

Max E. Lee

PhD expected: 2027

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CURRENT POSITION

PhD Candidate in Astronomy, Columbia University, U.S.A. *2022 – 2027 (expected)*

NSF Graduate Research Fellow, advised by Zoltán Haiman (Columbia) and Shy Genel (Flatiron CCA).

Applying to postdoctoral positions beginning Fall 2027.

RESEARCH INTERESTS

My research asks how the messy physics of galaxy formation — AGN feedback, galactic winds, gas cooling — reshapes the matter distribution that upcoming weak-lensing surveys will measure, and how to model those effects well enough that they sharpen rather than spoil cosmological constraints. I work at three levels of modeling: full cosmological hydrodynamical simulations (ILLUSTRISTNG, CAMELS), reduced-variance Gaussian-process emulators (CARPOOLGP), and field-level generative models (BIND, conditional flow matching), implemented in Python with GPU-accelerated deep-learning frameworks.

Guided by the requirements of Stage-IV surveys — Vera Rubin LSST, *Euclid*, and *Roman* — I quantify baryonic and intrinsic-alignment systematics in Gaussian and non-Gaussian weak-lensing statistics (power spectra, peak counts, one-point PDFs, Minkowski functionals) and in SZ observables, and I release the tools and data publicly: trained emulators, generated halo fields, and a suite of 1000-realization ray-traced lensing and SZ lightcones spanning the full IllustrisTNG galaxy-formation prior.

EDUCATION

- Columbia University** *2022 – 2027 (expected)*
PhD in Astronomy; M.S. in Astronomy, 2024 New York, U.S.A.
- University of California, Berkeley** *2018 – 2020*
B.A. in Astronomy & Physics Berkeley, U.S.A.
- Cabrillo College** *2016 – 2018*
A.A. in Mathematics & History Aptos, U.S.A.

FELLOWSHIPS & AWARDS

- NSF Graduate Research Fellowship** *2022 – 2027*
Awarded by the U.S. National Science Foundation
- National Osterbrock Leadership Fellowship** *2023 – 2026*
Leadership-development program of the American Astronomical Society
- Lead Teaching Fellowship** *2024 – 2026*
Columbia University Center for Teaching & Learning

LEAD-AUTHOR PUBLICATIONS (6)

- [1] **M. E. Lee**, S. Genel, Z. Haiman, G. L. Bryan, C. C. Lovell, B. Hadzhiyska (2026), *BIND (Baryonic INpainting with Deep learning): A Field-level Emulator for Galaxy Groups and Clusters*, submitted.
- [2] **M. E. Lee**, S. Genel, Z. Haiman, G. L. Bryan, B. Hadzhiyska (2026), *BINDing the lightcone: A suite of astrophysical ray-traced weak lensing and SZ maps*, submitted.
- [3] **M. E. Lee**, Z. Haiman, S. Genel (2026), *The impact of baryons on weak lensing statistics as a function of halo mass and radius*, arXiv:2603.11815.
- [4] **M. E. Lee**, Z. Haiman, S. Pandey, S. Genel (2026), *The effect of intrinsic alignments on weak lensing statistics in hydrodynamical simulations*, 2026 **ApJ**, arXiv:2504.12460.
- [5] **M. E. Lee**, S. Genel, B. D. Wandelt, B. Zhang, A. M. Delgado, et al. (2024), *Zooming by in the CARPool(GP) lane: new CAMELS-TNG simulations of zoomed-in massive halos*, 2024 **ApJ**, arXiv:2403.10609.
- [6] **M. E. Lee**, T. Lu, Z. Haiman, J. Liu, K. Osato (2023), *Comparing weak lensing peak counts in baryonic correction models to hydrodynamical simulations*, 2023 **MNRAS** 519, 573, arXiv:2201.08320.

CO-AUTHORED PUBLICATIONS (5)

- [1] C. Lovell, **M. E. Lee**, et al. (2026), *Efficiently emulating distribution functions in gigaparsec volumes for varying cosmological parameters*, arXiv:2604.17981.
- [2] M. Gebhardt, D. Anglés-Alcázar, S. Genel, D. Nagai, . . . , **M. E. Lee**, et al. (2026), *Cosmological back-reaction of baryons on dark matter in the CAMELS simulations*, 2026 **MNRAS**.
- [3] E. Hernández-Martínez, S. Genel, F. Villaescusa-Navarro, U. P. Steinwandel, **M. E. Lee**, et al. (2025), *Cosmological and Astrophysical Parameter Inference from Stacked Galaxy Cluster Profiles Using CAMELS-zoomGZ*, 2025 **ApJ**.
- [4] V. Böhm, Y. Feng, **M. E. Lee**, B. Dai (2021), *MADLens, a Package for Fast and Differentiable Non-Gaussian Lensing Simulations*, 2021 **Astronomy & Computing**, arXiv:2012.07266.
- [5] J. S. Dillon, **M. E. Lee**, A. R. Parsons, et al. (2020), *Redundant-Baseline Calibration of the Hydrogen Epoch of Reionization Array*, 2020 **MNRAS**, arXiv:2003.08399.

