

Calum Murray

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Profile

I am currently a postdoctoral researcher at CosmoStat (CEA Paris-Saclay), working on observational cosmology. My research focuses on understanding how galaxies populate the cosmic web by combining weak gravitational lensing observations with detailed characterization of observational systematics. I develop physically motivated models and forward-modeling strategies validated on real survey data from Euclid, UNIONS, and DESI, with particular focus on cluster cosmology and characterizing the galaxy-halo connection through both galaxy clustering and intrinsic alignments. I hold leadership positions in the Euclid collaboration as co-lead of the cluster catalogue work package and the COMB-CL processing function for cluster weak lensing measurements.

Research experiences

01/09/2024 – Present: Postdoctoral researcher at CosmoStat, CEA Saclay, France

Advisors: Dr. Martin Kilbinger & Dr. Samuel Farrens

01/09/2022 – 01/09/2024: Postdoctoral researcher at AstroParticle and Cosmology laboratory (APC), Université de Paris, France

Advisor: Prof. James G. Bartlett

01/11/2020 – 01/09/2022: Postdoctoral researcher at Laboratory of Subatomic Physics and Cosmology (LPSC), Université Grenoble Alpes, France

Advisor: Dr. Céline Combet

Education and key qualifications

30/10/2020: PhD, Astrophysics, Université Paris Cité, France

Thesis: *Galaxy cluster cosmology with the Euclid Dark Energy Survey*

Supervisor: Prof. James G. Bartlett

2017: Master of Mathematical Physics (MPhys), University of Edinburgh, UK

Thesis: *The colours of galaxies*

Supervisor: Prof. Robert Mann

Leadership roles in major collaborations

Euclid Consortium (2017 – Present)

- **Co-lead** of the Galaxy Clusters work package on catalogue selection and definition (since 2024)
- **Co-lead** of COMB-CL processing function for cluster weak lensing measurements (improved code speed by factor of 50 for large datasets) (since October 2025)
- **Lead author** on key paper analysing covariances between observed cluster properties using the 5,150 square degree Euclid Flagship simulation, in preparation.

UNIONS – Ultraviolet Near Infrared Optical Northern Survey (2024 – Present)

- Member, contributing to cosmic shear analysis and intrinsic alignment measurements using UNIONS galaxy shape measurements combined with DESI spectroscopic data

LSST Dark Energy Science Collaboration (2020 – Present)

- Member, contributed two-halo term computation and elliptical halo validation to DESC cluster weak lensing processing function CLMM

Wide-field Spectroscopic Telescope (WST)

- Member of WST Science Team

Statistical and methodological expertise

- Weak gravitational lensing: shear and magnification measurements, cluster mass estimation
- Development of statistical techniques: Wiener filtering, two-dimensional shear field analysis
- Forward modeling and simulation-based inference approaches
- Cross-correlation analyses for tests of gravity and cosmological systematics
- Extended GPU correlation code (cucount, <https://github.com/adematti/cucount>) for arbitrary spin-correlations, enabling rapid computation of shape-position and higher-order correlations (100x speedup)
- Cluster abundance cosmology: likelihood development, super-sample covariance
- Large-scale survey data validation and systematic characterization
- Analysis of photometric surveys (Euclid, UNIONS, HSC) and spectroscopic surveys (DESI)
- Production of mock observations and catalogue-level forward models

Supervising & Teaching

PhD Supervision

- Antonin Corinaldi (Sept 2025 – present), intrinsic alignments with UNIONS, DESI and Euclid, co-supervised with Dr. M. Kilbinger and Dr. S. Codis
- Constantin Payerne (co-supervised during his PhD), cluster abundance cosmology, resulted in 2 publications
- Raphaël Kou (co-supervised during his PhD), tests of modified gravity, resulted in 1 publication

Master’s Students

- Antonin Corinaldi (Jan–Sept 2025), intrinsic alignment with UNIONS and DESI
- Huy Nguyen Phu (Apr–Sept 2024), galactic acceleration using quasar proper motions
- Théo Courty (May–July 2023), intrinsic alignments of galaxies
- Mahmoud Osman (Apr–June 2022), optical mass proxies for galaxy clusters
- Margaux Scavini (May–June 2019), strong gravitational lensing

Teaching

- August 2025: Lecturer, Euclid Summer School. Delivered 6-hour graduate-level course on observational aspects of weak gravitational lensing
- June 2025: Lecturer, COLOURS Workshop. Developed and taught workshop on analyzing Euclid’s first data release

Contributions to the research community

Scientific life

- Since 2025: Organizer of monthly meetings for CEA researchers working on Euclid
- Since 2025: Peer reviewer for American Astronomical Society (AAS) journals
- 2022–2024: Organizer of weekly APC cluster journal club
- 2018–2020: Organizer of biweekly APC cosmology journal club
- 2021: Local Organizing Committee, Euclid France meeting, LPSC Grenoble
- 2019: Organizing Committee, Rencontres des Jeunes Physicien.ne.s, Collège de France, Paris

Outreach activities

- Since Nov 2023: Co-organizer of Astronomy on Tap, Paris. Principle organiser since January 2025. Organized monthly public lectures in bars in Paris making astronomy accessible to the general public
- Nov 2022 & Dec 2024: Rencontres du Ciel et de l’Espace, Paris. Volunteered at Euclid and Rubin stands explaining cosmological surveys to the public

Selected publications

23 total, including 3 published first author, 3 published second author with considerable contributions, 4 first author publications in preparation, 3 of which are complete and under-review.

