Thomas Flöss

Postdoctoral researcher in cosmology

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I am a postdoc at the University of Vienna. I work primarily on using late-time cosmological probes, such as the CMB, galaxy surveys, and intensity mapping (e.g. 21-cm) to study the primordial universe, particularly cosmic inflation through primordial non-Gaussianity. In my research, I make use of analytical, numerical and state-of-the-art machine learning (ML) methods. Currently, I am working on developing methods for field-level inference, as a means for optimal cosmological data analysis. Additionally, I like to think about formal aspects of cosmology such as inflationary consistency conditions and the cosmological bootstrap. I have also studied the amplitude double copy, its application to cosmology, and a possible connection with massive gravity.

Professional Experience

2024 – *present*
Postdoc in theoretical and computational cosmology, University of Vienna
Researcher and lecturer ("University Assistant") in the computational cosmology group led by Univ.-Prof. Oliver Hahn

2020 – 2024
PhD in Theoretical Cosmology (cum laude), University of Groningen
Thesis: A Skewed Perspective on the Universe
Advisors: Prof. Diederik Roest, Dr. Daan Meerburg, Prof. Léon Koopmans

- Determined the feasibility of a lunar-based 21-cm survey for constraining primordial non-Gaussianity using the three- and four-point correlation function
- Uncovered the impact and importance of including non-Gaussian covariance when constraining primordial non-Gaussianity using the bispectrum
- Developed and quantified ML-based reconstruction methods for recovering the information content of summary statistics lost due to non-Gaussian covariance
- Applied state-of-the-art generative ML models to probabilistic CMB-lensing reconstruction
- Derived duality-invariant non-linear electrodynamics from massive gravity

During my PhD I co-authored 7 research papers of which 5 as first author.

Education

2016 – 2018
MSc. Theoretical Physics, Utrecht University
Thesis: *Inflationary Consistency Conditions and Shift-Symmetric Cosmologies*
Advisors: Dr. Enrico Pajer and Dr. Garrett Goon. | GPA: 4.0/4.0

2013 – 2016
BSc. Physics & Astronomy, Utrecht University
Thesis: *Quantum Fluctuations and Magnon-Magnon Interactions in Antiferromagnets*
Advisors: Prof. Rembert Duine and Dr. Scott Bender. | GPA: 4.0/4.0

Awards & Grants

Sept 2020 — Fundamentals of the Universe PhD Scholarship, University of Groningen
Research proposal: *Sensing in the Dark: exploring the early universe through the Dark Ages.*

Research Visits

Sept – Nov 2023 — Center for Computational Astrophysics (Flatiron Institute), New York, USA
Guest researcher with Franscisco Villaescusa-Navarro and William Coulton

Teaching & Mentoring

2025 — Lecturer 'Early Universe and Structure Growth' (MSc. course), University of Vienna
2023 — Co-supervisor MSc. student Jelte Bottema, University of Groningen
2021 — Co-supervisor MSc. student Jorik Melsen, University of Groningen
2022 — Teaching Assistant, General Relativity (MSc. course), University of Groningen
2020 — Co-supervisor MSc. students Tim de Wild and Tom Westerdijk, University of Groningen
2017 — Teaching Assistant, Calculus II (BSc. course), Utrecht University

Organization

2020 – 2023 — Cosmology Journal Club, University of Groningen
2020 – 2021 — Seminar Series on Cosmological Correlators and Bootstrap, University of Groningen
2015 — Physics Symposium "Physical Creativity", Utrecht University

Skills

Languages — English (Fluent), Dutch (Native), German (Proficient)
Coding — Python, JAX, TensorFlow, julia, PyTorch, C/C++, LaTeX, Mathematica (incl. xAct), GitHub

Public Codes (see GitHub)

- PolyBin3D: a GPU accelerated unwindowed power spectrum and bispectrum estimator in Python (together with Oliver Philcox)
- BFast: a GPU accelerated FFT bispectrum estimator in JAX (Python)
- PyNG: Fisher forecast primordial non-Gaussianity including non-Gaussian covariance
- 21cmDA: Fisher forecast primordial non-Gaussianity from the Dark Ages' 21-cm signal

