

M. Sten Delos

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RESEARCH INTERESTS

October 6, 2025

Dark matter and gravitational dynamics

Origins of matter and structure in the Universe

PROFESSIONAL HISTORY

Sept. 2023-present	Carnegie Observatories CTAC Postdoctoral Fellow	Pasadena, CA, USA
Sept. 2020-Aug. 2023	Max Planck Institute for Astrophysics Postdoctoral Fellow	Garching, Germany
May 2020-Sept. 2020	University of North Carolina at Chapel Hill Postdoctoral Research Associate	Chapel Hill, NC, USA
Aug. 2016-May 2020	University of North Carolina at Chapel Hill Graduate Research Assistant Graduate Teaching Assistant	Chapel Hill, NC, USA
Jan. 2016-May 2016	Guilford Technical Community College Adjunct Instructor	Jamestown, NC, USA
Aug. 2010-May 2012	State University of New York at Stony Brook Graduate Teaching Assistant	Stony Brook, NY, USA

EDUCATION

May 2020	University of North Carolina at Chapel Hill Ph.D. in Physics Thesis: “Probing the early universe using dark matter minihalos” Advisor: Adrienne Erickcek	Chapel Hill, NC, USA
May 2015	State University of New York at Stony Brook M.A. in Physics	Stony Brook, NY, USA
May 2010	University of Virginia B.S. in Physics and Mathematics <i>with Highest Distinction</i>	Charlottesville, VA, USA

FUNDING AND FELLOWSHIPS

- 2023 **CTAC Fellowship** (Carnegie Observatories)
3-year fellowship providing salary and 12000 USD/year travel and research support
- 2020 **MPA Postdoctoral Fellowship** (Max Planck Institute for Astrophysics)
3-year fellowship providing salary and unrestricted travel and research support
- 2019 **Dissertation Completion Fellowship** (UNC-Chapel Hill)
18000 USD and two semesters of graduate school tuition
- 2019 **North Carolina Space Grant Graduate Research Fellowship**
8000 USD
- 2019 **Kenan Trust Graduate Student Research Grant** (UNC-Chapel Hill)
2500 USD

PROFESSIONAL SERVICE AND OUTREACH

- 2025 Subject-matter expert reviewer in a NASA peer review.
- 2025 Coauthor, outreach article: “A Universe made of Black Holes?”
MPA Research Highlight, May 2025,
<https://www.mpa-garching.mpg.de/1114849/hl202505>.
- 2024 Organizing Committee member for the *GalFRESCA 2024* conference.
- 2023 Main author, outreach article: “The lingering imprint of the first cosmic structures.”
MPA Research Highlight, February 2023,
<https://www.mpa-garching.mpg.de/1069215/hl202302>.
- 2023 Grant reviewer for *North Carolina Space Grant*.
- 2022 Cosmology group meeting organizer at the Max Planck Institute for Astrophysics.
- 2017 Senior graduate student pre-candidacy mentoring team at UNC-Chapel Hill.

Peer reviewer for

- *Astronomy and Astrophysics*
- *Journal of Cosmology and Astroparticle Physics*
- *Monthly Notices of the Royal Astronomical Society*
- *Physical Review D*
- *Physical Review Letters*
- *Publications of the Astronomical Society of Australia*
- *The Open Journal of Astrophysics*

Completed *Advancing Inclusive Mentoring* at Carnegie Science. This program provides 12+ hours of content and discussion about positive and inclusive mentoring practices.

MENTORED STUDENTS

As principal project advisor

Brandon Kelpis (2025)

Undergraduate Student, *College of the Canyons* (through the Cal-Bridge program)

Research project on signals of dark matter annihilation

Tejas Satheesh (2024-2025)

Graduate Student, *Perimeter Institute*

Research project on simulating cosmic structure formation in the radiation era

Himanish Ganjoo (2019-2024)

Graduate Student, *North Carolina State University & Perimeter Institute*

Research projects on the consequences of nonstandard early-universe histories

First-authored 2 journal articles

Now a postdoctoral researcher at the Paris Observatory

Co-mentored students

Kelly Yang (2025) with Mustafa Amin

Undergraduate Student, *Rice University* (Summer Undergraduate Research Fellow)

Research project on cosmic structure formation theory

Anisha (2023) with Fabian Schmidt

Master Student, *University of Hamburg* (summer research at MPA)

Research project on stellar streams and dark matter substructure

Margie Bruff (2018-2019) with Adrienne Erickcek

Undergraduate Student, *University of North Carolina at Chapel Hill*

Research project on the assembly of cosmic structure

Coauthored 1 journal article

TEACHING EXPERIENCE

Max Planck Institute for Astrophysics

Garching, Germany

Lecture: “The physical bases for the structures of collisionless dark matter halos.”

