Benjamin Thorne

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Experience

Postdoctoral Research Scholar *Jul. 2019 – Present*

Department of Physics, University of California, Davis

- Developed generative machine learning models of the distribution of Galactic dust. Implemented convolutional variational autoencoder in Tensorflow, and applied this model to various Bayesian inverse problems in image reconstruction. *Paper*, *code*.
- Developed extension to a Bayesian framework for the optimal analysis of high-dimensional image data from the South Pole Observatory. Implemented in Julia, using Zygote.jl for automatic differentiation and CUDA.jl for hardware acceleration. We perform Hamiltonian Monte Carlo sampling over millions of model parameters to constrain physical models of the early Universe. *In prep*, *code in private repository*.
- Supervised two graduate students conducting projects in machine learning and cosmological data analysis.
- Organized departmental cosmology and astronomy seminar series since January 2020.

Doctoral Researcher *Oct. 2015 – Jun. 2019*

Princeton University, University of Oxford, University of Tokyo, Kavli IPMU

- Developed widely-used Python package, *pysm*, which simulates cosmological data. This software now underpins Galactic and extragalactic sky simulations in the CMB Stage 4 experiment, South Pole Observatory, LiteBIRD, Simons Observatory. *Paper*, *code*.
- Derived theoretical predictions for astrophysical observables in a parity-violating cosmological model, and predicted the constraining power of the LISA laser interferometer, and LiteBIRD satellites for such a model. *Paper*.
- Developed Bayesian pixel-fitting code to be applied to multifrequency cosmic microwave background datasets, and applied it to forecast the impact of spurious signals from foreground contamination on science results from the upcoming Simons Observatory. *Paper 1*, *paper 2*, *code*.

Education

University of Oxford, St John's College *Oct. 2015 – Jun. 2019*

PhD in Astrophysics, supervised by Prof. Jo Dunkley

Princeton University *Sep. 2017 – Jun. 2019*

Visiting Graduate Student in Department of Astrophysical Sciences

University of Tokyo *Sep. 2016 – Aug. 2017*

Visiting Graduate Student, working with Prof. Eiichiro Komatsu

University of Oxford, New College *Oct. 2011 – Jul. 2015*

Master of Physics, first class honors

Publications

Below is a list of selected publications, for a more complete list, please see here.

First Author

- Thorne, B., et al., *Optimal Bayesian delensing and Galactic foreground removal for multifrequency data from next generation CMB surveys*, *in prep.*
- Thorne, B., et al., *A generative model for Galactic dust emission using variational inference*, arXiv:2101.11181, accepted by *MNRAS*, 2, 504:2603-2613, 2021.
- Thorne, B., et al., *Removal of Galactic foregrounds for the Simons Observatory primordial gravitational wave search*, arXiv:1905.08888, submitted to *Phys Rev D.*
- Thorne, B., et al., *Finding the chiral gravitational wave background of an axion-SU(2) inflationary model using CMB observations and laser interferometers*, arXiv:1707.03240, *Phys. Rev. D*, 97:043506, 2018
- Thorne, B., et al., *The Python Sky Model: Software for simulating the Galactic microwave sky*, arXiv:1608.02841, *MNRAS*, 3, 469:2821-2833, 2017.

Co-Author

- The Pan-Experiment Galactic Science Group, *The Python Sky Model 3.1: Stochastic Simulations of Small Scale Galactic Dust and Synchrotron Emission*, *in prep.*