Talks & Posters

July 2025 — New Strategies for Cosmology from Galaxy Surveys III, Sexten, Italy (contributed talk)
June 2025 — Cosmology Beyond the Analytic Lamppost (CoBALt), Paris (contributed talk)
March 2025 — Institute seminar LAPTh, Annency
July 2024 — Cosmology in the Adriatic, Split, Croatia (contributed talk)
New Strategies for Cosmology from Galaxy Surveys II, Sexten, Italy (contributed talk)
Oct 2023 — Dunkley group meeting, Princeton University
CMBAS/CCA group meeting, Flatiron Institute

Talks & Posters (continued)

May 2023	Weniger group meeting, GRAPPA, University of Amsterdam
Mar 2023	Netherlands Theoretical Cosmology (THC) meeting
Dec 2022	Hill group meeting, Columbia University
Sep 2022	PNG2022, International Conference, ITF Madrid (contributed talk)
May 2022	Kapteyn Institute Lunch Talk, University of Groningen
Apr 2022	Fundamentals of the Universe Symposium, University of Groningen (invited talk)
	State of the Universe Seminar, TIFR, India (invited talk, online)
Feb 2022	Friday Journal Club, KICP, UChicago (invited talk, online)
Sept 2021	Fundamentals of the Universe Symposium, University of Groningen (poster)

Research Publications

[1] J. Bottema, **T. Flöss**, and P. D. Meerburg, "Neural Network Reconstruction of Non-Gaussian Initial Conditions from Dark Matter Halos," Feb. 2025. arXiv: 2502.11846 [astro-ph.CO].

[2] J. Melsen, **T. Flöss**, and P. D. Meerburg, "Towards detecting Primordial non-Gaussianity in the CMB using Spherical Convolutional Neural Networks," Dec. 2024. arXiv: 2412.12377 [astro-ph.CO].

[3] **T. Flöss**, W. R. Coulton, A. J. Duivenvoorden, F. Villaescusa-Navarro, and B. D. Wandelt, "Denoising diffusion delensing: reconstructing the non-Gaussian CMB lensing potential with diffusion models," *Mon. Not. Roy. Astron. Soc.*, vol. 533, no. 1, pp. 423–432, 2024. DOI: 10.1093/mnras/stae1818. arXiv: 2405.05598 [astro-ph.CO].

[4] O. H. E. Philcox and **T. Flöss**, "PolyBin3D: A Suite of Optimal and Efficient Power Spectrum and Bispectrum Estimators for Large-Scale Structure," Apr. 2024. arXiv: 2404.07249 [astro-ph.CO].

[5] **T. Flöss**, D. Roest, and T. Westerdijk, "Non-linear Electrodynamics from Massive Gravity," Aug. 2023, Submitted to JHEP. arXiv: 2308.04349 [hep-th].

[6] G. Orlando, **T. Flöss**, P. D. Meerburg, and J. Silk, "Local non-Gaussianities from cross-correlations between the CMB and 21-cm," Jul. 2023, Submitted to PRD. arXiv: 2307.15046 [astro-ph.CO].

[7] **T. Flöss** and P. D. Meerburg, "Improving constraints on primordial non-Gaussianity using neural network based reconstruction," May 2023, Accepted in JCAP. arXiv: 2305.07018 [astro-ph.CO].

[8] **T. Flöss**, M. Biagetti, and P. D. Meerburg, "Primordial non-Gaussianity and non-Gaussian covariance," *Phys. Rev. D*, vol. 107, no. 2, p. 023 528, 2023. DOI: 10.1103/PhysRevD.107.023528. arXiv: 2206.10458 [astro-ph.CO].

[9] **T. Flöss**, T. de Wild, P. D. Meerburg, and L. V. E. Koopmans, "The Dark Ages' 21-cm trispectrum," *JCAP*, vol. 06, no. 06, p. 020, 2022. DOI: 10.1088/1475-7516/2022/06/020. arXiv: 2201.08843 [astro-ph.CO].

References

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