Postdoc/staff lecture series on cosmology, May 2023,

<https://www.mpa.mpa-garching.mpg.de/~komatsu/lectureseries/2023.html>.

University of North Carolina at Chapel Hill

Chapel Hill, NC, USA

Spring 2019 Cosmology (TA)

Fall 2017 Graduate Quantum Mechanics I (TA)

Summer 2017 Introductory Calculus-based Electromagnetism and Quanta (TA)

Spring 2017 Introductory Calculus-based Electromagnetism and Quanta (TA)

Fall 2016 Introductory Calculus-based Mechanics and Relativity (TA)

Guilford Technical Community College

Jamestown, NC, USA

Spring 2016 Conceptual Physics

State University of New York at Stony Brook

Stony Brook, NY, USA

Spring 2012 Physics for Life Sciences I (TA)

Fall 2011 Physics for Life Sciences II (TA)

Spring 2011 Physics for Life Sciences II (TA)

Fall 2010 Physics for Life Sciences I (TA)

REFERENCES

Simon White

Emeritus Director, *Max Planck Institute for Astrophysics*swhite@mpa-garching.mpg.de

Fabian Schmidt

Scientific Staff, *Max Planck Institute for Astrophysics*fabians@mpa-garching.mpg.de

Adrienne Erickcek (Ph.D. Thesis Advisor)

Associate Professor of Physics and Astronomy, *University of North Carolina at Chapel Hill*erickcek@physics.unc.edu

Tim Linden

Associate Professor of Physics, *Stockholm University*linden@fysik.su.se

Mustafa Amin

Associate Professor of Physics and Astronomy, *Rice University*mustafa.a.amin@rice.edu

Ana Bonaca

Staff Scientist, *Carnegie Observatories*abonaca@carnegiescience.edu

PRESENTATIONS

Invited Talks at International Conferences (4)

“Scalar fields and non-standard expansion histories: Implications for structure formation.”

PITT PACC Workshop: Non-Standard Cosmological Epochs and Expansion Histories; Pittsburgh, PA; September 2024.

“The smallest dark structures.”

32nd Texas Symposium on Relativistic Astrophysics; Shanghai, China; December 2023.

“Prompt cusp formation from the cosmological initial conditions.”

Mathematical Justification for the Kinetic and Fluid Equations of Plasmas and Self-Gravitating Systems; Marseille, France; July 2023.

“Density profiles of the first halos & microhalo evolution through stellar encounters.”

News from the Dark 7; Montpellier, France; June 2022.

Other Invited Conference and Seminar Presentations (33)

“Cosmology with the dark first structures.”

- COSGAL Seminar, Paris Observatory; Paris, France; July 2025.
- TAPIR seminar, Caltech; Pasadena, CA, USA; May 2025.
- PACMAN meeting at the Center for Computational Astrophysics; New York, NY, USA; April 2025.
- Institute for Advanced Study Astrophysics Seminar; Princeton, NJ, USA; March 2025.
- Rice University P & A AU Seminar; Houston, TX, USA; February 2025.
- KIPAC Seminar; Stanford, CA, USA; February 2025.
- DIPC Cosmology & Astrophysics seminar; Donostia, Spain; January 2025.

“Structure formation with primordial black holes: collisional dynamics, binaries, and gravitational waves.”

- ZOOMing in on primordial black holes (online seminar series); December 2024.

“Prompt cusps of dark matter.”

- Seminar at Carnegie Mellon University; Pittsburgh, PA; September 2024.
- CERN-TH cosmology seminar; Geneva, Switzerland; January 2024.
- Astro-seminar at the University of Southern California; Los Angeles, CA, USA; October 2023.
- Cosmology and Gravitation seminar at the Perimeter Institute for Theoretical Physics; Waterloo, ON, Canada; October 2023.
- Astrophysics seminar at the University of North Carolina at Chapel Hill; Chapel Hill, NC, USA; August 2023.
- Astrophysical and Cosmological Relativity seminar at the Albert Einstein Institute; Postdam, Germany; May 2023

- Cosmology seminar at the Helsinki Institute of Physics; Helsinki, Finland; April 2023.
- Seminar at the Lorentz Institute; Leiden, The Netherlands; February 2023.
- Seminar at the Strasbourg Observatory; Strasbourg, France; February 2023.
- Particle and Astroparticle Theory Seminar at the Max Planck Institute for Nuclear Physics; Heidelberg, Germany; November 2022.
- SFB1258 Neutrinos and Dark Matter colloquium; Garching, Germany; October 2022.
- Cosmology Seminar at the Max Planck Institute for Astrophysics; Garching, Germany; September 2022.
- ICAP Meeting at the Institut d'Astrophysique de Paris; Paris, France; September 2022.

“Primordial black holes and ultradense halos.”

