

# LUISA LUCIE-SMITH

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## RESEARCH INTERESTS

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- Formation and evolution of cosmic structures in the Universe.
- The connection between dark and visible matter.
- Computational techniques: numerical simulations, machine learning, Bayesian statistics.

## EMPLOYMENT

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- Tenure-track Junior Professor (W1)** Nov 2024 – present  
Hamburg Observatory, Hamburg University, Germany.
- MPA Research Fellowship** Nov 2020 – Nov 2024  
Max-Planck-Institut für Astrophysik, Garching, Germany.
- Postdoctoral Research Fellowship** Nov 2019 – Oct 2020  
University College London, UK.

## EDUCATION

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- Ph.D. in Astrophysics.** University College London, UK. Oct 2015 – Oct 2019  
Thesis: “Insights into cosmological structure formation with machine learning”  
Supervisors: Prof. Hiranya Peiris, Prof. Andrew Pontzen.  
Examiners: Prof. Benjamin Wandelt, Prof. Ofer Lahav.  
Date of thesis defense: 1st Nov 2019. Date of PhD award: 28 Feb 2020.
- MSc Quantum Fields and Fundamental Forces.** Imperial College London, UK. Sep 2013 – Sep 2014  
Thesis: “Reheating of the Universe and Gravitational Wave Production”  
Supervisor: Prof. Arttu Rajantie; Grade: Merit.
- BSc Mathematical Physics.** The University of Nottingham, UK. Sep 2010 – Jul 2013  
Thesis: “Tunnelling in Quantum Field Theory”  
Supervisor: Dr. Clare Burrage; Grade: 1<sup>st</sup> Class Honours.

## PUBLICATIONS

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Selected works:

1. Guo, L.; **Lucie-Smith L.**; Peiris H.V.; Pontzen A.; Piras, D., “Deep learning insights into non-universality in the halo mass function”. *Monthly Notices of the Royal Astronomical Society*, Volume 532, Issue 4, August 2024. [doi:10.1093/mnras/stae1696](https://doi.org/10.1093/mnras/stae1696).
2. **Lucie-Smith L.**; Despali G.; Springel V., “A deep learning model for the density profiles of subhaloes in IllustrisTNG”. *Monthly Notices of the Royal Astronomical Society*, Volume 532, Issue 1, July 2024. [doi:10.1093/mnras/stae1487](https://doi.org/10.1093/mnras/stae1487).
3. **Lucie-Smith L.**; Peiris H.V.; Pontzen A.; Nord B.; Thiyaalingam J.; Piras, D., “Explaining dark matter halo density profiles with neural networks”. *Physical Review Letters*, Volume 132, Pages 031001, January 2024. [doi:10.1103/PhysRevLett.132.031001](https://doi.org/10.1103/PhysRevLett.132.031001).
4. **Lucie-Smith L.**; Barreira, A.; Schmidt, F., “Halo assembly bias from a deep learning model of halo formation”. *Monthly Notices of the Royal Astronomical Society*, Volume 524, Issue 2, September 2023. [doi:10.1093/mnras/stad2003](https://doi.org/10.1093/mnras/stad2003).
5. **Lucie-Smith L.**; Adhikari, S.; Wechsler R. H., “Insights into the origin of halo mass profiles from machine learning”. *Monthly Notices of the Royal Astronomical Society*, Volume 515, Issue 2, September 2022. [doi:10.1093/mnras/stac1833](https://doi.org/10.1093/mnras/stac1833).
6. **Lucie-Smith L.**; Peiris H.V.; Pontzen A.; Nord B.; Thiyaalingam J.; Piras, D., “Discovering the building blocks of dark matter halo density profiles with neural networks”. *Physical Review D*, Volume 105, Issue 10, May 2022. [doi:10.1103/PhysRevD.105.103533](https://doi.org/10.1103/PhysRevD.105.103533).

7. **Lucie-Smith L.**; Peiris H.V.; Pontzen A.; Nord B.; Thiyaalingam J., “Deep learning insights into cosmological structure formation”, 2020. Under review at *Physical Review D*. Preprint [arXiv:2011.10577](https://arxiv.org/abs/2011.10577).
8. **Lucie-Smith L.**; Peiris H.V.; Pontzen A., “An interpretable machine learning framework for dark matter halo formation”. *Monthly Notices of the Royal Astronomical Society*, Volume 490, Issue 1, November 2019, Pages 331–342. [doi:10.1093/mnras/stz2599](https://doi.org/10.1093/mnras/stz2599).
9. **Lucie-Smith L.**; Peiris H.V.; Pontzen A.; Lochner M., “Machine learning dark matter halo formation”. *Monthly Notices of the Royal Astronomical Society*, Volume 479, Issue 3, September 2018, Pages 3405–3414. [doi:10.1093/mnras/sty1719](https://doi.org/10.1093/mnras/sty1719).

