	Git/GitHub, Linux, LaTeX; author of 5 open-source scientific software packages

EXPERIENCE

Massachusetts Institute of Technology 2023 – Present
Postdoctoral Research Fellow *Center for Theoretical Physics*

- Developed normalizing flow models to learn physically motivated prior distributions for Bayesian parameter estimation, improving inference speed by orders of magnitude over traditional MCMC sampling.
- Built simulation-based inference pipelines combining large-scale cosmological simulations with neural network surrogates to constrain fundamental physics parameters from galaxy survey data (DESI, BOSS, SDSS).
- Led end-to-end analysis of DESI survey data using novel statistical frameworks for model selection and Bayesian model comparison, resulting in 3 first-author publications.
- Designed and trained conditional diffusion models and vision transformers for super-resolution and feature extraction from noisy, high-dimensional image data.
- Initiated development of LLM-driven framework for automated scientific model-building; accepted to NeurIPS 2025 and the Conference on Language Modeling.
- Mentored 10+ graduate and undergraduate researchers across MIT, Harvard, and international institutions on ML-driven research projects.

Brown University 2018 – 2023
Graduate Research Assistant *Advisor: Prof. Stephon Alexander*

- Built deep learning pipelines (CNNs, unsupervised methods, domain adaptation) to detect and classify dark matter signatures in simulated gravitational lensing images; published in *The Astrophysical Journal*.
- Developed modified Boltzmann solvers and statistical inference frameworks to test cosmological models against observational data; key papers garnered 400+ combined citations.

· Created and released open-source software packages for Monte Carlo simulation (`NPTFit-Sim`), cosmological modeling (`CLASS_EDE`, `CLASS_KINETIC`), and ML-based image analysis (`DeepLense`).

Microsoft Research Summer 2020
Research Intern

· Collaborated with Jaron Lanier and Lee Smolin on a research program at the interface of theoretical physics, machine learning, and computer science; contributed to "The Autodidactic Universe" (2021).

Google Summer of Code 2019 – Present
Machine Learning for Science (ML4Sci) Mentor

· Mentored 25+ students across 6 years developing ML algorithms—transformers, diffusion models, physics-informed neural networks, anomaly detection—for scientific image analysis.
· Student projects resulted in 20+ publications and 10 NeurIPS ML4PS workshop acceptances.

U.S. Naval Research Laboratory (NRL) Summer 2016
NREIP Research Intern

· Developed Python-based automation tools for the Fermi Large Area Telescope (Fermi-LAT), streamlining the processing of terabytes of high-energy astrophysical data.
· Contributed to the automated identification of gamma-ray sources, directly supporting the mission's cataloging efforts.

EDUCATION

Brown University *2019 – 2023*
Ph.D., Physics

Brown University *2018 – 2019*
Sc.M., Physics

The Pennsylvania State University *2014 – 2018*
Schreyer Honors Scholar
B.S., Astronomy and Astrophysics; B.S., Physics — *cum laude* with Honors

SELECTED PUBLICATIONS & IMPACT

25 papers | 10 first-author | 1,100+ citations | h-index: 15 | 10 NeurIPS workshop papers

M. W. Toomey et al., *Learning Theory Informed Priors for Bayesian Inference: A Case Study with Early Dark Energy*, PRD 112, 103539 (2025) — Normalizing flows for accelerated cosmological parameter estimation.

M. W. Toomey et al., *How Theory-Informed Priors Affect DESI Evidence for Evolving Dark Energy*, under review at PRD (2025) — Bayesian model comparison applied to DESI DR2 survey data.

M. M. Ivanov, C. Cuesta-Lazaro, **M. W. Toomey** et al., *Full-shape analysis with simulation-based priors*, PRD 110 (2024); PRL 134 (2025) — Simulation-based inference pipelines for galaxy survey analysis.

P. Reddy, **M. W. Toomey** et al., *DiffLense: A Conditional Diffusion Model for Super-Resolution of Gravitational Lensing Data*, MLST 5 (2024) — Diffusion models for scientific image enhancement.

S. Alexander, S. Gleyzer, E. McDonough, **M. W. Toomey**, E. Usai, *Deep Learning the Morphology of Dark Matter Substructure*, ApJ 893 (2020) — Pioneering CNN-based dark matter detection from images.

M. M. Ivanov, E. McDonough, J. C. Hill, M. Simonović, **M. W. Toomey** et al., *Constraining Early Dark Energy with Large-Scale Structure*, PRD 102 (2020) — 320+ citations; foundational constraints paper.

J. C. Hill, E. McDonough, **M. W. Toomey**, S. Alexander, *Early Dark Energy Does Not Restore Cosmological Concordance*, PRD 102 (2020) — **Editors' Suggestion**; 260+ citations.

TEACHING

Instructor, Winnipeg Institute for Theoretical Physics Summer School *Summer 2023*
Taught lecture series on machine learning for astrophysics and cosmology.

Instructor, Summer@Brown, Brown University *Summer 2019*
Designed and taught a 3-week introduction to astrophysics and cosmology for high school students.

ADDITIONAL

- **Peer reviewer** for Physical Review Letters, Physical Review D, ApJ, JCAP, and Physics Letters B
- **Scientific advisor** for PBS NOVA's *Decoding the Universe: Cosmos*
- **29 talks and seminars** (21 invited) at IAS, Princeton, Cambridge, Edinburgh, Chicago, NYU, SLAC, and others
- **2 colloquia**: University of Alabama (2025), University of Winnipeg (2024)
- Organizer, MIT Cosmology Coffee Hour Seminar (2024–present) & Brown Student Machine Learning Initiative (2019 – 2023)