Lennart Balkenhol

Curriculum Vitae

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RESEARCH INTERESTS

- Cosmic microwave background anisotropies
- Phenomenology in cosmology
- Cosmological structure formation
- Analysis methods in astrophysics and cosmology
- Machine learning applications in cosmology
- Cosmological concordance

EDUCATION & POSITIONS

POSTDOCTORAL FELLOW 03/2023 - 02/2026
Institut d'Astrophysique de Paris
Advisor: Silvia Galli
Project: NEUCosmoS (ERC consolidator grant)

DOCTOR OF PHILOSOPHY 06/2019 - 01/2023
University of Melbourne
Thesis: Constraining Cosmology with SPT-3G
Advisory Committee: Christian Reichardt, Rachel Webster, Raymond Volkas

MASTER OF SCIENCE IN PHYSICS 02/2017 - 12/2018
University of Melbourne
Advisor: Christian Reichardt

BACHELOR OF SCIENCE WITH HONOURS IN PHYSICS WITH ASTROPHYSICS 09/2013 - 06/2016
University of Sussex
Advisor: Robert E. Smith

PROFESSIONAL ACTIVITIES AND RESPONSIBILITIES

Member of the SPT-3G Collaboration Since 2019
- Analysis coordinator "Theory and Likelihood" working group (since 2024)
- Organised and chaired high-level analysis session of multiple collaboration meetings.

Member of the CMB-S4 Collaboration Since 2023

Member of the "Comité contre le harcèlement et les discriminations", Institut d'Astrophysique de Paris Since 2024
- Organising institute-wide seminars related to diversity, equity, and inclusion

Organiser of the cosmology journal club, University of Melbourne 2020 - 2022

MENTORING

Aline Vitrier (PhD candidate, Institut d'Astrophysique de Paris) Since 2023
- Helping gain expertise in Fisher forecasting, likelihood analysis, and Bayesian inference
- Use of common cosmology software and code I personally developed adopted by the South Pole Telescope collaboration

SKILLS

- Programming: Python (Advanced), Objective-C (Intermediate), Fortran (Intermediate), C (Basic), HTML & CSS (Basic), Unix scripting (Basic)
- Technical: MCMC sampling (Cobaya, CosmoMC, MontePython, BlackJAX, flowMC), cosmologial theory codes and emulators (CAMB, CLASS, CosmoPower, Capse.jl), JAX, automatic differentiation, HEALPix, pip distribution, supercomputing using CPUs and GPUs
- Other: data visualisation, signal processing, statistical interpretation
- Languages: German (native), English (bilingual), French (B2)

AWARDS AND SCHOLARSHIPS

2022 Dr Albert Shimmins Postgraduate Writing-Up Award
2022 Laby PhD Travelling Scholarship
2021 Laby PhD Travelling Scholarship
2019 Melbourne Research Scholarship
2017 International Postgraduate Coursework Scholarship
2016 Andrew J. Symonds Memorial Award
2013 Scholar of the German National Academic Foundation

TEACHING

TEACHING ASSISTANT
University of Melbourne

- Introduction to Life, Earth and Universe 2021
- From the Solar System to the Cosmos 2020
- Physics First Year Laboratory 2017-2020, 2022

TEACHING ASSISTANT
University of Sussex

- Introduction to Scientific Python Programming 2015-2016

PROFESSIONAL EXPERIENCE

DATA ANALYST 08/2018-06/2019
Crypton Capital
96 Pelham St, Carlton VIC 3053, Australia

DEVELOPMENT INTERN 08/2018-06/2019
Touch Fantastic
Werks Central, 15-17 Middle Street, Brighton BN1 1AL, United Kingdom

INTERESTS

FENCING

- University of Melbourne Elite Athlete Scholarship (2017 - 2022)
- Awarded Melbourne University full blue award (2019)
- Achieved podium results at German, British, and Australian national competitions
- British coaching qualification
- Australian referee accreditation

- Volunteered as University of Sussex Fencing Club secretary (2015-2016)

SUSTAINABILITY

- Campaigning for the introduction of daily plant-based dishes at the shared canteen of the Institut d'Astrophysique de Paris and the Observatoire de Paris
- Wrote and circulated an open letter across the two institutes attracting 60 signatures
- Liaising with the canteen committee and the climate committee of the Institut d'Astrophysique de Paris

