HENRY S. GRASSHORN GEBHARDT

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Citizenships: USA and Germany

Current Occupation: Researcher in Cosmology at California Institute of Technology, Pasadena, CA

Specialties:

- 3D cosmological data analysis with galaxy surveys
- Fourier-space algorithms on the sphere, spherical Bessel functions, spherical harmonics, Wigner-3j
- Adaptive Metropolis-Hastings sampler (MCMC)
- Numerical computing, especially in the Julia scientific programming language
- Computing tools: Linux, C, git, package management with conda, conda-lock, Github CI/CD actions

Other quirks:

- Native speaker of both German and English
- Extensive Linux experience and Open Source enthusiast: Single-patch contributor to the Linux kernel (fixes race condition in USB driver)
- Team player: More concerned about supporting the team than myself.

ACADEMIA

California Institute of Technology – *Pasadena, CA, USA*

Postdoc working on SPHEREx all-sky galaxy survey. Started 2022

Scientific pipeline development and new algorithms on the curved sky to measure imprint of big bang physics on the large-scale structure of the universe.

Jet Propulsion Laboratory/California Institute of Technology – *Pasadena, CA, USA*

NASA Postdoctoral Program (NPP) fellow, advisor: Dr. Olivier Doré 2019 - 2022

Work on Roman Space Telescope wide-angle algorithms (projected launch 2027)

The Pennsylvania State University – *University Park, PA, USA*

Ph.D. in Astronomy and Astrophysics, advisor: Prof. Donghui Jeong 2019

M.S. in Astronomy and Astrophysics 2014

Work on high-performance numerical algorithms and analysis techniques for galaxy surveys.

Eberhard-Karls Universität Tübingen – *Germany*

Diplom in Physics 2010

Work on FPGA read-out electronics for X-ray space telescope missions, SpaceWire protocol.

University of Calfornia – *Davis, CA* 2002 - 2004

COMPUTING SKILLS

Programming languages:	Julia, C, Python, LaTeX, and others
Operating tools:	Linux, git, conda, parallel computing, supercomputing, CI/CD Github actions
Algorithms:	Fourier algorithms on the sphere, spherical Bessel functions, spherical harmonics, MCMC, 2-FAST algorithm
Github:	`https://github.com/hsgg/`
Personal website:	`http://2-node-supercomputer.net` (non-professional)
Electronics:	FPGA programming with VHDL, SpaceWire

RESEARCH

Caltech/JPL – *SPHEREx mission cosmological data anlysis pipeline* Started 2022

- The cosmological data analysis of galaxy surveys such as SPHEREx that map a large fraction of the sky will need to account for the curved geometry of the sky. I have specializd in bringing to maturity the analysis using the spherical Fourier-Bessel (SFB) basis, which fully accounts for the wide-angle effect, in both estimator and theory modeling.
- I am one of the main architects of the cosmological data analysis pipeline for SPHEREx. I also provide git and conda support for the rest of the team.
- I advise several grad students and postdocs on various aspects of modeling and measuring large-scale structure in the universe.

JPL/Caltech – *Optimal Extraction of Cosmological Parameters from Galaxy Surveys* 2019 - 2022

- My primary research revolves around optimizing the cosmological information from deep wide-angle galaxy surveys such as the *Nancy Grace Roman Space Telescope* and *SPHEREx* by exploiting the spherical Fourier-Bessel (SFB) basis that fully accounts for the geometry of the curved sky.
- Harmonic (Fourier) space analysis is used because it exploits translation symmetry and leads to a simpler covariance matrix. However, observational constraints such as the survey mask break the translation symmetry. I have developed CRYOFUNK that derives harmonic eigenfunctions custom-made for arbitrary masks.
- Traditional power spectrum analysis needs to model wide-angle effects. I supervised undergraduate students to model and assess the magnitude of this wide-angle effect, which has led to a publication.
- Also supervising an advanced undergraduate and graduate student in modeling the bispectrum in the SFB basis.
- I am part of the HETDEX project, specializing in accounting for the interloper effect, which occurs from misidentification of galaxies due to limited signal.

Penn State – *Cosmology, Galaxy Survey Systematics, Dark Black Holes, Algorithms* 2012 - 2019

- The primary goal of my Ph.D. thesis is to optimize the scientific gain from galaxy surveys using 2-point functions such as the power spectrum, modeling several observational systematics. For this I developed expertise in power spectrum analysis using fast Fourier transforms, maximum likelihood analysis, and Markov Chain Monte Carlo methods with an adaptive Metropolis-Hastings sampler.
- Highly oscillatory integrals over spherical Bessel functions frequently occur in cosmology. I developed the *Two-point function from Fast and Accurate Spherical Bessel Transform* (`TwoFAST`) algorithm to solve such integrals efficiently, achieving 500x-1000x speedups over traditional methods.
- In collaboration with Prof. Sarah Shandera and my advisor we showed that Black holes may have formed from dark matter after recombination. This project involved mainly atomic and molecular hydrogen physics, some nuclear.
- My first project at Penn State measured gas-phase metallicities (primarily oxygen – in Astrophysics anything that is heavier than hydrogen or helium is called a *metal*) from emission-line galaxies when the universe was $\sim 0.25\%$ its current age.

