Hayley J. Macpherson | *Curriculum Vitae*

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Education

PhD in Astrophysics, March 2016 - September 2019
Monash University, Clayton, Victoria, Australia
Thesis: Inhomogeneous cosmology in an anisotropic universe

Bachelor of Science (Honours), 2015
Monash University, Clayton, Victoria, Australia
Thesis: Inhomogeneous cosmology in an anisotropic universe

Bachelor of Science, 2012 - 2014
Monash University, Clayton, Victoria, Australia
Major: Astrophysics

Employment

NASA Einstein Fellow November 2022 - present
Kavli Institute for Cosmological Physics (KICP)
University of Chicago, Chicago, Illinois, USA

Herchel Smith Fellow October 2019 - October 2022
Department of Applied Mathematics and Theoretical Physics (DAMTP)
University of Cambridge, Cambridge, United Kingdom

Grants and allocations

- Marsden Fund project (New Zealand) entitled *"Changing the face of the Universe: Cosmological simulations from first principles in general relativity"* awarded NZD $941,000 in November 2023 (PI: D. Wiltshire, Co-I's: **H. J. Macpherson**, K. Bolejko, T. Buchert)
- Over 2.5 million CPU hours on the local University of Chicago's Midway3 supercomputer hosted by RCC (May 2023 - present)
- 1.35 million CPU hours on the COSMA8 machine in Durham, UK for DiRAC project *Einstein's Universe: Using numerical relativity to unveil the general-relativistic signatures in our cosmological observations* from October 2021 - April 2022 (**PI: H. J. Macpherson**)
- 1 million CPU hours on the Magnus machine at the Pawsey Supercomputing centre in Perth, Western Australia, awarded by the National Computational Merit Allocation Scheme (NCMAS) in 2016 and 2017
- 100 thousand CPU hours on Multi-modal Australian ScienceS Imaging and Visualisation Environment (MASSIVE) M2 machine in Melbourne, awarded by the National Computational Merit Allocation Scheme (NCMAS) in 2016 and 2017

Awards

- Swinburne Visiting Fellowship, Swinburne University of Technology, Melbourne, Australia, 2024
- NASA Hubble Fellowship Program Einstein Fellowship at the University of Chicago (2022-2025)
- Charlene Heisler Prize from the Astronomical Society of Australia (ASA) for the most outstanding PhD thesis in astronomy (2020)

- Robert Street Doctoral Prize in Physics for the best PhD thesis in the School of Physics & Astronomy at Monash University (2020)
- Mollie Holman Medal for the best PhD thesis in the Faculty of Science, Monash University (2020)
- Research Associateship, Fitzwilliam College, Cambridge (2020 & 2021)
- Herchel Smith Postdoctoral Fellowship (2019-2022)
- Monash University's Faculty of Science Young Science Leader Award (2018)
- Australian Postgraduate Award PhD scholarship (2016-2019)
- J.L William scholarship from the School of Physics & Astronomy (2016-2019)
- Monash Centre for Astrophysics top honours student prize (2015)
- Australian Astronomical Observatory Summer Internship (2014)

Student mentoring

Graduate students

Sana Elgamal at the University of Chicago	September 2023 - present
Ryn Grutkoski at the University of Chicago	March 2023 - present
Michael Williams at the University of Canterbury	May 2021 - present

Undergraduate students

Kihana Wilson at the University of Chicago	September 2023 - present
Jessica Cowell at the Institute of Astronomy, Cambridge	October 2021 - June 2022
Michael Williams at the University of Canterbury	November 2020 - March 2021

Teaching experience

Teaching Associate, Physics & Astronomy 2015 - 2019
Monash University, Clayton, Victoria, Australia
I worked as a teaching associate during my PhD for the following units offered as part of an Astrophysics major

- *ASP2011 - Astronomy.*
- *ASP2062 - Introduction to astrophysics.*
- *ASP3051 - Relativity and cosmology.*
- *ASP3162 - Computational astrophysics and the extreme universe.*

For all of these I took control of the weekly tutorial/laboratory classes, helping students with questions regarding content, marking weekly question sheets and exam marking.