OUTREACH

- Presentation to and engagement with hobby astronomers of the "Sternfreunde Menden", Germany (2024)
- Telescopes in schools volunteer, University of Melbourne (2018 - 2022)

PRESENTATIONS AT SCIENTIFIC CONFERENCES

* = Talk; Inv. = Invited talk; Sem. = Seminar

Sem. December 2024, Swinburne Institute of Technology, Australia — *'Changing the way we analyse CMB data with candl'*

Sem. December 2024, University of Melbourne, Australia — *'Changing the way we analyse CMB data with candl'*

Sem. November 2024, RWTH Aachen, Germany — *'CMBlite with Automatic Differentiation'*

Inv. November 2024, CMB-S4 maps to power spectra working group — *'Changing the way we analyse CMB data with candl'*

Inv. November 2024, GDR CoPhy Tools, Institut d'Astrophysique de Paris, France — *'Changing the way we analyse CMB data with candl'*

* October 2024, Cosmo24, Kyoto University, Japan — *'Constraining Cosmology with the South Pole Telescope'*

* May 2024, GDR CoPhy Episode 2, IP2I Lyon, France — *'candl: CMB Analysis with a differential likelihood'*

Sem. April 2024, RWTH Aachen, Germany — *'Changing the way we analyse CMB data with candl'*

*. April 2024, Rencontres de Moriond, La Thuile, Italy — *'candl: CMB Analysis with a differential likelihood'*

Sem. March 2024, Postdoc day, Institut d'Astrophysique de Paris, France — *'candl: CMB Analysis with a differential likelihood'*

* December 2023, Colloque National CMB-France, Institut d'Astrophysique de Paris, France — *'candl: CMB Analysis with a Differentiable Likelihood'*

Sem. October 2023, Laboratoire Univers et particules de Montpellier, France — *'A Differentiable Likelihood for CMB Data Analysis'*

* 2023 September, Cosmo23, Instituto de Física Teórica, Spain — *'SPT-3G 2018 TT/TE/EE Power Spectrum and Future Likelihood'*

Sem. 2023 March, Simons Observatory maps2cell working group — *'SPT-3G 2018 TT/TE/EE Power Spectrum'*

Sem. 2023 March, Institut d'Astrophysique de Paris, France — *'Cosmic Microwave Background Power Spectrum Measurements from SPT-3G 2018 Data'*

Inv. 2022 July, Intriguing Inconsistencies in the Growth of Structure over Cosmic Time, Sexten Center for Astrophysics, Italy — *'Constraints on Structure Growth from SPT-3G Power Spectrum Measurements'*

Sem. 2022 July, Imperial College London, UK — *'Searching for Physics Beyond the Standard Model with Planck, SPT, and ACT data'*

Sem. 2022 June, University of Cambridge, UK — *'Searching for Physics Beyond the Standard Model with Planck, SPT, and ACT data'*

Sem. 2022 June, University of Sussex, UK — *'Searching for Physics Beyond the Standard Model with Planck, SPT, and ACT data'*

Sem. 2022 June, Max Planck Institute for Astrophysics, Germany — *'Searching for Physics Beyond the Standard Model with Planck, SPT, and ACT data'*

* 2022 June, Colloque National CMB-France, Institut d'Astrophysique de Paris, France — *'Searching for Physics Beyond the Standard Model with Planck, SPT, and ACT data'*

Sem. 2022 February, Institut d'Astrophysique de Paris, France — *'Constraints on Cosmological Parameters from SPT-3G 2018'*

* 2021 August, Cosmo21, University of Illinois, USA — *'Constraints on Cosmology from the SPT-3G 2018 EE/TE Power Spectra'*

* 2021 July, ASA2021, University of Melbourne, Australia — *'Constraints on Cosmology from the SPT-3G 2018 EE/TE Power Spectra'*

Inv. 2021 June, Six week summer webinar series on the growth of structure over cosmic time — *'CMB Measurements of the Growth of Structure from SPT'*

Sem. 2021 May, University of Sussex, UK — *'Constraints on Cosmology from the SPT-3G 2018 EE/TE Power Spectra'*

Sem. 2021 April, KIPAC Tea Talk, Stanford University, USA — *'Constraints on* ΛCDM *Extensions from the SPT-3G 2018 EE/TE Power Spectra and their Implications for the Hubble Constant'*

* 2019 December, AIP Summer Meeting 2019, RMIT, Australia — *'Preparing Next-Generation CMB Experiments for Big Data Challenges Using Extreme Digitisation'*

* 2018 June, ASA 2018, Swinburne University, Australia — *'Using Extreme Digitisation to Combat Data Challenges in CMB Observations'*

Lennart Balkenhol

List of Publications

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REFEREED JOURNAL ARTICLES

859 total citations of published works, average of 43 per paper, h-index of 12, according to Inspire.