Tübingen, Germany – *X-ray Detector Electronics Development* 2007 - 2010

As part of the development of new X-ray space telescope detectors, I developed modern read-out and communication electronics, and I worked extensively on developing the commissioning and analysis software.

AWARDS AND FELLOWSHIPS

JPL/Caltech – *NASA Postdoctoral Program Fellowship*	2019-2022
Penn State – *Zaccheus Daniel Travel Fellowship*	2015, 2016
Penn State – *Stephen B. Brumbach Graduate Fellow*	2014 - 2015
UC Davis – *Scholarship from The Regents of the University of California*	2004

PUBLICATIONS

Wen, R. Y., **Grasshorn Gebhardt, H. S.**, Heinrich, C. & Doré, O., *Linear relativistic corrections in the spherical Fourier-Bessel power spectrum*, 2024, Phys. Rev. D, Vol 110, Issue 12, arXiv:2407.02753

Benabou, J. N., Sands, I., **Grasshorn Gebhardt, H. S.**, Heinrich, C. & Doré, O., *Wide-angle effects in the power spectrum multipoles in next-generation redshift surveys*, 2024, Phys. Rev. D, Vol. 110, Issue 8, arXiv:2404.04811

Wen, R. Y., **Grasshorn Gebhardt, H. S.**, Heinrich, C. & Doré, O., *Exact modeling of power spectrum multipole through spherical Fourier-Bessel basis*, 2024, Phys. Rev. D, Vol. 110, Issue 8, arXiv:2404.04812

Khek, B., **Grasshorn Gebhardt, H. S.**, & Doré, O., *Fast Theoretical Predictions for Spherical Fourier Analysis of Large-Scale Structures*, 2024, Phys. Rev. D, Vol. 110, Issue 6, arXiv:2212.05760.

Benabou, J. N., Testa, A., Heinrich, C., **Grasshorn Gebhardt, H. S.** & Doré, O., *Galaxy Bispectrum in the Spherical Fourier-Bessel Basis*, 2024, Phys. Rev. D, Vol. 109, Issue 10, arXiv:2312.15992.

Grasshorn Gebhardt, H. & Doré, O., *Validation of Spherical Fourier-Bessel power spectrum analysis with lognormal simulations and eBOSS DR16 LRG EZmocks*, 2024, Phys. Rev. D, Vol 109, issue 8, arXiv:2310.17677.

Grasshorn Gebhardt, H. S. & Doré, O., *CRYOFUNK: Harmonic Analysis on the Sphere with Arbitrary Masks*, 2022, JCAP, 038. doi:10.1088/1475-7516/2022/01/038

Grasshorn Gebhardt, H. S. & Doré, O., *SuperFaB: a fabulous code for Spherical Fourier-Bessel decomposition*, 2021, arXiv:2102.10079, PRD, 104, 123548. doi:10.1103/PhysRevD.104.123548

Farrow, D. J., Sánchez, A. G., Ciardullo, R., . . . , **Grasshorn Gebhardt, H. S.**, et al., *Correcting correlation functions for redshift-dependent interloper contamination*, 2021, MNRAS.

Grasshorn Gebhardt, H. S. & Jeong, D., *Nonlinear redshift-space distortions in the harmonic-space galaxy power spectrum*, 2020, PRD, 102, 083521.

Tomlinson, J., **Gebhardt, H. S. G.**, & Jeong, D., *Fast calculation of the nonlinear redshift-space galaxy power spectrum including selection bias*, 2020, PRD, 101, 103528.

Grasshorn Gebhardt, H. S., Jeong, D., et al., *Unbiased Cosmological Parameter Estimation from Emission Line Surveys with Interlopers*, 2019, ApJ, 876, 32. doi:10.3847/1538-4357/ab12d5

Shandera, S., Jeong, D., **Grassshorn Gebhardt, H. S.**, *Gravitational Waves from Binary Mergers of Subsolar Mass Dark Black Holes*, 2018, PRL, Volume 120, Issue 24, 241102

Grasshorn Gebhardt, H. S., Jeong, D., *Fast and Accurate Computation of Projected Two-point Functions*, 2018, PRD, 97, 023504

Grasshorn Gebhardt, H. S., Zeimann, G. R., Ciardullo, R., et al., *Young, star-forming galaxies and their local counterparts: the evolving relationship of mass–SFR–metallicity since* $z \sim 2.1$, 2016, ApJ, 817, 10