

Christopher Sheehy

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RESEARCH INTERESTS

Observational cosmology – instrumentation and data analysis for cosmic microwave background polarization and 21-cm intensity mapping

EDUCATION

Ph.D. in Astrophysics, University of Chicago, 2013

Thesis Advisor: Clem Pryke

Thesis: *Progress toward a detection of inflationary B-modes with the BICEP2 and Keck Array polarimeters*

B.A. in Physics and Astrophysics, University of California, Berkeley, 2005

POSITIONS HELD

- 2016–present** Goldhaber Postdoctoral Fellow, Brookhaven National Laboratory, Upton, NY
- 2013–2016** KICP Fellow, Kavli Institute for Cosmological Physics, University of Chicago, IL
- 2010–2013** Graduate Research Assistant, Physics Department, University of Minnesota, Minneapolis
- 2007–2010** Graduate Research Assistant, Department of Astronomy & Astrophysics and KICP, University of Chicago, IL

AWARDS

- Fall 2016 Goldhaber Postdoctoral Fellowship, Brookhaven National Lab
- Fall 2013 KICP Postdoctoral Fellowship, University of Chicago
- Fall 2000 Regent’s Scholarship, University of California, Berkeley

PROFESSIONAL SERVICE

Conference Organization

Tremendous Radio Arrays, Brookhaven National Lab (2018)

Reviewer

NASA APRA, CMB detectors panel

Seminar Organization

Particle Physics and Cosmology Seminar, BNL (2017)

Friday Cosmology Seminar, KICP, University of Chicago (2014-2015)

GRANTS

- 2018 PI; CMB-S4 Project Funds, **\$200,000** (provisional); grant to hire personnel and establish photolithography capabilities at BNL to produce metal mesh optical filters for CMB-S4. This is the amount of money earmarked in the CMB-S4 FY2019 funding request to fund my R&D proposal.
- 2015 KICP Initiative, **\$18,000**; seed funding plus full time undergraduate to design and construct an X-band, elevation tipping radiometer for a feasibility study of ground based CMB spectral distortions

RESEARCH HISTORY

- 2016-present **Low redshift 21-cm intensity mapping**
- project lead on the BMX experiment at BNL, a DOE funded prototype instrument to detect 21-cm large scale structure at $z < 1$ and demonstrate the viability of 21-cm as a technique for a Stage-V dark energy survey
 - antenna design, receiver design, simulation, data analysis, systematics
 - member of the DOE Cosmic Visions 21-cm working group and co-author of resulting white paper
- 2016-present **CMB Stage-IV**
- metal mesh filter development under CMB-S4 R&D funding
 - data analysis and foreground characterization; galactic dust systematics and “decorrelation”
 - leader of joint effort with BNL computational scientists to employ machine learning to generate predictive foreground models incorporating galactic 21-cm data
- 2007-present **BICEP/Keck Array**
- designed, tested, and deployed to the South Pole the pulse tube cooled cryostats for Keck Array
 - designed and fielded large scale upgrades to the existing telescope mount
 - led the instrumental systematics mitigation effort for BICEP2 and Keck Array, including the analysis technique of deprojecting beam systematics
 - key developer of all aspects of the BICEP and Keck Array data analysis pipeline, including data mocks, map making, and power spectrum estimation
- 2015-2016 **Site characterization for future ground based CMB experiments**
- helped design a suite of azimuth scanning water vapor radiometers, currently deployed to characterize possible northern hemisphere sites for future ground-based CMB campaigns, e.g. Greenland and Tibet
- 2015-2016 **Ground based CMB spectral distortions**
- developed and tested an experimental concept to measure CMB recombination lines from the ground; this was an original proposal for which I obtained KICP seed funding normally reserved for faculty. Currently shelved.
- 2004-2006 **Adaptive Optics**
- developed novel data analysis techniques for analyzing laser guide star adaptive optics images from the Keck Observatory

STUDENTS SUPERVISED

Primary Supervisor

William Tyndall, Stony Brook University master’s student (2017–2019, starting Physics Ph.D. program at Yale)
21-cm instrumentation and data analysis

