Alexander Mead

curriculum vitae

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Academic appointments

2022 **Research Associate**, *machine learning, neural surrogates, probabilistic programming*, University of British Columbia, Frank Wood.

2020 – 2021 **GLOBE Senior Postdoctoral Researcher**, *cosmological structure formation*, University of Edinburgh, Catherine Heymans.

2017 – 2020 **Marie Skłodowska Curie Fellowship**, *weak gravitational lensing*, University of Barcelona and University of British Columbia, Licia Verde.

2015 – 2017 **Canadian Institute of Theoretical Astrophysics National Fellowship**, *weak gravitational lensing*, University of British Columbia, Ludovic Van Waerbeke.

2014 – 2015 **Postdoctoral Fellow**, *baryonic feedback, matter clustering, weak gravitational lensing*, University of Edinburgh, Catherine Heymans.

Education

2010 – 2014 **PhD**, *Demographics of dark-matter haloes in standard and non-standard cosmologies*, University of Edinburgh, John Peacock.

2005 – 2010 **MPhys**, *astrophysics and theoretical physics*, University of Oxford, First Class.

Awards

2016 **Marie Skłodowska Curie fellowship**, *UBC and Barcelona*.

2015 **CITA National fellowship**, *UBC and CITA*.

2012 **Vitae Postgraduates Who Tutor Award (nom.)**, *Edinburgh*.

2012 **Teach First Innovative Teaching Award (nom.)**, *Edinburgh*.

2010 **STFC funded PhD position**, *Edinburgh*.

2010 **Peter Fisher prize**, *top results in college*, Oxford.

2009 **Trinity College scholarship**, *first-class results in exams*, Oxford.

PhD thesis

Title *Demographics of dark-matter haloes in standard and non-standard cosmologies*

Supervisors John Peacock, Alan Heavens, Sylvain de la Torre, Lucas Lombriser

Description (1) Tuning the halo model of structure formation to accurately predict the full non-linear matter power spectrum as a function of cosmological parameters. (2) Rescaling cosmological simulations, in terms of both matter distributions and halo catalogues, between cosmological models. (3) Rescaling simulations from standard to modified gravity models.

Research interests

Machine learning I am interested in how to best apply modern machine-learning techniques to inference problems in the physical sciences. This includes using amortised inference techniques to learn proposal distributions for later importance sampling. I am also interested in how deep-generative modelling can be used to model statistical fields.

Cosmology I have a strong background in fundamental cosmology with particular knowledge of the theory of structure formation including both the perturbative and deeply non-linear regime via the halo model. I am interested in how the halo model can be extended to better model the statistical properties of the density field when considering dark energy (DE) and modified gravity (MG) models.

Simulations I am experienced in using GADGET-2 to perform cutting-edge, multi-core simulations. I have modified GADGET-2 to include a dark energy component and I am interested in simulations of both DE and MG models. Over the course of my career I have developed a large library of software to analyse the output of simulations and to generate and analyse halo catalogues produced by simulations.

Publications - lead author

1. M. Asgari, A. J. Mead, and C. Heymans. "The halo model for cosmology: a pedagogical review". In: *arXiv e-prints*, arXiv:2303.08752 (Mar. 2023). DOI: 10.48550/arXiv.2303.08752. arXiv: 2303.08752 [astro-ph.CO]
2. A. J. Mead and L. Verde. "Including beyond-linear halo bias in halo models". In: *MNRAS* 503.2 (May 2021). DOI: 10.1093/mnras/stab748. arXiv: 2011.08858 [astro-ph.CO]
3. A. J. Mead et al. "HMCODE-2020: improved modelling of non-linear cosmological power spectra with baryonic feedback". In: *MNRAS* 502.1 (Mar. 2021). DOI: 10.1093/mnras/stab082. arXiv: 2009.01858 [astro-ph.CO]
4. A. J. Mead et al. "A hydrodynamical halo model for weak-lensing cross correlations". In: *A&A* 641, A130 (Sept. 2020). DOI: 10.1051/0004-6361/202038308. arXiv: 2005.00009 [astro-ph.CO]
5. A. J. Mead. "Spherical collapse, formation hysteresis and the deeply non-linear cosmological power spectrum". In: *MNRAS* 464 (Jan. 2017). DOI: 10.1093/mnras/stw2312. arXiv: 1606.05345
6. A. J. Mead et al. "Accurate halo-model matter power spectra with dark energy, massive neutrinos and modified gravitational forces". In: *MNRAS* 459 (June 2016). DOI: 10.1093/mnras/stw681. arXiv: 1602.02154
7. A. J. Mead et al. "An accurate halo model for fitting non-linear cosmological power spectra and baryonic feedback models". In: *MNRAS* 454 (Dec. 2015). DOI: 10.1093/mnras/stv2036. arXiv: 1505.07833
8. A. J. Mead et al. "Rapid simulation rescaling from standard to modified gravity models". In: *MNRAS* 452 (Oct. 2015). DOI: 10.1093/mnras/stv1484. arXiv: 1412.5195
9. A. J. Mead and J. A. Peacock. "Remapping simulated halo catalogues in redshift space". In: *MNRAS* 445 (Dec. 2014). DOI: 10.1093/mnras/stu1964. arXiv: 1408.1047
10. A. J. Mead and J. A. Peacock. "Remapping dark matter halo catalogues between cosmological simulations". In: *MNRAS* 440 (May 2014). DOI: 10.1093/mnras/stu345. arXiv: 1308.5183

