Roark Habegger

Theoretical and Computational Astrophysicist ◇ NASA FINESST Fellow
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Statement of Goals

Astrophysical plasmas make up most of the visible matter in the universe. Accurately modeling them and the astrophysical systems they make up requires all the fundamental pillars of modern physics, the most powerful supercomputers, and creative analysis. During my PhD, I have used cosmic-ray magnetohydrodynamic simulations to study cosmic-ray feedback, investigating how cosmic rays restructure the interstellar medium, modify turbulent cascades, and influence gamma-ray observations. As I continue in my academic career, I plan to branch out and study new topics, always testing the computational and theoretical models I develop against observational data. Along the way, I will cultivate a thriving research group, encouraging the next generation of astrophysicists to tackle challenging research topics.

Research Interests

Plasma Astrophysics	Cosmic rays, magnetohydrodynamics, instabilities, supernovae, interstellar medium, intracluster medium
Computational Methods	Magnetohydrodynamic simulations, data visualization, genetic algorithms, particle-in-cell methods (C++, Python)

Teaching Interests

Physics	Astrophysical fluid dynamics, electrodynamics, plasma physics, quantum mechanics, classical mechanics
Mathematics	Calculus, complex analysis, differential equations, nonlinear dynamics.
Computational Methods	Python, dynamical systems, numerical integration & interpolation, data visualization.

Publications

[1] Roark Habegger, David Hosking, and Ellen G. Zweibel. "Shifting Gears: Buoyancy Instability due to a Change in Cosmic Ray Transport". *In Prep* (Dec. 2025).

[2] Roark Habegger, Mateusz Ruszkowski, and Ellen G. Zweibel. "Decorrelation of Cosmic-Ray PRessure and Dense Gas in the Intracluster Medium". *In Prep* (Dec. 2025).

[3] Fabian Heitsch and Roark Habegger. "A Coscaling Grid for Athena++. II. Magnetohydrodynamics". *ApJS* 276.2, 61 (Feb. 2025), p. 61. DOI: 10.3847/1538-4365/ada289.

[4] Sophie Aerdker, Roark Habegger, Lukas Merten, Ellen Zweibel, and Julia Becker Tjus. "Cosmic ray transport and acceleration in an evolving shock landscape". *Submitted to A&A*, arXiv:2501.14331 (Jan. 2025), arXiv:2501.14331. DOI: 10.48550/arXiv.2501.14331.

[5] Roark Habegger and Ellen G. Zweibel. "Cosmic-Ray Feedback from Supernovae in a Parker-unstable Medium". *ApJ* 990.1, 75 (Sept. 2025), p. 75. DOI: 10.3847/1538-4357/adf4d7.

[6] Roark Habegger, Ka Wai Ho, Ka Ho Yuen, and Ellen G. Zweibel. "Cosmic-Ray Feedback on Bistable Interstellar Medium Turbulence". *ApJ* 974.1, 17 (Oct. 2024), p. 17. DOI: 10.3847/1538-4357/ad67da.

[7] Roark Habegger, Ellen G. Zweibel, and Sherry Wong. "The Impact of Cosmic Ray Injection on Magnetic Flux Tubes in a Galactic Disk". *ApJ* 951.2, 99 (July 2023), p. 99. DOI: 10.3847/1538-4357/accf8e.

[8] Roark Habegger and Fabian Heitsch. "A Coscaling Grid for Athena++". *ApJS* 256.2, 42 (Oct. 2021), p. 42. DOI: 10.3847/1538-4365/ac2511.

Education

University of Wisconsin - Madison:

Expected 2026	Astronomy Ph.D.
2022	Physics M.A.
	Astronomy M.S.

University of North Carolina at Chapel Hill:

2020	Physics B.S. with Highest Honors (Thesis)
	Mathematics B.S.
	Creative Writing (Poetry) Minor with Highest Honors (Thesis)
	Highest Distinction, Honors Carolina Laureate, Phi Beta Kappa