PROJECTS LEAD OR WITH MAJOR CONTRIBUTION

I have lead the following projects or made major contributions to them.

1. *Compressed 'CMB-lite' Likelihoods Using Automatic Differentiation*
   L. Balkenhol
   Submitted to The Open Journal of Astrophysics, arXiv:2412.00826

2. *'candl: Cosmic Microwave Background Analysis with a Differentiable Likelihood'*
   L. Balkenhol, C. Trendafilova, K. Benabed, S. Galli
   Astronomy & Astrophysics, V686 (June 2024), A10

3. *'A Measurement of the CMB Temperature Power Spectrum and Constraints on Cosmology from the SPT-3G 2018 TT/TE/EE Data Set'*
   L. Balkenhol, D. Dutcher, A. Spurio Mancini, A. Doussot, K. Benabed, S. Galli, ... et al. [87 authors]
   Physical Review D 108 (2023) 2, 023510

4. *'The Parameter-Level Performance of Covariance Matrix Conditioning in Cosmic Microwave Background Data Analyses'*
   L. Balkenhol and C. L. Reichardt
   Monthly Notices of the Royal Astronomical Society vol. 512 (2022), no. 3, pp.4394-4403

5. *'Constraints on* ΛCDM *extensions from the SPT-3G 2018 EE and TE power spectra'*
   L. Balkenhol, D. Dutcher, ... et al. [120 authors]
   Physical Review D 104 (2021) 8, 083509

6. *'Measurements of the E -mode polarization and temperature-E -mode correlation of the CMB from SPT-3G 2018 data'*
   D. Dutcher, **L. Balkenhol**, ... et al. [121 authors]
   Physical Review D 104 (2021) 2, 022003

7. *'Extreme digitization for ground-based cosmic microwave background experiments'*
   L. Balkenhol and C. L. Reichardt
   Monthly Notices of Royal Astronomical Society vol. 487 (2019), no. 3, pp. 3279–3287

LIMITED CONTRIBUTION

I have made modest contributions to the following projects.

1. *'Hints of Early Dark Energy in Planck, SPT, and ACT data: new physics or systematics?'*
   T. Smith, M. Lucca, V. Poulin, G. Abellan, **L. Balkenhol**, K. Benabed, S. Galli, and R. Murgia
   Physical Review D 106 (2022) 4, 043526

2. *'Consistency of Planck, ACT and SPT constraints on magnetically assisted recombination and forecasts for future experiments'*
   S. Galli, L. Pogosian, K. Jedamzik, and **L. Balkenhol**
   Physical Review D 105 (2022) 2, 023513

COLLABORATION WORK

I am a co-author of the papers below as part of the SPT-3G collaboration.

1. *'Cosmology From CMB Lensing and Delensed EE Power Spectra Using 2019-2020 SPT-3G Polarization Data'*
   F. Ge, M. Millea, E. Camphuis, C. Daley, N. Huang, Y. Omori, W. Quan, ... **L. Balkenhol**, ... et al. [96 authors]
   Submitted to Physical Review D, arXiv:2411.06000

2. *'Detection of Thermal Emission at Millimeter Wavelengths from Low-Earth Orbit Satellites'*
   A. Foster, A. Chokshi, ... **L. Balkenhol**, ... et al. [92 authors]
   Submitted to The Open Journal of Astrophysics, arXiv:2411.03374

3. *'Measurement and Modeling of Polarized Atmosphere at the South Pole with SPT-3G'*
   A. Coerver, J. A. Zebrowski, S. Takakura, W. L. Holzapfel, ... **L. Balkenhol**, ... et al. [105 authors]
   Submitted to The Astrophysical Journal, arXiv:2407.20579

4. *'Mass calibration of DES Year-3 clusters via SPT-3G CMB cluster lensing'*
   B. Ansarinejad, S. Raghunathan, ... **L. Balkenhol**, ... et al. [145 authors]
   Journal of Cosmology and Astroparticle Physics 07 (2024) 024