Lindsay Berkhout, Chandler Conn, Sebastian Lee, BNL SULI undergraduates (2016–2019),
21-cm instrumentation

Evan Arena, Stony Brook University undergraduate (2016–2018)
Parabolic dish surface accuracy measurements

Jessica Avva, University of Chicago undergraduate (2014–2015, now in Physics Ph.D. program, U.C. Berkeley)

Honors thesis: *Atmospheric characterization for future CMB experiments*

Jonathan Kyl, University of Chicago undergraduate (2015–2016)

Honors thesis: *A pathfinder instrument for ground based CMB spectral distortions*

Co-supervisor

Hindy Drillick, Stony Brook undergraduate (2017–2018)

21-cm GPU spectrometer coding, real-time RFI mitigation

TEACHING

Guest Lectures, University of Chicago

Graduate courses *Advanced CMB* (prof. Wayne Hu, Spring 2015) and *Advanced Methods of Data Analysis* (prof. Abigail Vieregg, Spring 2015)

Teaching Assistant, University of Chicago

Undergraduate courses *Evolution of the Universe*, *Stellar Astronomy and Astrophysics*, *The Origin of the Universe and How we Know* (Fall 2006–Spring 2007)

Teaching Assistant, University of California, Berkeley

Undergraduate courses *Infrared astronomy laboratory* (Fall 2006), *Radio astronomy laboratory* (Winter 2006); developed and delivered multiple lectures

INVITED TALKS AND SEMINARS

“How to believe a detection of primordial gravitational waves”

Tuesday Astronomy Seminar, New York University, April 2019

“21-cm Cosmology at Brookhaven National Lab”

Research Techniques Seminar, Fermilab, January 2019

KIPAC Tea Talk, SLAC, November 2017

Friday Graduate Student Seminar, Stony Brook University, May 2017

“A Closer Look at Dust Decorrelation in Planck Data”

CMB Foregrounds Workshop, University of California, San Diego, November 2017

“Measuring CMB Recombination Lines from the Ground”

Probing Fundamental Physics with CMB Spectral Distortions, CERN, March 2018

Seminar, MIT Haystack Observatory, May 2017

CMB Spectral Distortions Workshop, Raman Research Institute, Bangalore, July 2016

Cosmology seminar, University of Minnesota, Minneapolis, February 2016

“Improved Constraints on Cosmic Inflation with New 95 GHz Data from the Keck Array”

Cosmology seminar, Brookhaven National Lab, Upton, NY, April 2016

Physics theory group seminar, University of Texas, Austin, January 2016

Theoretical astrophysics seminar, University of Illinois, Urbana-Champaign, November 2015

“Results from BICEP2”

Physics Colloquium, Arizona State University, November 2014

Cosmology After Planck, MIAPP Munich, Garching, Germany, September 2014

Santa Fe Cosmology Workshop, Santa Fe, New Mexico, July 2014

Users Group Meeting, Jefferson Lab, June 2014

Physics division seminar, Argonne National Lab, April 2014

Implications of BICEP2 conference, Perimeter Institute, April 2014

KICP special colloquium, University of Chicago, March 2014

“BICEP2 Instrumental Systematics”

KICP Postdoc Symposium, University of Chicago, April 2014

“The Keck Array”

Cosmology lunch seminar, University of Minnesota, May 2011

“PSF Reconstruction for Accurate Stellar Photometry”

REFEREED PUBLICATIONS

C. Sheehy, *Deprojecting Beam Systematics for CMB-S4*, (in prep.)

G. Zhang, C. Chiang, C. Sheehy, A. Slosar, & J. Wang, *Predicting CMB dust foreground using galactic 21-cm data*, Submitted to JCAP (arXiv:1904.13265)

BICEP2/Keck Array Collaborations, *BICEP2/Keck Array X: Constraints on Primordial Gravitational Waves using Planck, WMAP, and New BICEP2/Keck Observations through the 2015 Season*, Phys. Rev. Lett. accepted, Editor's Suggestion (arXiv:1810.05216)

