

Sebastian Hoof

Marie Skłodowska-Curie Actions Postdoctoral Fellow

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Employment

Università degli Studi di Padova

Padua, Italy

MSCA Postdoctoral Fellow

Since 2023

Marie Skłodowska-Curie Fellowship "AxiTools" (responsible: Paride Paradisi), funded by the EU's Horizon programme (GA No. 101065579). Development of software tools to study axion phenomenology in astrophysical systems and beyond.

KIT

Karlsruhe, Germany

Postdoctoral researcher

2022

Member of Felix Kahlhoefer's group. Work on axions and axion-like particles in cosmology and using SN1987A data.

Georg-August-Universität Göttingen

Göttingen, Germany

Postdoctoral researcher

2019–2022

Member of David 'Doddy' J. E. Marsh's Sofja Kovalevskaja research group. Work on the phenomenology of QCD axions and axion-like particles, incl. experimental searches (Xenon-1T, TOORAD, IAXO), statistical methodology and global fits with GAMBIT.

Education

Imperial College London

London, UK

PhD in Physics

2015–2019

PhD thesis on "Global Fits of Axions and WIMPs in Astrophysics, Cosmology, and Particle Physics" supervised by Pat Scott and Roberto Trotta. Global statistical analyses combining the available experimental data and theoretical constraints for axions and WIMPs. I used Bayesian and frequentist techniques in C++ and Python, and contributed to the GAMBIT global fitting software.

Ruprecht-Karls-Universität Heidelberg

Heidelberg, Germany

Master of Science (Physics)

2013–2015

Overall grade: 1,0. Master's thesis on "Axion Dark Matter and Two Periods of Inflation" (supervised by Joerg Jaeckel).

Ruprecht-Karls-Universität Heidelberg

Heidelberg, Germany

Bachelor of Science (Physics)

2009–2013

Overall grade: 1,2. Bachelor's thesis in medical physics on the "Correlation of Particle and Background Signal in $\text{Al}_2\text{O}_3:\text{C,Mg}$ Fluorescent Nuclear Track Detectors" (supervised by Oliver Jäkel and Steffen Greilich).

LCN (London Centre for Nanotechnology)

London, UK

Summer student at the Hoogenboom lab

06/2012–08/2012

I improved and characterised the design of my magnetically actuated cantilever setup and used it to image DNA samples [17].

UCL (University College London)

London, UK

Erasmus Exchange Programme

2011–2012

"Physics Project BSc" dissertation on "Bio-AFM by magnetic resonance-enhancement" (supervised by Bart Hoogenboom).

Publications

Up-to-date overview of citations from e.g. the [INSPIRE database](#); current h -index ≈ 12 .

Textbooks

- [1] D. J. E. Marsh and S. Hoof, *Astrophysical Searches and Constraints*, in *The Search for Ultralight Bosonic Dark Matter* (D. F. J. Kimball and K. van Bibber, eds.), pp. 73–122. 2023. [[arXiv:2106.08797](#)].