Publications - significant contribution

1. Shiming Gu et al. "A non-standard Halo Mass Function as a solution to the structure-growth tension, application to KiDS-1000 and DES-y3". In: *arXiv e-prints*, arXiv:2302.00780 (Feb. 2023). arXiv: 2302.00780 [astro-ph.CO]
2. Andrej Dvornik et al. "KiDS-1000: Combined halo-model cosmology constraints from galaxy

abundance, galaxy clustering and galaxy-galaxy lensing". In: *arXiv e-prints*, arXiv:2210.03110 (Oct. 2022). arXiv: 2210.03110 [astro-ph.CO]
3. Constance Mahony et al. "The halo model with beyond-linear halo bias: unbiasing cosmological constraints from galaxy-galaxy lensing and clustering". In: *MNRAS* 515.2 (Sept. 2022). DOI: 10.1093/mnras/stac1858. arXiv: 2202.01790 [astro-ph.CO]
4. Tilman Tröster et al. "Joint constraints on cosmology and the impact of baryon feedback: Combining KiDS-1000 lensing with the thermal Sunyaev-Zeldovich effect from Planck and ACT". in: *A&A* 660, A27 (Apr. 2022). DOI: 10.1051/0004-6361/202142197. arXiv: 2109.04458 [astro-ph.CO]
5. Ziang Yan et al. "Probing galaxy bias and intergalactic gas pressure with KiDS Galaxies-tSZ-CMB lensing cross-correlations". In: *A&A* 651, A76 (July 2021). DOI: 10.1051/0004-6361/202140568. arXiv: 2102.07701 [astro-ph.CO]
6. Z. Yan et al. "Galaxy cluster mass estimation with deep learning and hydrodynamical simulations". In: *MNRAS* 499.3 (Dec. 2020). DOI: 10.1093/mnras/staa3030. arXiv: 2005.11819 [astro-ph.CO]
7. D. V. Gomez-Navarro et al. "Impact of cosmological signatures in two-point statistics beyond the linear regime". In: *MNRAS* (Nov. 2020). DOI: 10.1093/mnras/staa3393. arXiv: 2009.12717 [astro-ph.CO]
8. M. Cataneo et al. "On the road to percent accuracy: non-linear reaction of the matter power spectrum to dark energy and modified gravity". In: *MNRAS* 488.2 (2019). DOI: 10.1093/mnras/stz1836. arXiv: 1812.05594 [astro-ph.CO]
9. Nora Elisa Chisari et al. "Modelling baryonic feedback for survey cosmology". In: *The Open Journal of Astrophysics* 2.1, 4 (June 2019). DOI: 10.21105/astro.1905.06082. arXiv: 1905.06082 [astro-ph.CO]
10. N. E. Chisari et al. "Core Cosmology Library: Precision Cosmological Predictions for LSST". in: *arXiv e-prints* (Dec. 2018). arXiv: 1812.05995
11. Kyle Lawson et al. "Gravitationally trapped axions on the Earth". In: *PRD* 100.4, 043531 (Aug. 2019). DOI: 10.1103/PhysRevD.100.043531. arXiv: 1905.00022 [astro-ph.CO]
12. A. Hall and A. Mead. "Perturbative Gaussianizing transforms for cosmological fields". In: *MNRAS* 473 (Jan. 2018). DOI: 10.1093/mnras/stx2575. arXiv: 1709.03924
13. S. Joudaki et al. "KiDS-450: testing extensions to the standard cosmological model". In: *MNRAS* 471 (Oct. 2017). DOI: 10.1093/mnras/stx998. arXiv: 1610.04606
14. S. Joudaki et al. "CFHTLenS revisited: assessing concordance with Planck including astrophysical systematics". In: *MNRAS* 465 (Feb. 2017). DOI: 10.1093/mnras/stw2665. arXiv: 1601.05786
15. L. Lombriser, F. Simpson, and A. Mead. "Unscreening Modified Gravity in the Matter Power Spectrum". In: *Physical Review Letters* 114.25, 251101 (June 2015). DOI: 10.1103/PhysRevLett.114.251101. arXiv: 1501.04961
16. D. H. Forgan et al. "Surface flux patterns on planets in circumbinary systems and potential for photosynthesis". In: *International Journal of Astrobiology* 14 (July 2015). DOI: 10.1017/S147355041400041X. arXiv: 1408.5277 [astro-ph.EP]
17. S. P. Brown et al. "Photosynthetic potential of planets in 3:2 spin-orbit resonances". In: *International Journal of Astrobiology* 13 (Oct. 2014). DOI: 10.1017/S1473550414000068. arXiv: 1402.5044 [astro-ph.EP]