Publications

- **Macpherson, H. J.**, *The Impact of Anisotropic Sky Sampling on the Hubble Constant in Numerical Relativity*, 2024, ApJ, 970, 111
- Koksbang, S. M., Heinesen, A., **Macpherson, H. J.**, *Redshift drift in a universe with structure III: Numerical relativity*, 2024, *Accepted for publication in Phys. Rev. D*, eprint arXiv:2404.06242
- Williams, M. J., **Macpherson, H. J.**, Wiltshire, D. L., and Stevens, C., *First investigation of void statistics in numerical relativity simulations*, 2024, *In review for MNRAS*, eprint arXiv:2403.15134
- Adamek, A. J., Clarkson, C., Durrer, R., Heinesen, A., Kunz, M., and **Macpherson, H. J.**, *Towards Cosmography of the Local Universe*, 2024, OJAp, 7, 44
- Magnall, S. J., Price, D. J., Lasky, P. D., and **Macpherson, H. J.**, *Inhomogeneous cosmology using general relativistic smoothed particle hydrodynamics coupled to numerical relativity*, 2023, Phys. Rev. D, 108, 103534

- Cowell, J. A., Dhawan, S., and **Macpherson, H. J.**, *Potential signature of a quadrupolar Hubble expansion in Pantheon+ supernovae*, 2023, MNRAS, 526, 1482
- **Macpherson, H. J.**, *Cosmological distances with general-relativistic ray tracing: framework and comparison to cosmographic predictions*, 2023, JCAP, 2023, 019
- Dhawan, S., Borderies, A., **Macpherson, H. J.** and Heinesen, A., *The quadrupole in the local Hubble parameter: first constraints using Type Ia supernova data and forecasts for future surveys*, 2023, MNRAS, 519, 4841
- Heinesen, A., **Macpherson, H. J.**, *A prediction for anisotropies in the nearby Hubble flow*, 2022, JCAP, 2022, 057
- Ota, A., **Macpherson, H. J.**, Coulton, W. R., *Covariant transverse-traceless projection for secondary gravitational waves*, 2022, Phys. Rev. D, 106, 063521
- **Macpherson, H. J.**, Heinesen, A., *Luminosity distance and anisotropic sky-sampling at low redshifts: a numerical relativity study*, 2021, Phys. Rev. D, 104, 023525
- Adamek, J., Barrera-Hinojosa, C., Bruni, M., Li, B., **Macpherson, H. J.**, and Mertens, J. B., *Numerical solutions to Einstein's equations in a shearing-dust Universe: a code comparison*, 2020, Classical and Quantum Gravity, 37(15):154001
- **Macpherson H. J.**, Price D. J., Lasky P. D., *Einstein's Universe: Cosmological structure formation in numerical relativity*, 2019, Phys. Rev. D., 99, 063522
- **Macpherson H. J.**, Lasky P. D., Price D. J., *The trouble with Hubble: Local versus Global Expansion Rates in Inhomogeneous Cosmological Simulations with Numerical Relativity*, 2018, ApJ, 865, L4
- **Macpherson H. J.**, Lasky P. D., Price D. J., *Inhomogeneous cosmology with numerical relativity*, 2017, Phys. Rev. D, 95, 064028
- De Silva G. M., Carraro G., D'Orazi V., Efremova V., **Macpherson H.**, Martell S., Rizzo L., *Binary open clusters in the Milky Way: photometric and spectroscopic analysis of NGC 5617 and Trumpler 22*, 2015, MNRAS, 453, 106

Invited Conference Talks

- *"Einstein's Universe: Cosmological structure formation in numerical relativity"* at the American Physical Society (APS) April 2024 meeting
- *"Fully nonlinear ray-tracing in cosmological simulations with numerical relativity"* at the Testing Gravity meeting, Vancouver, BC, Canada, January 18-21, 2023
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: A numerical relativity study"* AAPPS-DACG workshop on Astrophysics, Astroparticle Physics, Cosmology and Gravitation (online) from November 14-17th, 2022
- *"Numerical relativity as a tool to study inhomogeneous cosmology"* European Einstein Toolkit meeting, University College Dublin, Ireland from August 29th-September 2nd, 2022
- *"Numerical relativity as a tool for cosmology"* Plenary talk at ACGRG11 at the University of Tasmania, Australia, February 2-4, 2022
- *"Numerical relativity as a tool to study inhomogeneous cosmology"* CIRM Theory of Gravitation and Variation in Cosmology Virtual Research School, April 12-16th, 2021
- *"Cosmological simulations of large-scale structure with numerical relativity"* at the "From Dark Energy to Bright Synergies" workshop, Sexten Centre for Astrophysics, Sesto-Sexten, Italy, July 23-27 2018