First-author publications

C. Murray, C. Combet, C. Payerne, M. Ricci (2025). Filtering out large-scale noise for cluster weak lensing mass estimation. *Astronomy & Astrophysics*, 697, A141

C. Murray, J.G. Bartlett, E. Artis, J.B. Melin (2022). Measuring weak lensing masses on individual clusters. *Monthly Notices of the Royal Astronomical Society*, 512(4), 4785-4791

C. Murray (2022). The effects of lensing by local structures on the dipole of radio source counts. *Monthly Notices of the Royal Astronomical Society*, 510(2), 3098-3101

C. Murray, J.G. Bartlett, R. Kou (submitted to A&A). Gravitational lensing by matter currents. arXiv:2510.19798

C. Murray, M. Kilbinger (under internal review within UNIONS). Observational evidence for the origin of intrinsic alignments of galaxies.

C. Murray (in preparation). Two-dimensional shear field estimation of cluster masses, concentration, miscentering and ellipticity.

Euclid Collaboration: **C. Murray**, S. Bhargava, et al. (in preparation). Euclid preparation: Covariances between observed cluster properties with the Euclid Flagship simulation.

Key collaborative publications (co-supervised students)

C. Payerne, **C. Murray**, C. Combet, C. Doux, M. Penna-Lima (2024). Cluster abundance cosmology: Including super-sample covariance in the unbinned likelihood. Submitted to A&A, arXiv:2401.10024

C. Payerne, **C. Murray**, C. Combet, C. Doux, A. Fumagalli, M. Penna-Lima (2023). Testing the accuracy of likelihoods for cluster abundance cosmology. *Monthly Notices of the Royal Astronomical Society*, 520(4), 6223-6236

C. Payerne, **C. Murray**, et al. (in preparation). Simulation-based inference framework for optical cluster cosmology incorporating selection effects and galaxy population systematics

R. Kou, **C. Murray**, J.G. Bartlett (2024). Constraining $f(R)$ gravity with cross-correlation of galaxies and cosmic microwave background lensing. arXiv:2311.09936

Other significant collaborative publications

E. Artis, J.B. Melin, J.G. Bartlett, **C. Murray** (2021). Impact of the calibration of the halo mass function on galaxy cluster number count cosmology. *Astronomy & Astrophysics*, 649, A47

Euclid Collaboration publications

Euclid Collaboration: S. Bhargava, C. Benoist, A.H. Gonzalez, ..., **C. Murray**, et al. (2025). Euclid Quick Data Release (Q1): First detections from the galaxy cluster workflow. arXiv:2503.19196

UNIONS Collaboration publications

F. Hervas Peters, M. Kilbinger, ..., **C. Murray**, et. al (2025). UNIONS: A direct measurement of intrinsic alignment with BOSS/eBOSS spectroscopy. 2412.01790

Plus 7 additional published Euclid papers (with minor contributions), 2 DESC papers under internal review

Invited talks & conference presentations

Selected invited seminars

- July 2025: Le comptage d'amas de galaxies dans notre Univers avec Euclid, 27ème Congrès Général de la Société Française de Physique, Troyes, France
- January 2025: Constraining $f(R)$ gravity with cross-correlation of galaxies and cosmic microwave background lensing, Max Planck Institute for Extraterrestrial Physics, Munich, Germany
- April 2024: Beyond cosmic variance: galaxy cluster weak lensing, Royal Observatory of Edinburgh, United Kingdom
- March 2024: Robust estimation of the quasar dipole, Laboratoire Univers et Particules de Montpellier, France
- February 2023: Gravitational lensing by matter currents, CPPM, Marseille, France
- January 2021: Individual weak lensing masses with HSC, LPSC, Grenoble, France
- January 2020: Individual weak lensing masses with HSC, CosmoStat, CEA Saclay, France
- December 2018: Individual weak lensing masses for Euclid, Observatoire de Paris, Meudon, France

Conference & collaboration presentations

8 international conferences (including Rencontres de Moriond, Tracing Cosmic Evolution with Clusters of Galaxies Sexten, Progress on Old and New Themes in Cosmology Avignon) · 25 Euclid collaboration meetings (Euclid France, general Consortium meetings, Galaxy Clusters Science Working Group, Theory Science Working Group) · 8 LSST Dark Energy Science Collaboration meetings

References

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