C. Sheehy & Anže Slosar, *No evidence for dust B-mode decorrelation in Planck data*, Phys. Rev. D 97 (2018) 043522 (arXiv:1709.09729)

BICEP2/Keck Array Collaborations, *BICEP2 / Keck Array IX: New bounds on anisotropies of CMB polarization rotation and implications for axionlike particles and primordial magnetic fields*, Phys. Rev. D 96 (2016) 102003 (arXiv:1705.02523)

BICEP2/Keck Array Collaborations, *BICEP2 / Keck Array VIII: Measurement of gravitational lensing from large-scale B-mode polarization*, ApJ 833 (2016) 228 (arXiv:1606.01968)

BICEP2/Keck Array Collaborations, *BICEP2/Keck Array VII: Matrix Based E/B Separation Applied to BICEP2 and the Keck Array*, ApJ 825 (2016) 66 (arXiv:1603.05976)

BICEP2/Keck Array Collaborations, *BICEP2/Keck Array VI: Improved Constraints On Cosmology and Foregrounds When Adding 95 GHz Data From Keck Array*, Phys. Rev. Lett. 116 (2016) 031302 (arXiv:1510.09217)

BICEP2/Keck Array/Planck Collaborations, *A Joint Analysis of BICEP2/Keck Array and Planck Data*, Phys. Rev. Lett. 114 (2015) 101301 (arXiv:1502.00612)

BICEP2/Keck Array Collaborations, *BICEP2/Keck Array V: Measurements of B-mode Polarization at Degree Angular Scales and 150 GHz by the Keck Array*, ApJ 811 (2015) 126 (arXiv:1502.00643)

BICEP2/Keck Array/SPIDER Collaborations, *Antenna-coupled TES bolometers used in BICEP2, Keck Array, and SPIDER*, ApJ 812 (2015) 176 (arXiv:1502.00619)

BICEP2/Keck Array Collaborations, *BICEP2 IV: Optical Characterization and Performance of the BICEP2 and Keck Array Experiments*, ApJ 806 (2015) 206 (arXiv:1502.00596)

BICEP2 Collaboration (**corresponding author**), *BICEP2 III: Instrumental Systematics*, ApJ 814 (2015) 110 (arXiv:1502.00608)

BICEP2 Collaboration, *BICEP2 II: Experiment and Three-Year Data Set*, ApJ 792 (2014) 62 (arXiv:1403.4302)

BICEP2 Collaboration, *Detection of B-Mode Polarization at Degree Angular Scales by BICEP2*, Phys. Rev. Lett. 112 (2014) 241101 (arXiv:1403.3985)

J. P. Kaufman, et al., *Self-calibration of BICEP1 three-year data and constraints on astrophysical polarization rotation*, Phys. Rev. D 89 (2014) 062006 (arXiv/1312.7877)

BICEP1 Collaboration, *Degree-scale Cosmic Microwave Background Polarization Measurements from Three Years of BICEP1 Data*, ApJ 783 (2014) 67 (arXiv:1310.1422)

S. Moyerman, et al., Scientific verification of Faraday Rotation Modulators: Detection of Diffuse Polarized Galactic Emission, *ApJ* 765 (2013) 64 (arXiv:1212.0133)

Z. Staniszewski, et al., *The Keck Array: A Multi Camera CMB Polarimeter at the South Pole*, *JLTP* 167 (2012) 827

E. M. Bierman, et al., *A Millimeter-wave Galactic Plane Survey with the BICEP Polarimeter*, *ApJ* 741 (2011) 81 (arXiv:1103.0289)

H. C. Chiang, et al., *Measurement of Cosmic Microwave Background Polarization Power Spectra from Two Years of BICEP Data*, *ApJ* 711 (2010) 1123 (arXiv:0906.1181)