- *"Cosmological simulations of large-scale structure with numerical relativity"* at the "General relativistic effects in cosmological large-scale structure" workshop, Sexten Centre for Astrophysics, Sesto-Sexten, Italy, July 16-20 2018
- *"General Relativistic cosmological structure formation"* at the 9th Australasian Conference on General Relativity and Gravitation, Gingin, Perth, November 27-30 2017

Invited Seminars and Colloquia

- *"Numerical relativity in the era of precision cosmology"* Astrophysics Colloquium at the University of Melbourne, Australia, August 14th, 2024
- *"Low-redshift cosmic anisotropy in simulations using numerical relativity"* Astrophysics Seminar at the University of Illinois at Urbana-Champaign, October 11th, 2023
- *"The low-redshift distance-redshift relation beyond FLRW"* Astrophysical and Cosmological Relativity division seminar at Max Planck Institute for Gravitational Physics (Albert Einstein Institute), April 5th, 2023 (online)
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: A numerical relativity study"* University of Hawaii at Manoa cosmology seminar, Honolulu, HI, USA, March 2nd, 2023
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: A numerical relativity study"* Princeton Gravity Initiative seminar, Princeton, NJ, USA, February 13th, 2023
- *"Low-redshift cosmic anisotropy in simulations using numerical relativity"* Monash University Astrophysics seminar, Melbourne, Australia, July 19th, 2022
- *"Low-redshift cosmic anisotropy in simulations using numerical relativity"* University of Milano-Bicocca AstroBicocca seminar, Milan, Italy, June 16th, 2022
- *"Low-redshift cosmic anisotropy in simulations using numerical relativity"* University College London cosmology and extra-galactic seminar (online), June 1st, 2022
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: A numerical relativity study"* Institute of Theoretical Astrophysics colloquium at the University of Oslo, May 13th, 2022
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: A numerical relativity study"* Liverpool John Moores University ARI seminar, March 23rd, 2022
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: A numerical relativity study "* Queen Mary University of London cosmology seminar (online), December 15th, 2021
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: A numerical relativity study"* Institute for Cosmology and Gravitation Portsmouth seminar (online), October 6th, 2021
- *"Low-redshift cosmic anisotropy in simulations using numerical relativity"* MIT Brown Bag Lunch talk (online), October 4th, 2021
- *"Luminosity distance and anisotropic sky-sampling at low redshifts: a numerical relativity study"* Cambridge/LMU Munich joint journal club seminar, June 11th, 2021
- *"How much are local anisotropies biasing our measurements?"* Cosmology Talks online seminar (joint with Asta Heinesen) on YouTube, June 3rd, 2021

- *"Luminosity distance and anisotropic sky-sampling at low redshift: a numerical relativity study"* DAMTP General Relativity seminar, Cambridge (on Zoom), May 28th, 2021
- *"Luminosity distance and anisotropic sky-sampling at low redshift: a numerical relativity study"* University of Hawaii online seminar, April 1st, 2021
- *"The importance of anisotropy in sky-sampling of cosmological data"* University of Leicester online seminar, March 10th, 2021
- *"An improved calculation of cosmological backreaction in simulations with numerical relativity"* University of Helsinki online seminar, November 11th, 2020
- *"Einstein's Universe: Cosmological structure formation in numerical relativity"* DAMTP Cosmology Seminar, University of Cambridge, February 24th, 2020
- *"Einstein's Universe: Cosmological structure formation in numerical relativity"* Kenyon College, Columbus, OH, USA, February 21st, 2020
- *"Einstein's Universe: Cosmological structure formation in numerical relativity"* DAMTP General Relativity Seminar, University of Cambridge, November 29th, 2019
- *"Einstein's Universe: Cosmological structure formation in numerical relativity"* School of Physics & Astronomy, Queen Mary University of London, November 20th, 2019
- *"The trouble with H_0: a general relativistic point of view"* Centre for Astrophysics & Supercomputing, Swinburne University of Technology, Melbourne, May 16th 2018
- *"Inhomogeneous cosmology in an anisotropic Universe"* Institute of Cosmology and Gravitation, University of Portsmouth, United Kingdom, July 12th 2017
- *"Inhomogeneous cosmology in an anisotropic Universe"* Department de Physique Theorique, Universite de Geneve, Switzerland, June 30th 2017
- *"Inhomogeneous cosmology with the Einstein Toolkit"* Department of Physics, University of Trento, Italy, June 20th 2016