- Zonca, A., et al., *The Python Sky Model 3 Software*, arXiv:2108.01444, , *JOSS*, 6, 67, 2021.
- Millea, M., et al., *Optimal CMB Lensing Reconstruction and Parameter Estimation with SPTpol Data*, arXiv:2012.01709, 2020, accepted.
- Choi, S., et al., *The Atacama Cosmology Telescope: A Measurement of the Cosmic Microwave Background Power Spectra at 98 and 150 GHz*, arXiv:2007.07289, *JCAP*, 12, 045, 2020.
- Aiola, S., et al., *The Atacama Cosmology Telescope: DR4 maps and cosmological parameters*, arXiv:2007.07288, *JCAP*, 12, 047, 2020.
- The CMB-S4 Collaboration, *CMB-S4: Forecasting Constraints on Primordial Gravitational Waves*, arXiv:2008.12619, accepted by *ApJ* 2020.
- The Simons Observatory Collaboration, *The Simons Observatory: Science Goals and Forecasts*, arXiv:1808.07445, *JCAP*, 02, 056, 2019.
- De Lorenzo-Cáceres, A., et al., *Deconstructing double-barred galaxies in 2D and 3D. II. Two distinct groups of inner bars*, arXiv:1901.08881, *MNRAS*, 2, 494:1826-1837, 2020.
- De Lorenzo-Cáceres, A., et al., *Deconstructing double-barred galaxies in 2D and 3D. I. Classical nature of the dominant bulges*, arXiv:1901.02684, *MNRAS*, 1, 484:665-686, 2019.
- Alonso, D., et al., *Simulated forecasts for primordial B-mode searches in ground-based experiments*, arXiv:1608.00551, *Phys. Rev. D*, 95:043504, 2017.

As part of wider collaboration

- Ferguson, K., et al., *Searching for axion-like time-dependent cosmic birefringence with SPT-3G*, arXiv:2203.16567, *submitted to Phys. Rev. D.*
- Chaubal, P., et al., *Cosmological constraints from CMB cluster lensing data from the SPT-SZ survey*, arXiv:2111.07491, *accepted by ApJ.*
- Chichura, P. M., et al., *Asteroid Measurements at Millimeter Wavelengths with the South Pole Telescope*, arXiv:2202.01406, *submitted to ApJ.*
- Sobrin, J., et al., *Design and Integrated Performance of the SPT-3G Instrument*, arXiv:2106.11202, *ApJS*, 258 (2), 42, 2022.
- Montgomery, J., et al., *Performance and characterization of the SPT-3G digital frequency-domain multiplexed readout system using an improved noise and crosstalk model*, arXiv:2103.16017, *JATIS*, 8 (1), 014001, 2022.
- Guns, S., et al., *Detection of Galactic and Extragalactic Millimeter-Wavelength Transient Sources with SPT-3G*, arXiv:2103.06166, *ApJ*, 916 (2), 98, 2021.
- Balkenhol, L., et al., *Constraints on Cosmology and the Hubble Constant from the SPT-3G 2018 EE and TE Power Spectra*, arXiv:2103.13618, *Phys. Rev. D* 104 (8), 083509, 2021.
- Dutcher, D., et al., *Measurements of the E-Mode Polarization and Temperature-E-Mode Correlation of the CMB from SPT-3G 2018 Data*, arXiv:2101.01684, *Phys. Rev. D* 104 (2), 022003, 2021.

Conference proceedings, mission proposals, and white papers

- The CMB-S4 Collaboration, *Snowmass 2021 CMB-S4 White Paper*, arXiv:2203.08024, *submitted to the Proceedings of the US Community Study on the Future of Particle Physics (Snowmass 2021).*
- Montier, L., et al., *LiteBIRD: JAXA's new strategic L-class mission for all-sky surveys of cosmic microwave background polarization*, arXiv:2102.00809, *SPIE*, 11443, 2020.
- Montier, L., et al., *Overview of the Medium and High Frequency Telescopes of the LiteBIRD satellite mission*, arXiv:2102.00809, *SPIE*, 11443, 2020.
- Sekimoto, Y., et al., *Concept design of low frequency telescope for CMB B-mode polarization satellite LiteBIRD*, arXiv:2101.06342, *SPIE*, 11453, 2020.
- Sugai, H., et al., *Updated design of the CMB polarization experiment satellite LiteBIRD*, arXiv:2001.01724, *Journal of Low Temperature Physics*, 199 (3), 1107-1117 2020.
- The Simons Observatory Collaboration, *The Simons Observatory: Astro2020 Decadal Project Whitepaper*, arXiv:1907.08284, , *Bull.Am.Astron.Soc.*, 51, 147 2019
- Hazumi, M., et al., *LiteBIRD: a satellite for the studies of B-mode polarization and inflation from cosmic background radiation detection*, arXiv:1801.06987, *Journal of Low Temperature Physics*, 194 (5), 443-452, 2018.
- Suzuki, A., et al., *The LiteBIRD Satellite Mission: Sub-Kelvin Instrument*, arXiv:1801.06987, *Journal of Low Temperature Physics*, 193 (5), 1048-1056, 2018.