H. Maness, F. Martins, S. Trippe, R. Genzel, J. R. Graham, **C. Sheehy**, M. Salaris, S. Gillessen, T. Alexander, T. Paumard, T. Ott, R. Abuter, F. Eisenhauer, *Evidence for a Long-standing Top-heavy Initial Mass Function in the Central Parsec of the Galaxy*, *ApJ* 669 (2007) 1024 (arXiv:0707.2382)

W. D. Vacca, **C. Sheehy**, J. R. Graham, *Imaging of the Stellar Population of IC10 with Laser Guide Star Adaptive Optics and the Hubble Space Telescope*, *ApJ* 662 (2007) 272 (arXiv:0701628)

C. Sheehy, N. McCrady, J. R. Graham, *Constraining the Adaptive Optics Point-Spread Function in Crowded Fields: Measuring Photometric Aperture Corrections*, *ApJ* 647 (2006) 1517 (arXiv:0604551)

CONFERENCE PROCEEDINGS and WHITE PAPERS

Cosmic Visions 21-cm Collaboration, *Inflation and Early Dark Energy with a Stage II Hydrogen Intensity Mapping experiment* (arXiv:1810.09572)

D. Barkats, R. Bowens-Rubin, W.H. Clay, T. Culp, R. Hills, J.M. Kovac, N.A. Larsen, S. Paine, **C.D. Sheehy**, A.G. Vieregg, *High-precision scanning water vapor radiometers for cosmic microwave background site characterization and comparison*, Proceedings of the SPIE, August, 2018 (arxiv:1808.01349)

D. Barkats et al., *Ultra-thin large-aperture vacuum windows for millimeter wavelengths receivers*, Proceedings of the SPIE, August, 2018 (arxiv:1808.00570)

M. Crumrine et al., *BICEP Array cryostat and mount design*, Proceedings of the SPIE, August, 2018 (arxiv:1808.00569)

H. Hui et al., *BICEP Array: a multi-frequency degree-scale CMB polarimeter*, Proceedings of the SPIE, August, 2018 (arxiv:1808.00568)

H. Hui et al., *BICEP3 focal plane design and detector performance*, Proceedings of the SPIE, June, 2016 (arxiv:1607.06861)

J. A. Grayson et al., *BICEP3 performance overview and planned Keck Array upgrade*, Proceedings of the SPIE, June, 2016 (arxiv:1607.04668)

K. S. Karkare, et al., *Optical Characterization of the BICEP3 CMB Polarimeter at the South Pole*, Proceedings of the SPIE, June, 2016 (arxiv:1607.04567)

K. S. Karkare, et al., *Keck array and BICEP3: spectral characterization of 5000+ detectors*, Proceedings of the SPIE, August, 2014

I. Buder, et al., *BICEP2 and Keck array: upgrades and improved beam characterization*, Proceedings of the SPIE, August, 2014

A. G. Vieregg, et al., *Optical Characterization of the Keck Array Polarimeter at the South Pole*, Proceedings of the SPIE, July, 2012 (arXiv:1208.0844)

R. O'Brien, et al., *Antenna-coupled TES bolometers for the Keck Array, Spider, and Polar-1*, Proceedings of the SPIE, July, 2012 (arXiv:1208.1247)

S. Kernasovskiy, et al., *Optimization and sensitivity of the Keck Array*, Proceedings of the SPIE, July, 2012 (arXiv:1208.0857)

R. W. Ogburn IV, et al., *BICEP2 and Keck Array operational overview and status of observations*, Proceedings of the SPIE, July, 2012 (arXiv:1208.0638)

C. Sheehy, et al., *The Keck Array: a Pulse Tube Cooled CMB Polarimeter*, Proceedings of the SPIE, June, 2010 (arXiv:1104.5516)

OUTREACH

University of Chicago

Organizer and course instructor for KICP *Short Course for Museum and Planetarium Staff*, September 2014

Popular science writing

Contributed editorial advice for "The Ultimate Fate of the Universe" article on cosmology, *The Believer*, vol. 9, no. 8, October 2011

Contributed copy and editorial advice for "Living with a Yellow Dwarf" article on solar physics, *McSweeney's Quarterly*, Issue 33, January 2010

REFERENCES

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