Conference Presentations

In addition to the invited talks listed above, I have given 17 contributed talks at international workshops and conferences since 2015.

Tutorials

- *FLRWSolver and the Einstein Toolkit* at the GR Simulations in Cosmology Workshop (September 7&8 2020)
- *Introduction to the Einstein Toolkit numerical relativity code* at the Inhomogeneous Cosmologies III workshop in Kraków, Poland (2018)

Select Public Outreach

- *"Listen carefully: how astronomers can hear gravitational waves in space"* online YouTube livestream talk for Astronomy on Tap, Cambridge, 2021
- *"The Big Bang and Black Holes: In Celebration of Stephen Hawking's Birthday"* online YouTube livestream with the Centre for Theoretical Cosmology (leader of panel discussion), 2021
- *"How to build a Universe"* online YouTube livestream for the IoA Cambridge open evening, 2020
- *"Newton vs Einstein: battle of the brains"* kids talk online YouTube stream for the IoA Cambridge, 2020
- *"How to make a Universe"* talk at Astronomy on Tap, Cambridge, 2020

- Organiser for "*Astronomy on Tap*" Cambridge 2019–2022
- Co-founder of the School of Physics and Astronomy Women in Physics & Astronomy mentoring program, Monash University 2017–2019
- Panel member for Science Week Q&A session at "The Academy" Catholic Girls Secondary School, Melbourne 2019
- Live science demonstrations for "Science Night" at Overport Primary School, Melbourne 2017 & 2019
- Monash Centre for Astrophysics outreach stand at the Astrolight Festival at Scienceworks, Melbourne 2017

Academic Involvement

Assessment panels:

- PhD thesis examination: University of Sydney (November 2023)
- Judging panel for the Kerr Prize for best student talk at ACGRG11 in Hobart, Australia (February 2022)

Committee involvement:

- Organiser for the GR Simulations in Cosmology Workshop, held online and hosted by Queen Mary University of London (September 7&8 2020)
- Local organising committee member for the 13th Australian National Institute for Theoretical Astrophysics (ANITA) science workshop in Melbourne, 2019
- Scientific organising committee member for the Inhomogeneous Cosmologies III workshop in Kraków, Poland, 2018
- Local organising committee member for the 1st Phantom Users Workshop in Melbourne, 2018
- Steering committee member for the Monash University Graduate Research Conference in Melbourne, 2017
- Member of the Postgraduate Committee (PGC) and representative for students within the School of Physics & Astronomy, 2017
- Local organising committee member for the ADACS Data Intensive Astronomy Workshop in Melbourne, 2017
- Scientific organising committee member for the 1st Inhomogeneous Cosmologies workshop in Torun, Poland 2017

Local organisation:

- KICP seminar series at the University of Chicago (2023-2024)
- KICP/Astronomy & Astrophysics weekly journal club at the University of Chicago (2022-2023)
- Cambridge Cosmology group meetings plus joint group meetings with LMU Munich cosmology group (2020-2022)
- DAMTP Racism Discussion Group (2020)

References

- **Professor Joshua Frieman**
  Chair of Astronomy and Astrophysics
  Department of Astronomy and Astrophysics, University of Chicago
  Email: jfrieman@uchicago.edu

- **Professor Paul Shellard**
  Director of Centre for Theoretical Cosmology
  DAMTP, University of Cambridge, United Kingdom
  Email: gr-secretary@damtp.cam.ac.uk

- **Professor Paul Lasky**
  PhD supervisor
  School of Physics & Astronomy, Monash University
  Email: paul.lasky@monash.edu