- UCLA TEPAPP Seminar; Los Angeles, CA; May 2023
- Padova cosmology journal club; Padua, Italy; March 2023

“The structures of dark halos.”

- Institute Seminar at the Max Planck Institute for Astrophysics; Garching, Germany; January 2023.

“Stellar streams and dark substructure.”

- Munich Dark Matter Meeting; Munich, Germany; March 2022.
- Ringberg Meeting of the MPA Galaxy Group; Kreuth, Germany; July 2021.

“Observational signatures of early matter domination.”

- Particle seminar at Carleton University; Ottawa, Canada; September 2021.

“Probing cosmology using dark matter microhalos.”

- CGI Seminar at the University of California, Santa Cruz; Santa Cruz, CA, USA; April 2021.
- Joint Cambridge-LMU online cosmology workshop; January 2021.
- Fermilab CPC Seminar; Batavia, IL, USA; November 2020.
- Institute Seminar at the Max Planck Institute for Astrophysics; Garching, Germany; October 2020.
- Seminar at the Perimeter Institute; Waterloo, ON, Canada; February 2020.

“Predicting the dark matter distribution at the smallest scales.”

- Munich/Garching *Dark Matter Day* mini-workshop; Garching, Germany; October 2020.

Contributed Conference Presentations (12)

“Prompt cusps of dark matter.”

- *Cambridge-LMU Cosmology Meeting*; Munich, Germany; September 2025.
- *Cosmology 2025 @ Elba Island*; Isola D'Elba, Italy; September 2025.
- *GalFRESCA 2024*; Pasadena, CA, USA; September 2024.
- *Small Galaxies, Cosmic Questions – II*; Durham, UK; July 2024.
- *Cosmic Signals of Dark Matter Physics: New Synergies*; Santa Barbara, CA, USA; June 2024.
- *Cosmology from Home 2023*; July 2023.
- *COSMO'22*; Rio de Janeiro, Brazil; August 2022.

“Structure formation with primordial black holes.”

Black Holes & Cosmology 2025; Reykjavik, Iceland; August 2025.

“Primordial black holes and ultradense halos.”

Black Hole and Gravitational-Wave Day; Garching, Germany; May 2023.

“The gamma-ray signature of an early matter-dominated era.”

- *APS April Meeting 2019*; Denver, CO, USA; April 2019.
- *Eighth International Fermi Symposium*; Baltimore, MD, USA; October 2018.

“Constraining the primordial power spectrum using minihalos.”

APS April Meeting 2018; Columbus, OH, USA; April 2018.

PUBLICATION LIST

29 papers (21 as lead author)

INSPIRE: <https://inspirehep.net/authors/1743687>

974 citations, h-index = 14

ADS: https://ui.adsabs.harvard.edu/public-libraries/GUqU2T2DTYW9Ha3jdF_pTA

815 citations (492 as lead author), h-index = 13 (11 as lead author)

Lead author publications (21)

M. Sten Delos. “The cusp-halo relation.” Accepted by *ApJ* September 2025 [arXiv:2506.03240].

M. Sten Delos. “Detecting dark objects with plasma microlensing by their gravitational wakes.” *ApJ* **978** 71 [arXiv:2409.16348].

M. Sten Delos, Antti Rantala, Sam Young, and Fabian Schmidt. “Structure formation with primordial black holes: collisional dynamics, binaries, and gravitational waves.” *JCAP* **12** (2024) 005 [arXiv:2410.01876].

M. Sten Delos, Michael Korsmeier, Axel Widmark, Carlos Blanco, Tim Linden, and Simon D. M. White. “Limits on dark matter annihilation in prompt cusps from the isotropic gamma-ray background.” *Phys. Rev. D* **109**, 083512 (2024) [arXiv:2307.13023].

M. Sten Delos. “An analytical description of substructure-induced gravitational perturbations in stellar systems.” *MNRAS* **529**, 2349 (2024) [arXiv:2312.13338].

M. Sten Delos. “Can prompt cusps of WIMP dark matter be detected as individual gamma-ray sources?” *Phys. Rev. D* **109**, 023532 (2024) [arXiv:2310.15214].

M. Sten Delos. “Accurate halo mass functions from the simplest excursion set theory.” *MNRAS* **528**, 1372 (2024) [arXiv:2311.17986].

M. Sten Delos and Simon D. M. White. “Prompt cusps and the dark matter annihilation signal.” *JCAP* **10** (2023) 008 [arXiv:2209.11237].

M. Sten Delos, Kayla Redmond, and Adrienne L. Erickcek. “How an era of kination impacts substructure and the dark matter annihilation rate.” *Phys. Rev. D* **108**, 023528 (2023) [arXiv:2304.12336].

M. Sten Delos. “Massive prompt cusps: a new signature of warm dark matter.” *MNRAS: Letters* **522**, L78 (2023) [arXiv:2302.03040].