## GRANTS AND AWARDS

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### Fellowships:

- **Max Planck Institute for Astrophysics Fellowship**, 2020 – 2025.
- **PhD studentship** UK Science & Technology Facilities Council (£68,770), 2015.

### Grants:

- **Universities Research Association Grant**. *Deep learning dark matter halo formation*. PI; \$12,500. Grant awarded for a six-month visit at the Fermi National Accelerator Laboratory (USA) to conduct my proposed research collaboratively with Prof. Josh Friemann and Dr. Brian Nord, *April–October 2019*.
- **Cosmology and Astroparticle Student and Postdoc Exchange Network Grant**. *Machine learning the density profile of dark matter halos*. PI; £2,600. Grant awarded for a one-month visit at Stanford University (USA) to conduct my proposed research collaboratively with Prof. Risa Wechsler and Dr. Susmita Adhikari, *March 2019*.
- **Royal Astronomical Society Grant**. Travel support to present my research at 22nd annual International Conference on Particle Physics and Cosmology, South Korea. £1,014. *Nov 2015*.

### Prizes:

- **Physicist of the Week**. Awarded by the Working Group on Equal Opportunities of the German Physical Society. *July 2021*.
- **Michael Penston Thesis Prize 2020**. Awarded by the Royal Astronomical Society for runner-up for best doctoral thesis in Astronomy and Astrophysics in the UK. *May 2021*.
- **George Green Prize**. Awarded by University of Nottingham for most outstanding student of the year in the BSc Mathematical Physics course. £400. *July 2013*.

## PROFESSIONAL PRESENTATIONS

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Presentations about my research to broad and specialized audiences in astrophysics and machine learning:

1. University of Zurich, Switzerland. *Astrophysics seminar*, **invited** talk. *October 2024*.
2. ETH Zurich, Switzerland. *Cosmology seminar*, **invited** talk. *October 2024*.
3. London, UK. *London PhySTAT machine learning x physics* conference, **invited** talk. *September 2024*.
4. Split, Croatia. *Cosmology in the Adriatic – From PT to AI* conference, talk. *July 2024*.
5. Sesto, Italy. *New Strategies for extracting cosmology from galaxy surveys* conference, talk. *July 2024*.
6. (virtual) *Cosmology from home* conference, **invited plenary** talk. *June 2024*.
7. Chania, Crete. *COSMO21 Statistical Challenges in 21st Century Cosmology* conference, **invited keynote** talk. *May 2024*.
8. Amsterdam, *European AI for Fundamental Physics Conference*, highlight talk. *May 2024*.
9. Cardiff University, UK. *Astrophysics Seminar*, **invited** talk. *March 2024*.
10. University of Vienna, Austria. *Building Galaxies from Scratch* conference, **invited review** talk. *February 2024*.
11. Institut d’Astrophysique de Paris (France)/Flatiron Institute (USA). **Invited panelist** in a debate at “*Debating the potential of machine learning in astronomical surveys*” workshop. *December 2023*.
12. The Oskar Klein Centre, Stockholm, Sweden. *Astrophysics Colloquium*, **invited** talk. *October 2023*.
13. Instituto de Física Teórica, Madrid, Spain. *COSMO’23* conference, talk. *September 2023*.
14. Scuola Internazionale Superiore di Studi Avanzati (SISSA), Italy. *Astrophysics and Cosmology seminar*, **invited** talk. *June 2023*.
15. Donostia International Physics Center (DIPC), Spain. *Cosmology with the Large Scale Structure of the Universe* workshop, **invited** talk. *May 2023*.