RESEARCH EXPERIENCE

- **Columbia University, PhD Candidate & NSF Graduate Research Fellow** *New York, U.S.A.*, 2022 – present

I develop field-level generative models of baryonic physics for Stage-IV lensing surveys. I created **BIND**, a *conditional flow-matching emulator* that paints dark matter, gas, and stellar fields onto dark-matter-only halos across the full 35-dimensional CAMELS SB35 parameter space (Lee et al. 2026a, submitted), and applied it halo-by-halo to N-body volumes to build a *public suite of 1000-realization ray-traced weak-lensing and SZ lightcones* spanning the IllustrisTNG galaxy-formation prior (Lee et al. 2026b, submitted), with a live explorer running inference on a cloud GPU. I diagnosed the *critical halo mass and radius scales* that baryon-correction models must capture (Lee et al. 2026, arXiv:2603.11815) and quantified *intrinsic-alignment contamination of non-Gaussian lensing statistics* (Lee et al.

2026, ApJ). I also developed **CARPoolGP**, a reduced-variance emulation method, and used it to extend CAMELS with 768 zoom-in simulations of massive halos (Lee et al. 2024, ApJ).

- **Columbia Astrophysics Laboratory, Research Assistant** *New York, U.S.A., 2021 – 2022*

I tested semi-analytic **baryonic correction models against full hydrodynamical simulations** at the level of weak-lensing peak counts, across the noise levels of DES, KiDS, HSC, LSST, *Roman*, and *Euclid*, identifying where they suffice and where they break for non-Gaussian statistics (Lee et al. 2023, MNRAS).

- **Berkeley Center for Cosmological Physics, Research Assistant** *Berkeley, U.S.A., 2021*

I contributed to **MADLens**, a fully differentiable particle-mesh package for non-Gaussian lensing simulations designed as a forward model for derivative-aided Bayesian inference (Böhm et al. 2021, Astronomy & Computing).

- **University of California, Berkeley, Undergraduate Researcher** *Berkeley, U.S.A., 2018 – 2020*

With the HERA collaboration, I worked on **redundant-baseline calibration** of the Hydrogen Epoch of Reionization Array, quantifying the impact of real-world non-redundancy on 21 cm calibration solutions (Dillon, Lee, et al. 2020, MNRAS).

OPEN-SOURCE SOFTWARE & DATA PRODUCTS

- **BIND** — trained flow-matching models, generated halo fields, and a live GPU-backed halo explorer; **BIND lightcone suite** — ray-traced convergence, optical-depth, and Compton- y maps (1000 realizations $\times$ 5 source redshifts) across the IllustrisTNG prior.
- **CARPoolGP** — Gaussian-process regression with control variates for reduced-variance emulation from expensive simulation suites.
- **BCM_lensing** — baryon-correction-model pipeline for weak-lensing convergence maps and peak-count statistics.
- **hydro_replace** — particle-level replacement of dark-matter-only halos with their hydrodynamical counterparts.
- **STAR_emu**, **cosmoANP**, **zoomGZ** — stellar-to-halo-mass emulator; attentive neural processes for cosmological inference; zoom-in simulation-suite management.

TALKS

- Seminar, CMB group meeting, University of Cambridge, U.K.: *The impact of baryons on weak lensing statistics: diagnosing failures as a function of halo mass and radius*, March 2026.

TEACHING & MENTORSHIP EXPERIENCE

- **Lead Teaching Fellow**, Center for Teaching & Learning, Columbia University — pedagogy programming and workshops for graduate-student instructors, 2024 – 2026.
- **Instructor of record**, Undergraduate Astronomy Lab, Department of Astronomy, Columbia University, *Fall 2023 and Spring 2024*.
- **Teaching assistant**, Theories of the Universe: From Babylon to the Big Bang, Columbia University, *Spring 2023*.
- **Teaching assistant**, Introduction to Astronomy I, Columbia University, *Fall 2022*.

- **Research mentor**, ULAB 21 cm Cosmology Group, UC Berkeley, *2019 – 2020*.
- **Undergraduate mentor**, Foundational Course for Physical Science Transfers, UC Berkeley, *2019 & 2020*.

SERVICE & OUTREACH

- **Astronomy Youth Outreach Coordinator**, Department of Astronomy, Columbia University, *2023 – present*.
- **STEM Coach**, Columbia School of General Studies, *January – June 2024*.