Articles

- [2] S. Hoof, J. Jaeckel, and L. J. Thormaehlen, *Axion helioscopes as solar thermometers*, *JCAP* **2023** (2023) 024, [[arXiv:2306.00077](#)]. With **C++** and **Python**.
- [3] S. Hoof and L. Schulz, *Updated constraints on axion-like particles from temporal information in supernova SN1987A gamma-ray data*, *JCAP* **2023** (2023) 054, [[arXiv:2212.09764](#)]. With **C++** and **Python**.
- [4] C. Balázs, S. Bloor, et. al., *Cosmological constraints on decaying axion-like particles: a global analysis*, *JCAP* **2022** (2022) 027, [[arXiv:2205.13549](#)]. With **C++**.
- [5] S. Hoof, J. Riess, and D. J. E. Marsh, *Statistical Uncertainties of the $N_{DW} = 1$ QCD Axion Mass Window from Topological Defects*, *The Open Journal of Astrophysics* **5** (2022) 5, [[arXiv:2108.09563](#)]. With **Python**.
- [6] V. Plakkot and S. Hoof, *Anomaly ratio distributions of hadronic axion models with multiple heavy quarks*, *Phys. Rev. D* **104** (2021) 075017, [[arXiv:2107.12378](#)]. With **Python**.
- [7] A. Fowlie, S. Hoof, and W. Handley, *Nested Sampling for Frequentist Computation: Fast Estimation of Small p-Values*, *Phys. Rev. Lett.* **128** (2022) 021801, [[arXiv:2105.13923](#)]. With **Python**.
- [8] J. Schütte-Engel, D. J. E. Marsh, et. al., *Axion quasiparticles for axion dark matter detection*, *JCAP* **2021** (2021) 066, [[arXiv:2102.05366](#)].
- [9] S. Hoof, J. Jaeckel, and L. J. Thormaehlen, *Quantifying uncertainties in the solar axion flux and their impact on determining axion model parameters*, *JCAP* **2021** (2021) 006, [[arXiv:2101.08789](#)]. With **C++ & Python**.
- [10] S. S. AbdusSalam, F. J. Agocs, et. al., *Simple and statistically sound recommendations for analysing physical theories*, *Reports on Progress in Physics* **85** (2022) 052201, [[arXiv:2012.09874](#)].
- [11] J. J. Renk, P. Stöcker, et. al., *CosmoBit: a GAMBIT module for computing cosmological observables and likelihoods*, *JCAP* **2021** (2021) 022, [[arXiv:2009.03286](#)]. With **C++**.
- [12] P. Athron, C. Balázs, et. al., *Global fits of axion-like particles to XENON1T and astrophysical data*, *Journal of High Energy Physics* **2021** (2021) 159, [[arXiv:2007.05517](#)]. With **C++**.
- [13] S. Ando, A. Geringer-Sameth, et. al., *Structure formation models weaken limits on WIMP dark matter from dwarf spheroidal galaxies*, *Phys. Rev. D* **102** (2020) 061302, [[arXiv:2002.11956](#)]. With **C++ & Python**.
- [14] S. Hoof, A. Geringer-Sameth, and R. Trotta, *A global analysis of dark matter signals from 27 dwarf spheroidal galaxies using 11 years of Fermi-LAT observations*, *JCAP* **2020** (2020) 012, [[arXiv:1812.06986](#)]. With **C++ & Python**.
- [15] S. Hoof, F. Kahlhoefer, P. Scott, C. Weniger, and M. White, *Axion global fits with Peccei-Quinn symmetry breaking before inflation using GAMBIT*, *Journal of High Energy Physics* **2019** (2019) 191, [[arXiv:1810.07192](#)]. With **C++**.
- [16] S. Hoof and J. Jaeckel, *QCD axions and axionlike particles in a two-inflation scenario*, *Phys. Rev. D* **96** (2017) 115016, [[arXiv:1709.01090](#)]. With **Mathematica**.
- [17] S. Hoof, N. Nand Gosvami, and B. W. Hoogenboom, *Enhanced quality factors and force sensitivity by attaching magnetic beads to cantilevers for atomic force microscopy in liquid*, *J. Appl. Phys.* **112** (2012) 114324, [[arXiv:1211.1881](#)].

Proceedings & White Papers

- [18] J. Jaeckel, G. Rybka, and L. Winslow, *Axion Dark Matter*, *arXiv e-prints* (2022) arXiv:2203.14923, [[arXiv:2203.14923](#)].
- [19] GAMBIT: S. Hoof, *A Preview of Global Fits of Axion Models in GAMBIT*, in *Proceedings, 13th Patras Workshop on Axions, WIMPs and WISPs, (PATRAS 2017): Thessaloniki, Greece, 15 May 2017 - 19, 2017* (2018) 32–38, [[arXiv:1710.11138](#)].