Talks

Invited

- *Next generation tools for CMB B-mode analysis*, Astrophysics Colloquium, University of Melbourne. *Sep. 2021*
- *Next generation tools for CMB B-mode analysis*, Cosmology Seminar, University of Chicago. *Apr. 2021*
- *Generative models of Galactic foregrounds*, UC Berkeley machine learning workshop, UC Berkeley. *Mar. 2021*
- *Generative models of Galactic foregrounds*, UC Berkeley cosmology seminar. *Mar. 2020*
- *Galactic foreground simulation and removal*, UC Davis cosmology and astrophysics seminar. *Nov. 2019*
- *Robot Astronomers*, Astronomy on Tap, Davis (public talk). *Sep. 2019*
- *Galactic foreground removal for the Simons Observatory*, UC Berkeley and LBNL CMB lunch. *Aug. 2018*
- *Galactic foreground removal for the Simons Observatory*, KIPAC tea talk, Stanford / SLAC. *Jul. 2018*
- *The Python Sky Model*, CMB Foregrounds, UC San Diego. *Nov. 2017*
- *The Python Sky Model*, Cosmology in light of data, NORDITA. *Jul. 2017*
- *Detecting a chiral axion-SU(2) model of inflation*, Kavli IPMU. *Apr. 2017*

Contributed Talks

- *Talk*, CMB Stage 4 remote Spring Meeting, virtual. *Mar. 2021*
- *Talk*, South Pole Telescope face-to-face, virtual. *Feb. 2021*
- *Talk*, South Pole Observatory face-to-face, virtual. *Feb. 2021*
- *Talk*, Atacama Cosmology Telescope face-to-face, Princeton University. *Jan. 2018*
- *Talk*, B-modes from Space, UC Berkeley. *Dec. 2017*
- *Poster*, Cosmology in light of data, NORDITA. *Jul. 2017*
- *Talk*, National Astronomy Meeting, University of Hull. Jul. 2017
- *Talk*, LiteBIRD face-to-face, McGill University. *Jan. 2017*
- *Talk*, Cosmology with CMB-S4, Lawrence Berkeley National Laboratory. *Mar. 2016*
- *Talk*, Atacama Cosmology Telescope face-to-face, Princeton University. *Feb. 2016*

Awards and Grants

- XSEDE Comet GPU startup allocation, 2500 Service Units, Co-PI with Prof. Llyod Knox. *Jan. 2020*
- Inaugural Kavli IPMU fellow, funding PhD study at Kavli IPMU, University of Tokyo. *Sep. 2016 – Aug. 2017*
- Academic scholarship at New College, University of Oxford. *Sep. 2011 – Jun. 2015*

Service

- Organizer of the cosmology and astrophysics seminar at UC Davis *Jan. 2020 – present*
- Galactic Foregrounds parallel session organizer CMB S4 Spring meeting *Mar. 2020*
- Reviewer for EPJC, MNRAS

Technical Skills

Languages: Python (expert), Julia (competent)
Developer Tools: Git, GitHub (Actions), Docker.
Libraries: Tensorflow, Keras, scientific Python stack, dask, mpi4py, xarray, Zygote.jl, CUDA.jl.
Techniques: High-dimensional Bayesian inference, markov chain monte carlo, generative machine learning.