16. Yukawa Institute for Theoretical Physics, Kyoto University, Japan. *Future Science with CMB  $\times$  LSS* conference, talk. *April 2023*.
17. University of Vienna, Austria. *Astrophysics Colloquium*, **invited** talk. *March 2023*.
18. Ludwig Maximilian University of Munich, Germany. *Lunch seminar*, **invited** talk. *February 2023*.
19. Excellence Cluster ORIGINS, Garching, Germany. *Data Science days*, overview talk representing research-unit C (cosmology) of Excellence Cluster ORIGINS, **invited**. *January 2023*.
20. Max Planck Institute for Astrophysics, Garching, Germany. *Fachbeirat Scientific Advisory Board*, one of four selected talks representing research at MPA, **invited**. *November 2022*.
21. Instituto de Astrofísica de Andalucía, Granada, Spain. *Fundamental Cosmology Meeting*, **invited review** talk on machine learning and neural networks. *November 2022*.
22. University of Barcelona, Spain. *Institute seminar*, **invited** talk. *September 2022*.
23. (Virtual) *Physics Meets Machine Learning seminar series*, **invited** talk. *July 2022*.
24. MIAPP, Garching, Germany. *Advances in Cosmology through Numerical Simulations* workshop, talk. *May 2022*.
25. University of Louvain-la-Neuve, Belgium. *Astrophysics seminar*, **invited** talk. *May 2022*.
26. University of Michigan, USA. *Cosmology seminar*, **invited** (virtual) talk. *April 2022*.
27. Ringberg Castle, Germany. *Breakthroughs in Galaxy Formation* workshop, **invited** talk. *April 2022*.
28. The Max Planck Institute for Physics, Germany. *The Astroparticle physics seminar*, **invited** talk. *March 2022*.
29. University College London. *Cosmology seminar*, **invited** talk. *March 2022*.
30. Institute for Advanced Studies at Princeton University. *Cosmology lunch seminar*, talk. *August 2021*.
31. Flatiron Institute, New York. *Learn the Universe workshop*, **invited** talk. *August 2021*.
32. (Virtual) *Cosmology from Home conference*, talk. *July 2021*.
33. Laboratoire d'Astrophysique de Marseille, *Stars-Galaxies-Cosmology Seminar*, **invited** talk. *May 2021*.
34. Max-Planck-Institut für Astrophysik, Germany. *Institute Seminar*, **invited** talk. *April 2021*.
35. LMU Munich, Germany. *Machine learning meeting*, **invited** talk. *March 2021*.
36. Origins Excellence Cluster, Munich. *Origins data science meeting*, **invited** talk. *Feb 2021*.
37. Cambridge – LMU online cosmology workshop. *Connecting through the cosmic web*, talk. *Jan 2020*.
38. GRAPPA (Gravitation Astroparticle Physics Amsterdam). *ML journal club*, **invited** talk. *Nov 2020*.
39. Max-Planck-Institut für Astrophysik, Germany. *Cosmology Seminar*, **invited** talk. *Nov 2020*.
40. The University of Amsterdam, Netherlands. *AI for Science Colloquium*, **invited** talk. *Nov 2020*.
41. University of Oxford, UK. *Cosmology Seminar*, **invited** talk. *Feb 2020*.
42. Max-Planck-Institut für Astrophysik, Germany. *Cosmology Seminar*, **invited** talk. *Jan 2020*.
43. University of Cambridge, UK. *Cavendish mini-seminar series*, **invited** talk. *Jan 2020*.
44. Ringberg Castle, Germany. *Machine learning in Astronomy*, **invited** talk. *Dec 2019*.
45. Fermi National Accelerator Laboratory, USA. *Astrophysics Seminar*, **invited** talk. *Sep 2019*.
46. Argonne National Laboratory, USA. *High Energy Physics Seminar*, **invited** talk. *Sep 2019*.
47. Flatiron CCA, New York. *Cosmology X Data Science Meeting*, talk. *Jun 2019*.
48. Fermi National Accelerator Laboratory, USA. *New Perspectives 2019*, talk. *Jun 2019*.
49. Villars-sur-Ollon, Switzerland. *BASP Frontiers Workshop*, **invited** deluxe poster. *Mar 2019*.
50. University of Sheffield, UK. *Astrophysics Seminar*, **invited** talk. *Mar 2019*.
51. Stanford University, USA. *Cosmology Meeting*, talk. *Feb 2019*.
52. Institute of Cosmology, London. *London Cosmology Discussion Meeting*, talk. *Oct 2018*.
53. Institute for Basic Science, South Korea. *22nd annual International Conference on Particle Physics and Cosmology*, talk. *Aug 2018*.
54. University of Oxford, UK. *Statistical Challenges for Large-scale Structure in the Era of LSST*, talk. *Apr 2018*.
55. Oskar Klein Centre, Stockholm. *Astrophysics Seminar*, talk. *Mar 2018*.
56. University Paris Diderot, France. *21st annual International Conference on Particle Physics and Cosmology*, talk. *Aug 2017*.
57. Queen Mary University, London. *Machine Learning in Physics*, **invited** talk. *Dec 2016*.