Data & Software

- [20] S. Hoof, C. Balázs, M. Lacroix, and L. Schulz, *Snax. Computational routines for axion and axion-like particle signatures from supernovae*, 2022. [[C++ & Python Github repo](#)].
- [21] V. Plakkot and S. Hoof, *Model catalogues and histograms of KSVZ axion models with multiple heavy quarks*, 2021. [[Zenodo record](#)].
- [22] A. Fowlie, S. Hoof, and W. Handley, *Code and data for ‘Nested sampling for frequentist computation’*, 2021. [[Python Github repo](#)].
- [23] S. Hoof and L. Thormaehlen, *Solar Axion Flux. A C++ library to calculate the expected flux from axion-photon and axion-electron interactions inside the Sun*, 2021. [[C++ & Python Github repo](#)].
- [24] The GAMBIT Cosmology Workgroup, *Supplementary Data: CosmoBit: A GAMBIT module for computing cosmological observables and likelihoods (arXiv:2009.03286)*, 2020. [[Zenodo record](#)].
- [25] S. Hoof, A. Geringer-Sameth, and R. Trotta, *Supplementary Material for A Global Analysis of Dark Matter Signals from 27 Dwarf Spheroidal Galaxies using 11 Years of Fermi-LAT Observations*, 2019. [[Zenodo record](#)].
- [26] GAMBIT Collaboration, *Supplementary Data: Axion global fits with Peccei-Quinn symmetry breaking before inflation using GAMBIT*, 2018. [[Zenodo record](#)].

Supervision

As main supervisor

2020/21	B.Sc. student , Lena Schulz, on the statistical analysis of ALP decays into photons from SN1987A (co-supervisor: Jens Niemeyer)	<i>U Göttingen</i>
2020/21	M.Sc. student , Vaisakh Plakkot, on the landscape of KSVZ axion models; parts of the results published in [6] (co-supervisor: Laura Covi)	<i>U Göttingen</i>

As co-supervisor

2023/24	M.Sc. student , Ruben Zatini, on ALP signals from magnetic white dwarf stars. Primary supervisor: Luca Di Luzio.	<i>U Padua</i>
2022/23	B.Sc. student , Santiago Rosellón Inclán, on freeze-in production of axion-like particles. Primary supervisor: Felix Kahlhöfer.	<i>KIT</i>
2021	Internship student (postgrad) , Jamal El Kuweiss, on solving the Saha equation in multi-ion plasmas. Primary supervisor: Jens Niemeyer.	<i>U Göttingen</i>
2020	Internship student (postgrad) , Jana Riess, on statistical uncertainties of the QCD axion relic density, including realignment, axion strings and domain walls; parts of the results published in [5]. Primary supervisor: David J. E. Marsh.	<i>U Göttingen</i>
2019	Summer student (postgrad) , Marie Lecroq (ENS Paris-Saclay), on ALP decays from Supernova 1987A. Primary supervisor: Csaba Balzacs (Monash U)	<i>remotely</i>

Teaching

Certificates

2014	Heidelberg Didactics Teaching Certificate , comprised of several training workshops in didactics and communicational skills, a peer-reviewed tutorial session, and a reflective report at the end of the term.	<i>U Heidelberg</i>
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Graduate Teaching

2017	Teaching assistant (tutorials), Advanced Quantum Field Theory	<i>King's College London</i>
2014/15	Teaching assistant (tutorials), Quantum Field Theory	<i>U Heidelberg</i>

Undergraduate Teaching

2016/17	Teaching assistant (tutorials), Electrodynamics	<i>King's College London</i>
2016	Teaching assistant/supervisor (short project), First Year Laboratory Projects	<i>Imperial College</i>
2015/16	Teaching assistant (lab course), Second Year laboratory course "Charges and Fields"	<i>Imperial College</i>
2014	Teaching assistant (tutorials), <i>Theoretische Physik II</i> (Analytical Mechanics)	<i>U Heidelberg</i>
2013/14	Teaching assistant (tutorials), <i>Theoretische Physik I</i> (Classical Mechanics)	<i>U Heidelberg</i>
2013	Teaching assistant (tutorials), <i>Theoretische Physik IV</i> (Quantum Mechanics)	<i>U Heidelberg</i>
2012/13	Teaching assistant (tutorials), in <i>Theoretische Physik III</i> (Electrodynamics)	<i>U Heidelberg</i>
2011, '13, '14	Teaching assistant (tutorials), <i>Physik für Mediziner</i> (physics for medical students)	<i>U Heidelberg</i>