Publications - less significant contribution

1. Andreas Munk, Alexander Mead, and Frank Wood. "Uncertain Evidence in Probabilistic Models and Stochastic Simulators". In: *arXiv e-prints*, arXiv:2210.12236 (Oct. 2022). DOI: 10.48550/arXiv.2210.12236. arXiv: 2210.12236 [stat.ML]
2. Tilman Tröster et al. "KiDS-1000 Cosmology: Constraints beyond flat ΛCDM". in: *A&A* 649, A88 (May 2021). DOI: 10.1051/0004-6361/202039805. arXiv: 2010.16416 [astro-ph.CO]
3. Z. Yan et al. "An analysis of galaxy cluster mis-centring using cosmological hydrodynamic simulations". In: *MNRAS* (2020). DOI: 10.1093/mnras/staa295. arXiv: 1912.06663 [astro-ph.CO]
4. Xunyu Liang et al. "Axion quark nugget dark matter: Time modulations and amplifications". In: *PRD* 101.4, 043512 (Feb. 2020). DOI: 10.1103/PhysRevD.101.043512. arXiv: 1908.04675 [astro-ph.CO]
5. H. Hildebrandt et al. "KiDS+VIKING-450: Cosmic shear tomography with optical and infrared data". In: *A&A* 633, A69 (Jan. 2020). DOI: 10.1051/0004-6361/201834878. arXiv: 1812.06076 [astro-ph.CO]
6. Hideki Tanimura et al. "Probing hot gas around luminous red galaxies through the Sunyaev-Zel'dovich effect". In: *MNRAS* 491.2 (Jan. 2020). DOI: 10.1093/mnras/stz3130. arXiv: 1903.06654 [astro-ph.CO]
7. H. Tanimura et al. "A search for warm/hot gas filaments between pairs of SDSS Luminous Red Galaxies". In: *MNRAS* 483 (Feb. 2019). DOI: 10.1093/mnras/sty3118. arXiv: 1709.05024
8. S. Joudaki et al. "KiDS-450 + 2dFLenS: Cosmological parameter constraints from weak gravitational lensing tomography and overlapping redshift-space galaxy clustering". In: *MNRAS* 474 (Mar. 2018). DOI: 10.1093/mnras/stx2820. arXiv: 1707.06627
9. H. Hildebrandt et al. "KiDS-450: cosmological parameter constraints from tomographic weak gravitational lensing". In: *MNRAS* 465 (Feb. 2017). DOI: 10.1093/mnras/stw2805. arXiv: 1606.05338
10. A. Lawrence et al. "Slow blue nuclear hypervariables in PanSTARRS-1". In: *ArXiv e-prints* (May 2016). arXiv: 1605.07842 [astro-ph.HE]
11. M. Nicholl et al. "Superluminous supernovae from PESSTO". in: *MNRAS* 444 (Nov. 2014). DOI: 10.1093/mnras/stu1579. arXiv: 1405.1325 [astro-ph.HE]

Software

I currently maintain, or contribute heavily to, the following publicly available software:

1. A. Mead. *HMcode: Halo-model matter power spectrum computation*. Astrophysics Source Code Library. Aug. 2015. ascl: 1508.001
2. A. Lewis and A. Challinor. *CAMB: Code for Anisotropies in the Microwave Background*. Astrophysics Source Code Library. Feb. 2011. ascl: 1102.026
3. Nora Elisa Chisari et al. *CCL: Core Cosmology Library*. Astrophysics Source Code Library. Jan. 2019. ascl: 1901.003

