

# 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

MSCA PF for my project "AxiTools" with Luca Di Luzio, funded by the EU's Horizon programme (grant agreement No 101065579).

### KIT

Karlsruhe, Germany

#### Postdoctoral researcher

2022

Three-month stay in 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

Postdoc position funded by David 'Doddy' J. E. Marsh's Sofja Kovalevskaja grant. Research 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 [18].

### 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  $\approx 11$ .

### 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](#)].

### Proceedings & White Papers

- [2] J. Jaeckel, G. Rybka, and L. Winslow, *Axion Dark Matter*, *arXiv e-prints* (2022) [arXiv:2203.14923](#), [[arXiv:2203.14923](#)].
- [3] 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](#)].

## Articles

- [4] S. Hoof and L. Schulz, *Updated constraints on axion-like particles from temporal information in supernova SN1987A gamma-ray data*, *arXiv e-prints* (2022) arXiv:2212.09764, [[arXiv:2212.09764](#)]. Accepted in JCAP, with **Python**.
- [5] 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++**.
- [6] 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**.
- [7] 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**.
- [8] 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**.
- [9] J. Schütte-Engel, D. J. E. Marsh, et. al., *Axion quasiparticles for axion dark matter detection*, *JCAP* **2021** (2021) 066, [[arXiv:2102.05366](#)].
- [10] 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**.
- [11] 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](#)].
- [12] 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++**.
- [13] 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++**.
- [14] 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**.
- [15] 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**.
- [16] 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++**.
- [17] 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**.
- [18] 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](#)].

## Data & Software

- [19] 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](#)].
- [20] V. Plakkot and S. Hoof, *Model catalogues and histograms of KSVZ axion models with multiple heavy quarks*, 2021. [[Zenodo record](#)].
- [21] A. Fowlie, S. Hoof, and W. Handley, *Code and data for 'Nested sampling for frequentist computation'*, 2021. [[Python Github repo](#)].
- [22] 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](#)].
- [23] The GAMBIT Cosmology Workgroup, *Supplementary Data: CosmoBit: A GAMBIT module for computing cosmological observables and likelihoods (arXiv:2009.03286)*, 2020. [[Zenodo record](#)].
- [24] 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](#)].
- [25] 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>B.Sc. student</b> , Lena Schulz, on the statistical analysis of ALP decays into photons from SN1987A (co-supervisor: Jens Niemeyer)	Göttingen U
2020/21	<b>M.Sc. student</b> , Vaisakh Plakkot, on the landscape of KSVZ axion models; parts of the results published in [7] (co-supervisor: Laura Covi)	Göttingen U

## As co-supervisor

2021	<b>Internship student (postgrad)</b> , Jamal El Kuweiss, on solving the Saha equation in multi-ion plasmas. Primary supervisor: Jens Niemeyer.	Göttingen U
2020	<b>Internship student (postgrad)</b> , Jana Riess, on statistical uncertainties of the QCD axion relic density, including realignment, axion strings and domain walls; parts of the results published in [6]. Primary supervisor: David J. E. Marsh.	Göttingen U
2019	<b>Summer student (postgrad)</b> , Marie Lecroq (ENS Paris-Saclay), on ALP decays from Supernova 1987A. Primary supervisor: Csaba Balzacs (Monash U)	remotely

## Teaching

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### Certificates

2014	<b>Heidelberg Didactics Teaching Certificate</b> , 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.	Heidelberg U
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### Graduate Teaching

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

### Undergraduate Teaching

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

## Awards & Funding

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2023	<b>Marie Skłodowska-Curie Actions Postdoctoral Fellowship</b> , total ca. €173 000	Padua, Italy
2022	<b>Paris Region Fellowship (MSCA COFUND)</b> , research fellowship (total ca. €147 000) — <i>declined</i>	Paris, France
2022	<b>MSCA Seal of Excellence@UNIPD 2022 Call</b> , research fellowship (total €100 000) — <i>declined</i>	Padua, Italy
2022	<b>Marie Skłodowska-Curie Actions Certificate of Excellence</b> , awarded by the European Union for MSCA applications with a score above 85% (score: 90.6%).	
2015	<b>The Imperial College President's Scholarship</b> , to undertake PhD studies at Imperial College London (total value ca. €112 000)	London, UK
2012	<b>Vacation bursary</b> , 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>	London, UK
2011/12	<b>Erasmus stipend</b> , for a one-year exchange programme at UCL (total value: ca. €6 900)	London, UK

## Service

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<b>Refereeing</b>	Physical Review Letters (3 papers reviewed), Astronomy & Astrophysics (1), JCAP (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)

### Cosmology Journal Club

Organiser

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

Göttingen & online

10/2021–06/2022

Göttingen & online

10/2020–12/2021

## Fuzzy Dark Matter Workshop 2020

Conference co-organiser

online

20–22 July 2020

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](#)

### Spokesperson

PhD student representative

London, UK

10/2017–10/2018

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

## Skills & Experience

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

**HPC** Work on 3 tier-0, 1 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	<b>Outreach</b> , 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	<b>Outreach</b> , 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	<b>Volunteering</b> , Public engagement activities for the pavilion of the European Union at EXPO Milano 2015	Milan, Italy

## Presentations

In total **7** invited talks, **9** regular talks, **1** poster.

### Invited talks

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”, TTK Theory Seminar, RWTH Aachen	Aachen, Germany
Mar. 2019	“Global Fits for BSM Physics”, Oberseminar Particle Phenomenology, Institut für theoretische Physik (Heidelberg U)	Heidelberg, Germany
Mar. 2019	“Global Fits of Axion Models with PQ Symmetry Breaking Before Inflation”, IAXO Collaboration Meeting, Sorbonne Université	Paris, France
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” ( <a href="#">slides</a> ), 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

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

### Posters

Sept. 2016	“Axions in GAMBIT”, Invisibles 16	Padua, Italy
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