5. *'Testing the* ΛCDM *Cosmological Model with Forthcoming Measurements of the Cosmic Microwave Background with SPT-3G'*
   K. Prabhu, S. Raghunathan, M. Millea, G. Lynch, ... **L. Balkenhol**, ... et al. [101 authors]
   The Astrophysical Journal 973 (2024) 4

6. *'First Constraints on the Epoch of Reionization Using the non-Gaussianity of the Kinematic Sunyaev-Zel'dovich Effect from the South Pole Telescope and Herschel-SPIRE Observations'*
   S. Raghunathan, ... **L. Balkenhol**, ... et al. [124 authors]
   Physical Review Letters 133, 121004

7. *'Flaring Stars in a Non-targeted mm-wave Survey with SPT-3G'*
   C. Tandoi, S. Guns, A. Foster, ... **L. Balkenhol**, ... et al. [99 authors]
   The Astrophysical Journal 972 (2024) 6

8. *'A Measurement of Gravitational Lensing of the Cosmic Microwave Background Using SPT-3G 2018 Data'*
   Z. Pan, F. Bianchini, W. L. K. Wu, ... **L. Balkenhol**, ... et al. [136 authors]
   Physical Review D 108 (2023) 12, 122005

9. *'A measurement of the mean central optical depth of galaxy clusters via the pairwise kinematic Sunyaev-Zel'dovich effect with SPT-3G and DES'*
   E. Schiappucci, F. Bianchini, ... **L. Balkenhol**, ... et al.
   Physical Review D 107 (2023) 4, 042004

10. *'Searching for axion-like time-dependent cosmic birefringence with data from SPT-3G'*
    K. R. Ferguson, A. J. Anderson, N. Whitehorn, ... **L. Balkenhol**, ... et al. [81 authors]
    Physical Review D 106 (2022) 4, 042011

11. *'Asteroid Measurements at Millimeter Wavelengths with the South Pole Telescope'*
    P. M. Chichura, A. Foster, C. Patel, N. Ossa-Jaen, ... **L. Balkenhol**, ... et al. [144 authors]
    The Astrophysical Journal 936 (2022) 2,173

12. *'Improving cosmological constraints from galaxy cluster number counts with CMB-cluster-lensing data: Results from the SPT-SZ survey and forecasts for the future'*
    P. S. Chaubal, C. L. Reichardt, N. Gupta, ... **L. Balkenhol**, ... et al. [43 authors]
    The Astrophysical Journal 931 (2022) 2, 139

13. *'The Design and Integrated Performance of SPT-3G'*
    J. A. Sobrin, A. J. Anderson, A. N. Bender, B. A. Benson, D. Dutcher, A. Foster, N. Goeckner-Wald, J. Montgomery, A. Nadolski, A. Rahlin, ... **L. Balkenhol**, ... et al. [123 authors]
    The Astrophysical Journal Supplement Series 258 (2022) 2, 42

14. *'Performance and characterization of the SPT-3G digital frequency-domain multiplexed readout system using an improved noise and crosstalk model'*
    J. Montgomery, ... **L. Balkenhol**, ... et al. [121 authors]
    Journal of Astronomical Telescopes, Instruments, and Systems 8 (2022), 014001

15. *'Detection of Galactic and Extragalactic Millimeter-Wavelength Transient Sources with SPT-3G'*
    S. Guns, A. Foster, C. Daley, A. Rahlin, N. Whitehorn, ..., **L. Balkenhol**, ... et al. [122 authors]
    The Astrophysical Journal 916 (2021) 2, 98

16. *'Searching for Anisotropic Cosmic Birefringence with Polarization Data from SPTpol'*
    F. Bianchini, W. L. K. Wu, ... **L. Balkenhol**, ... et al. [72 authors]
    Physical Review D 102 (2020) 8, 083504

THESES

1. *'Constraining Cosmology with SPT-3G'*
   PhD Thesis, 2022
   Available at: https://minerva-access.unimelb.edu.au/items/4b67dae4-60f1-416b-80a7-d60d580d899c/full

2. *'Few-Bit Digitisation for Ground-Based Cosmic Microwave Background Experiments'*
   MSc Thesis, 2018
   Available upon request.

3. *'Analytical Aperture Mass Models and Tools of Gravitational Lensing in Python'*
   BSc Thesis, 2016
   Available upon request.