Technical skills

OS	LINUX, MAC
Coding	PYTHON, FORTRAN, C, STAN, PYRO
Simulation	GADGET, N-GENIC, 2LPTIC, halo finding, simulation analysis tools

Academic talks

2020 Halo model cross correlations – *group meeting*, *San Sebastián*
2019 How to not run cosmological simulations – *cosmology colloquium*, *Standford*
2018 Multi-component halo model – *statistical-challenges in LSS*, *Oxford*
2017 Intermediate dark energy – *cosmology discussion group*, *UBC*
2017 Formation hysteresis in cosmology – *colloquium*, *CITA*
2017 Formation hysteresis in cosmology – *cosmology discussion group*, *UBC*
2016 Non-linear cosmological structure formation – *theory seminar*, *TRIUMF*
2016 Non-linear cosmological structure formation – *colloquium*, *LIneA*
2016 Non-linear cosmological structure formation – *colloquium*, *UBC*
2016 Non-linear cosmological structure formation – *colloquium*, *CITA*
2016 The halo model – *cosmology discussion group*, *UBC*
2016 HMcode – *gravity meeting*, *Vancouver*
2015 Rescaling simulations from standard to modified gravity – *DEX meeting*, *ROE*
2014 Rescaling simulations from standard to modified gravity – *group meeting*, *Oxford*
2014 Rescaling simulations from standard to modified gravity – *seminar*, *McGill*
2014 Central configuration solutions to the n-body problem – *Stobie Talk*, *ROE*
2014 Rescaling simulations from standard to modified gravity – *workshop*, *Benasque*
2014 Rescaling in redshift space – *cross-correlations meeting*, *UCL*
2014 Rescaling simulations from standard to modified gravity – *seminar*, *Edinburgh*
2013 Rescaling dark matter halo catalogues – *seminar*, *ROE*
2013 Life in 3:2 spin-orbit resonance – *Stobie Talk*, *ROE*
2012 Halofit 2 – *DEX meeting*, *Durham*
2012 Halofit 2 – *workshop*, *Benasque*
2012 Halofit 2 – *cosmology school*, *Passo Tonale*

PhD student supervision

2019 – 2020 Samuel Brieden: HMCODE accuracy for forthcoming surveys
2018 – 2019 Xunyu Liang: Axion-quark-nugget interactions with Earth
2016 – 2019 Zi'ang Yan: Machine learning halo properties from hydrodynamic simulations
2015 – 2018 Tilman Tröster: Cosmological cross correlations
2015 – 2017 Hideki Tanimura: Modelling cluster gas from SZ observations

Master student research supervision

2014 – 2015 Olivia Steele: The effect of dark energy on cosmological structure formation

Postgraduate research internship supervision

2018 – 2019 Md. Shahriar Rahim Siddiqui: Axion-quark-nugget interactions within the Solar System

Undergraduate student research supervision

2019 Hikari Rachmat: Axion-quark-nugget emission as seen by XMM Newton
2019 Marc-Antoine Dor: Exploring the halo mass function via weak-gravitational lensing
2015 Alexander Falk: The binary orbit menagerie
2015 Calum Hervieu: Planetary orbits in Lagrange points
2014 Felipe Knöner Thames: Planetary systems perturbed by passing stars

Teaching

2022 Probabilistic programming – master
2021 Introductory Astronomy – undergraduate
2021 Mathematics for Physics 2 – undergraduate
2017 Galaxies – undergraduate
2016 Cosmology – undergraduate
2013 – 2015 The Distant Universe – public lectures
2012 – 2013 General Relativity – undergraduate
2010 – 2013 Cosmology – undergraduate
2010 – 2011 Mathematics for Physics 3 – undergraduate

Involvement in academic institutions

2016 – 2017 Organiser of the UBC cosmology reading group
2012 – 2015 Organiser of the Edinburgh large-scale structure reading group

Outreach

2013 – 2015 The distant Universe – *Course of ten public lectures, given each year for three years*
2014 Dark energy – *Talk given to the Edinburgh astronomical society*
2012 – 2013 Progress in astronomy lectures – *Public talks given every month on new discoveries*
2013 Mass transfer in binary stars – *ROE public lecture*
2012 Large-scale structure formation – *ROE public lecture*

Referees

1 Professor John Peacock – *jap@roe.ac.uk*
2 Professor Catherine Heymans – *heymans@roe.ac.uk*
3 Professor Licia Verde – *liciaverde@icc.ub.edu*