Awards & Funding

2023	IS CRA Class C Project , 100,000 CPUh on GALILEO100	<i>Italy</i>
2023	IS CRA Class C Project , 50,000 CPUh on GALILEO100	<i>Italy</i>
2023	Marie Skłodowska-Curie Actions Postdoctoral Fellowship , ca. €173 000	<i>Padua, Italy</i>
2022	Paris Region Fellowship (MSCA COFUND) , research fellowship (ca. €147 000) — <i>declined</i>	<i>Paris, France</i>
2022	MSCA Seal of Excellence@UNIPD 2022 Call , research fellowship (€100 000) — <i>declined</i>	<i>Padua, Italy</i>
2022	Marie Skłodowska-Curie Actions Certificate of Excellence , awarded by the European Union for MSCA applications with a score above 85% (score: 90.6%).	
2015	The Imperial College President's Scholarship , to undertake PhD studies at Imperial College London (ca. €112 000)	<i>London, UK</i>
2012	Vacation bursary , awarded by the EPSRC (British Engineering and Physical Sciences Research Council) to conduct a summer research project in the group of Bart Hoogenboom at the <i>London Centre for Nanotechnology</i>	<i>London, UK</i>
2011/12	Erasmus stipend , for a one-year exchange programme at UCL (total value ca. €6 900)	<i>London, UK</i>

Service

Refereeing	Physical Review Letters (3 papers reviewed), Astronomy & Astrophysics (1), JCAP (1), NIMA (1), Physical Review D (3), Scientific Reports (Nature Research journal; 1)
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CAT Seminar Series

Co-organiser (with Viraf M. Mehta)

Organising the “CAT Seminar Series” at the interface of cosmology, astroparticle physics, and theory (11 talks in total)

Göttingen & online

10/2021–06/2022

Cosmology Journal Club

Organiser

Chairing the journal club short presentations and encouraging discussions of the papers, administrative tasks

Göttingen & online

10/2020–12/2021

Fuzzy Dark Matter Workshop 2020

Conference co-organiser

Online conference with mostly pre-recorded talks, live discussion sessions and talks, as well as virtual interactions mediated through an avatar-based online platform. Website available at [this link](#)

online

20–22 July 2020

Spokesperson

PhD student representative

Representing the interests of the Astrophysics PhD students in staff and faculty-level meetings at Imperial College, organising social events within the group and other research groups, moderating conflicts between students

London, UK

10/2017–10/2018

Skills & Experience

Programming C++, Python, Git, LaTeX, Mathematica, R

HPC Work on 3 tier-0, 2 tier-1, 3 tier-2, and 2 tier-3 clusters as defined by PRACE

Languages German (native speaker), English (professional fluency), Italian (conversational fluency), French (basics)

Outreach & Volunteering

10 July 2016 **Outreach**, Public engagement for the “What happened at the Big Bang?” exhibit at the Summer Science Exhibition of the Royal Society London, UK

5–6 July 2016 **Outreach**, Joint presentation and supervision for bubble chamber lab experiments for students from junior high schools in outer London at the NEUTRINO 2016 conference London, UK

10–22 Sept. 2015 **Volunteering**, Public engagement activities for the pavilion of the European Union at EXPO Milano 2015 Milan, Italy

Presentations

In total **12** invited talks, **13** regular talks, **1** poster.