Research Presentations

July 2025	**Invited Talk** at Ruhr University Bochom on *Cosmic-Ray Feedback Across Scales*
July 2025	18th AIP Potsdam Thinkshop: **Poster** on *The Dynamical Implications of a Shift in Cosmic-Ray Transport*
Oct. 2024	APS-DPP Annual meeting: **poster** on *Cosmic Ray Feedback on the ISM: The Effects of Variable Cosmic Ray Propagation*, **tutorial talk** at Student Day on *Oh the places you'll go: Turbulence across time and space*
Jun. 2024	AAS 244th Annual meeting: **talk** on *Cosmic Ray Feedback from Supernovae in a Stratified ISM*, **invited talk** on *Cosmic Ray Feedback on Bi-stable ISM Turbulence*.
Oct. 2023	APS-DPP Annual Meeting: **poster** on *The Large-Scale Impact of Localized Cosmic Ray Injection*, **talk** on *Magnetized Turbulence with Cosmic Rays and Radiative Cooling*, **lightning talk** at Student Day on *Cosmic Rays in a Galactic Context*
May 2023	Modelling of Multiphase Astrophysical Media Conference in Kochel, Germany: **talk** on *Cosmic Ray Injection at Modelling of Multiphase Astrophysical Media conference*
May 2023	**Invited colloquium** at Ruhr University in Bochum on *Cosmic Ray Injection in a Realistic Galactic Disk*.
May 2023	Les Houches School of Physics Doctoral Training on Plasmas in Extreme Environments: **poster** on *Cosmic Ray Injection in a Realistic Galactic Disk*
Oct. 2022	APS-DPP Annual Meeting: **poster** on *Cosmic Ray Injection in a Realistic Galactic Disk*
Oct. 2021	APS-DPP Annual Meeting: **poster** on *Cosmic Ray Loaded Magnetic Flux Tubes*
Oct. 2020	APS-DPP Annual Meeting: **poster** on *Coscaling Grid in Athena++*
Apr. 2019	NC Space Symposium: **poster** on Polarimeter Software development
Nov. 2017	SESAPS: **poster** on Polarimeter Hardware

Accepted Funding and Grants

2022-2025	NASA Future Investigators in NASA Earth and Space Science and Technology (FINESST): The Impact of Localized Cosmic Ray Injections on Galactic Evolution ($146,703)
2022	APS Topical Group on Plasma Astrophysics Student Travel Grant ($2,000)
2019	Sigma Xi Grant-In-Aid-of-Research ($5,000)
Summer 2018	North Carolina Space Grant Undergraduate Research Scholarship ($5,000)
Summer 2017	North Carolina Space Grant Undergraduate Research Scholarship ($5,000)

Teaching and Mentorship

2025-2026, UW-Madison	Teaching Assistant for Astronomy 104: Our Exploration of the Solar System
2023-2025, UW-Madison	Provided free tutoring for Astronomy Majors in physics, math, and astronomy classes (quantum mechanics, multivariable calculus, complex analysis, interestellar medium)
Summer 2023, UW-Madison	Mentor for Madison Metropolitan School District Summer Research Internship
2020-2023, UW-Madison	Mentor for the Undergraduate Research Scholar (URS) program
Aug. 2019, UNC	Educational Research In Radio Astronomy (ERIRA) Project Coordinator & Mentor
2018-2019, UNC	Introductory Physics Teaching Assistant (Phys-119: Introductory Calculus based Electromagnetism and Quanta)

Outreach

Feb. 2024	Astronomy On Tap talk: Untangling & Understanding Magnetic Fields at Working Draft Beer Company.
Apr. 2023	Astronomy Graduate Lecture for Undergraduates (AstroGLU) on Synchrotron Radiation
2021-2022	Contributor to Radio Astronomy podcast on local Madison radio station WORT 89.9
Sep. 2022	Research presentation to UW Astronomy Dept. Board of Visitors
Nov. 2022	AstroGLU on Magnetic Fields
Oct. 2022	Wisconsin Science Festival – Computational Astrophysics Booth
Oct. 2021	AstroGLU on Plasma Astrophysics

Department Service

2025-2026	Representative on the Graduate Admissions Committee
2023-2024	Graduate Student Bench ("chair" of the Astronomy Dept. graduate students)
2023-2024	Led Mathematical and Computational Methods Coffee hour (MCMCoffee)
2022-2023	Representative on the Graduate Admissions Committee
2021-2022	Department Website Content Manager

Other Fun Stuff

Since 2010	Running! I've completed 3 marathons, a 50km ultramarathon, and many more 5km, 4 mile, 10 mile, and half-marathon races.
Summer 2018	Worked as a Volunteer for the United States Forest Service in Superior National Forest as a Wilderness Ranger Intern. Spent over a week at a time with a Wilderness Ranger canoeing around the Boundary Waters Canoe Area Wilderness, where we repaired campsites and cleared trails.