## DUTIES, TEACHING & MENTORING

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### Institutional roles

- Organizer of Cosmology seminar, Max-Planck-Institut for Astrophysics. *Sep 2021 – Sep 2023.*
- Organizer of Women Encouragement Group, Max-Planck-Institut for Astrophysics. *Dec 2020 – present.*
- Organizer of Cosmology seminar, University College London. *Nov 2019 – Nov 2020.*

### Teaching

- Lecture series on *Cosmic structure formation* at the PhD Astroparticle Physics School in Erlangen, Germany. *5th – 7th Oct 2022.*
- Guest lecturer on my research at 1<sup>st</sup> year BSc Classical Mechanics lecture, University College London. *Dec 2020.*
- Led workshop: *Effective remote presentations.* University College London. *Oct 2020.*
- Lecture: *An Introduction to Decision Trees and Random Forests.* University College London. *Mar 2018.*
- Led workshop: *Clean code: guidelines for elegant and efficient code.* University College London. *Nov 2017.*
- Lecture: *An Introduction to Machine Learning.* University College London. *Oct 2016, Oct 2017.*
- Lecture: *Feature Importances in Random Forest.* Oskar Klein Centre, Stockholm, Sweden. *Nov 2016.*

### Supervision

- Primary supervisor of intern Lennard Dufner at Max Planck Institute for Astrophysics. *Apr – July 2022.*
- Co-supervising PhD student Lillian Guo at University College London. *Oct 2020 – present.*
- One-to-one and group career mentorship to PhD students in the Physical Cosmology group at Max Planck Institute for Astrophysics. *Nov 2020 – present.*
- Peer-mentoring for incoming PhD students at University College London, *2017.*

### Professional activities

- Referee for *Monthly Notices of the Royal Astronomical Society* and *Journal of Cosmology and Astroparticle Physics.* *2019 – present.*

## PRESS & PUBLIC ENGAGEMENT

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- News article for the general public based on one of my publications (*February 2021*): [‘Deep learning’ provides insights into cosmological structure formation](#)
- News article on Royal Astronomical Society Michael Penston Thesis Prize award (*June 2021*): [Cosmoparticle PhD student Luisa Lucie-Smith awarded RAS Michael Penston Thesis Prize - runner up!](#)
- Invited to present my research on *Exploring the Universe with Artificial Intelligence* at the European Commission Joint Research Centre, Ispra, Italy. *Oct 2021.*
- Invited to present my research (virtually) to undergraduate students at the Vietnam University Joint Seminar Series, Vietnam. *July 2021.*
- Presenter at Kathleen Lonsdale Building Opening, University College London, UK. *April 2018.*
- Presenter for science events, festivals and astronomy groups, including for *Highgate High School* (Nov 2017), *Blackheath High School* (May 2017), *International Federation of Business and Professional Women, Italy* (Mar 2017) and *Your Universe Festival* (Mar 2016).
- Led tour guides at the *University College London Observatory* to members of the public to introduce the field of Astrophysics and explain the workings of telescopes. *Oct 2015 – Oct 2016.*

## ACADEMIC AND PROFESSIONAL DEVELOPMENT

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- European Space Astronomy Centre, Madrid. *Data Analysis & Statistics Workshop.* Statistical inference, Bayesian statistics, computational Bayesian inference, Monte Carlo Markov Chain, machine learning. *Nov 2017.*
- Les Houches, France. Summer school on *Cosmology after Planck: what is next?* *Apr 2016.*
- NVIDIA, London. *Deep Learning and Neural Networks GPU.* *Feb 2016.*
- Imperial College, London. *Bayesian Data Analysis Workshop.* *Sep 2016.*
- University College, London. *Advanced Python course.* *Nov 2015.*
- University College, London. *Software Carpentry Workshop.* *Nov 2015.*
- Imperial College, London. *Introduction to High Performance and Throughput Computing.* *Oct 2015.*

## TECHNICAL SKILLS

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**Programming languages and tools:** proficient with Python (NumPy, SciPy, Pandas, scikit-learn, Keras, TensorFlow, LightGBM), Git, slurm; basic ability with C++, Perl; HPC unix systems.

**Cosmological simulations:** AREPO, GADGET, SUBFIND, PYNBODY, ASTROPY, CAMB, AHF.