Invited talks

April 2024	“Helioscope Searches for Axion Phenomenology”, Seminar, LNF	Frascati, Italy
Jan. 2024	“Tools for axion model predictions and prospects for their detection in astrophysics”, Seminar, Nikhef (U Amsterdam)	Amsterdam, Netherlands
Nov. 2023	“Searching for axions using data from astrophysics, cosmology, and the lab”, Seminar, INFN Sezione di Napoli	Naples, Italy
Sept. 2023	“Axion Helioscopes as Solar Thermometers”, IAXO Collaboration Meeting, CEFCA Teruel	remotely
May 2023	“Selected aspects of the particle vs wave nature of dark matter” (slides), PONT 2023	Avignon, France
June 2022	“Nested sampling for Bayesian evidence calculation and beyond”, CCM Colloquium, Flatiron Institute	New York City, USA
Nov. 2021	“Definition and Probes of the Axion Model Landscape”, Seminar, TTK Theory Group (RWTH Aachen)	Aachen, Germany
Mar. 2019	“Global Fits of Axion Models with PQ Symmetry Breaking Before Inflation”, IAXO Collaboration Meeting, Sorbonne Université	Paris, France
Mar. 2019	“Global Fits for BSM Physics”, Seminar, Institut für theoretische Physik (Heidelberg U)	Heidelberg, Germany
Dec. 2018	“Global Fits of Axion Models with PQ Symmetry Breaking Before Inflation”, Stockholm-London-Amsterdam-Paris Workshop (SLAP), King's College London (KCL)	London, UK
Oct. 2018	“Global Fits of Axion Models” (slides), DESY Theory Workshop 2018	Hamburg, Germany
Sept. 2018	“Axion Global Fits with Peccei-Quinn Symmetry Breaking Before Inflation using GAMBIT”, CAST Collaboration Meeting, CERN	remotely

Regular talks

April 2024	“Finding Axions in a Universe of Data and Envisioning Their Use as Multi-Messenger Probes”, Seminar, LPTHE (Sorbonne U)	Paris, France
Oct. 2023	“Visions of Axion Multi-Messenger Physics with Helioscopes”, Seminar & COST Action “Cosmic WISPerS” Colloquium, Osservatorio Astronomico d'Abruzzo	Teramo (hybrid), Italy
Sept. 2023	“Axion Helioscopes as Solar Thermometers” (slides), Axions++, LAPTh	Annecy, France
June 2023	“Axions as Solar Thermometers”, GGI Conference “Axions across boundaries...”, Galileo Galilei Institute	Florence, Italy

Feb. 2023	“Updated constraints on axion-like particles from supernova SN1987A gamma-ray data”, COST Action “Cosmic WISPerS” Journal Club	<i>online</i>
Nov. 2022	“Cosmological constraints on decaying axion-like particles” (slides), DISCRETE 2022	<i>Baden-Baden, Germany</i>
Aug. 2022	“Cosmological constraints on decaying axion-like particles: a global analysis” (slides), 17th Patras Workshop	<i>Mainz, Germany</i>
July 2022	“Cosmological constraints on decaying axion-like particles: a global analysis” (slides), 14th Conference on the Identification of Dark Matter	<i>Vienna, Austria</i>
Sept. 2021	“Uncertainties of the Solar Axion Flux and the KSVZ Axion Model Landscape” (slides), DESY Theory Workshop 2021	<i>Hamburg, Germany</i>
June 2021	“Uncertainties of the Solar Axion Flux Computation” (slides), 16th Patras Workshop	<i>online</i>
Mar. 2021	“Quantifying uncertainties in the solar axion flux and their impact on determining axion model parameters” (video), Seminar, Virtual Axion Institute	<i>online</i>
June 2017	“Axion dark matter and Bayesian searches for dark matter in dwarf galaxies”, RISE-ASTROSTAT Collaboration Meeting	<i>Crete, Greece</i>
May 2017	“Axion Global Fits in GAMBIT” (slides), 13th Patras Workshop	<i>Thessaloniki, Greece</i>

Posters

Sept. 2016	“Axions in GAMBIT”, Invisibles 16	<i>Padua, Italy</i>
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