DANIEL J BALLARD

Curriculum Vitae

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SUMMARY

PhD candidate in cosmology, using strong gravitational lens modelling techniques to constrain the nature of dark matter and dark energy. Enthusiastic about building a career in cosmological research and excited to bring my expertise forward into the incoming big data era of strong lensing.

SKILLS

Expertise: Galaxy-galaxy strong lens modelling, Bayesian inference, image processing, data visualisation, scientific writing, public speaking, theatre, piano.

Computing: Python, jax, numpyro, scipy, astropy, lenstronomy, emcee, zeus, dynesty, pocoMC, SLURM, OpenMPI, git, C#, Unity, SQL, Office, DS9, GIMP.

Languages: English (native speaker).

REFERENCES

Prof Thomas E Collett thomas.collett@port.ac.uk
Dr Russell J Smith russell.smith@durham.ac.uk
Dr Wolfgang J R Enzi wolfgang.enzi@port.ac.uk

EDUCATION

2020 - 2024 **PhD Cosmology** — **Institute of Cosmology and Gravitation, University of Portsmouth**
Thesis: *Probing the nature of dark matter and dark energy with strong gravitational lensing*

2018 - 2019 **MSc Astrophysics** — **School of Physics and Astronomy, Cardiff University**
Graduated with **distinction**.
Dissertation: *Virtual reality for cosmological simulation data visualisation*

2015 - 2018 **BSc Physics and Music** — **School of Physics and Astronomy, Cardiff University**
Graduated with **first class honours**.
Dissertation: *Detailed Fourier analysis on the imperfect vibrations of piano strings*

PUBLICATIONS

First author:

in prep. **Dark energy cosmography with a triple source plane lens** (working title)
D J Ballard, C M Krawczyk, W J R Enzi, T E Collett

I am leading a project using the three source planes of SDSSJ0946+1006 to geometrically probe the Universe's expansion history out to $z \sim 6$, as a test of dark energy as a cosmological constant. Using fast forward modelling in *jax* and *numpyro*, and cutting-edge GPU hardware, we are cosmographically testing a plethora of dark energy models (CDM cosmologies where $w = -1$, $w \neq -1$, or an evolving w, with and without the assumption of $\Omega_k = 0$). to see if the standard model is recovered with this unique probe.

Sep 2023 (submitted) **Gravitational imaging through a triple source plane lens: revisiting the ΛCDM–defying dark subhalo in SDSSJ0946+1006** — **arXiv:2309.04535**
D J Ballard, W J R Enzi, T E Collett, H C Turner, R J Smith

I led a project to produce the first published lens models of SDSSJ0946+1006 to utilise every background source and multiple wavelength bands of HST data, whilst testing for a perturbing dark substructure. Under a barrage of systematic tests on the mass model assumptions and source reconstruction techniques, we found consistent $\sim 5\sigma$ preference for a lensing perturbation in this system, whose mass and concentration were in significantly less tension with CDM than in previous studies.

Non-First author:

Aug 2023 (published) **The impact of human expert visual inspection on the discovery of strong gravitational lenses**
K Rojas, T E Collett, **D Ballard**, M R Magee, S Birrer et al. — **MNRAS.523.4413**

I beta-tested and participated in a *Zooniverse* experiment to test strong lensing experts' ability to identify strong lenses. We found that success rates were similar despite participants' prior experience in lensing. Lens candidates were more successfully identified if they had high signal-to-noise and large Einstein radii.

CONFERENCES & WORKSHOPS

Aug 2023	**Lensing at different scales: strong, weak and the synergies between the two** Spotlight talk & poster: *Dark energy cosmography with a triple source plane lens*	**Chicago, USA**
Jun 2023	**Strong gravitational lensing in the era of big data** Contributed talk: *Gravitational imaging through a triple source plane lens*	**Otranto, Italy**
Sep 2022	**From particle physics to gravitation: the crossover with data science** Contributed talk: *Gravitational lensing as a dark matter tracer*	**Southampton, UK**
Jun 2022	**EAS Annual Meeting 2022** Contributed talk: *Compound lensing as a dark matter tracer*	**Valencia, Spain**
Apr 2022	**South Coast Cosmology** Contributed talk: *The gravitational lensing-of-a-lens in SDSSJ0946+1006*	**Portsmouth, UK**
Aug 2021	**24th international conference on particle physics and cosmology (COSMO '21)** Virtual attendee	**Urbana-Champaign, USA**
Jul 2021	**DISCnet machine learning course** In-person attendee	**Liphook, UK**
Jan 2021	**Time-domain cosmology with strong gravitational lensing** Virtual attendee	**Tokyo, Japan**
Oct 2020	**South coast cosmology** Virtual attendee	**Sussex, Southampton & Portsmouth, UK**

OUTREACH & PUBLIC ENGAGEMENT

2022 - present — ***Field of View*** **Youtube channel**
I am a producer, presenter and editor of *Physics Chat*: a chat show-like series on the *Field of View* Youtube channel, featuring a different astronomer or physicist in every episode, discussing their background, research and interests in and out of physics

Jan 2023 — ***Stargazing*** **at Portsmouth's Historic Dockyard**
I helped to plan, run and participated as a guest astronomer in *Physics Chat Live*, a live panel-show format of our Youtube series, featuring Q&A from members of the public, as part of the Institute of Cosmology and Gravitation's flagship large-scale public event, *Stargazing*.

Jan 2022 — ***Virtual Pompey Stargazing***
I helped behind the scenes to ensure the smooth operation of live-streamed cosmology talks.

AWARDS & GRANTS

- UKRI STFC studentship.
- IAU conference travel grant.
- KICP workshop travel grant.
- *Highly commended* in Newcomer category at SEPnet public engagement awards.

OBSERVING PROPOSALS

- co-I on successful **ALMA proposal** *Lighting up dark matter with dust: probing the anomolous lensing substructure in J0946+1006* 2023.1.00774.S (PI: Russell J Smith).
- co-I on successful **VLT-ERIS proposal** *Emission-line mapping the double ring in the Jackpot gravitational lens: steps towards a multi-plane compound lens model* 110.257M (PI: Russell J Smith).
- co-I on successful **Liverpool Telescope proposals** *Observations of the first sample of gravitationally lensed supernovae* PL23B11 (PI: Ana Sainz de Murieta) and PL22B01/PL23A04 (PI: Mark R Magee).

OTHER EXPERIENCE

- Founder and organiser of weekly **strong lensing journal club** at Institute of Cosmology and Gravitation, University of Portsmouth.
- **Secondary supervisor** to Ridima Sur, undergraduate summer intern at University of Portsmouth studying lensed supernovae.
- Co-organiser of *From particle physics to gravitation: the crossover with data science*, SEPnet **student-led conference** at University of Southampton.
- Teaching assistant for *Computational physics* (2nd year undergraduate physics course, University of Portsmouth).
- Marker for *Introduction to Mathematical physics* (1st year undergraduate physics course, University of Portsmouth).