M. Sten Delos and Gabriele Franciolini. “Lensing constraints on ultradense dark matter halos.” *Phys. Rev. D* **107**, 083505 (2023) [arXiv:2301.13171].

M. Sten Delos and Joseph Silk. “Ultradense dark matter haloes accompany primordial black holes.” *MNRAS* **520**, 4370 (2023) [arXiv:2210.04904].

M. Sten Delos and Simon D. M. White. “Inner cusps of the first dark matter haloes: Formation and survival in a cosmological context.” *MNRAS* **518**, 3509 (2023) [arXiv:2207.05082].

M. Sten Delos and Tim Linden. “Dark matter microhalos in the solar neighborhood: Pulsar timing signatures of early matter domination.” *Phys. Rev. D* **105**, 123514 (2022) [arXiv:2109.03240].

M. Sten Delos and Fabian Schmidt. “Stellar streams and dark substructure: the diffusion regime.” *MNRAS* **513**, 3682 (2022) [arXiv:2108.13420].

M. Sten Delos, Tim Linden, and Adrienne L. Erickcek. “Breaking a dark degeneracy: The gamma-ray signature of early matter domination.” *Phys. Rev. D* **100**, 123546 (2019) [arXiv:1910.08553].

M. Sten Delos. “Evolution of dark matter microhalos through stellar encounters.” *Phys. Rev. D* **100**, 083529 (2019) [arXiv:1907.13133].

M. Sten Delos. “Tidal evolution of dark matter annihilation rates in subhalos.” *Phys. Rev. D* **100**, 063505 (2019) [arXiv:1906.10690].

M. Sten Delos, Margie Bruff, and Adrienne L. Erickcek. “Predicting the density profiles of the first halos.” *Phys. Rev. D* **100**, 023523 (2019) [arXiv:1905.05766].

M. Sten Delos, Adrienne L. Erickcek, Avery P. Bailey, and Marcelo A. Alvarez. “Density profiles of ultracompact minihalos: Implications for constraining the primordial power spectrum.” *Phys. Rev. D* **98**, 063527 (2018) [arXiv:1806.07389].

M. Sten Delos, Adrienne L. Erickcek, Avery P. Bailey, and Marcelo A. Alvarez. “Are ultracompact minihalos really ultracompact?” *Phys. Rev. D Rapid Communications* **97**, 041303(R) (2018) [arXiv:1712.05421].

Student publications as principal advisor (2)

Himanish Ganjoo and **M. Sten Delos**. “Limits on early matter domination from the isotropic gamma-ray background.” *JCAP* 05 (2025) 063 [arXiv:2403.18893].

Himanish Ganjoo and **M. Sten Delos**. “Simulations of gravitational heating due to early matter domination.” *JCAP* 04 (2024) 015 [arXiv:2306.14961].

Coauthor publications (6)

Mustafa A. Amin, **M. Sten Delos**, and Mehrdad Mirbabayi. “Structure formation with warm white noise: Effects of finite number density and velocity dispersion in particle and wave dark matter.” Submitted April 2025 [arXiv:2503.20881].

Milena Crnogorčević, **M. Sten Delos**, Nadia Kuritzén, and Tim Linden. “Gamma-ray observations of galaxy clusters strongly constrain dark matter annihilation in prompt cusps.” Accepted by *Phys. Rev. D* September 2025 [arXiv:2501.14865].

Hwan Bae, Adrienne L. Erickcek, **M. Sten Delos**, and Julian B. Muñoz. “21-cm constraints on dark matter annihilation after an early matter-dominated era.” *Phys. Rev. D* **112**, 083013 (2025) [arXiv:2502.08719].

Brian Batell, Keith R. Dienes, Brooks Thomas, Scott Watson, Rouzbeh Allahverdi, Mustafa Amin, Kimberly K. Boddy, **M. Sten Delos**, Adrienne L. Erickcek, Akshay Ghalsasi, *et al.* “Conversations and Deliberations: Non-Standard Cosmological Epochs and Expansion Histories.” *Int. J. Mod. Phys. A* 2530004 (2025) [arXiv:2411.04780].

Rouzbeh Allahverdi, Mustafa A. Amin, Asher Berlin, Nicolás Bernal, Christian T. Byrnes, **M. Sten Delos**, Adrienne L. Erickcek, Miguel Escudero, Daniel G. Figueroa, Katherine Freese, *et al.* “The First Three Seconds: a Review of Possible Expansion Histories of the Early Universe.” *Open J. Astrophys.* **4** (2021) [arXiv:2006.16182].

Carlos Blanco, **M. Sten Delos**, Adrienne L. Erickcek, and Dan Hooper. “Annihilation signatures of hidden sector dark matter within early-forming microhalos.” *Phys. Rev. D* **100**, 103010 (2019) [arXiv:1906.00010].