Dowthwaite MScR Scholarship 2023/24 entry

DEPARTMENT OF PHYSICS

Principal Supervisor: Prof Mathilde Jauzac

Other Supervisors: Dr Guillaume Mahler (PDRA)

Project Title/Theme: Testing different flavours of dark matter with gravitational lensing, from simulation to observations.

Project Description

Dark matter is making about 80% of the matter content of our universe. However, its properties remain elusive and we have yet to be able to successfully detect it. The standard cosmology using cold dark matter is able to successfully reproduce most of the structure formation in our universe but still fails to adequately reproduce observations in a few cases. Such examples are the mass profiles of galaxy clusters. Galaxy clusters are the largest and most massive structures in our universe, they are dominated by dark matter and therefore represent an ideal laboratory to study it.

Today, our most accurate tool to map dark matter within clusters is gravitational lensing (Kneib & Natarajan 2010), i.e. the apparent bending of light from background galaxies near a massive foreground object such as galaxy clusters. The bending can be so strong that the image of the galaxy appears multiple times and produces highly distorted images of these background galaxies. Using this bending, we can recover the mass distribution responsible for it, and thus the one within clusters. However, being able to directly connect the mass distribution derived from our observations to the properties of dark matter requires theoretical predictions. Researchers have built large cosmological simulations of dark matter to match observed clusters (e.g. EAGLE/C-EAGLE or Hydrangea Bahé et al. 2019) or with alternative dark matter properties (BAHAMAS, McCarthy et al. 2017,). A few hints at the ability of clusters to test alternatives models of dark matter have been developed, such as the ellipticity and flatness of the profile (Robertson et al. 2019), the peak offset between the light and the dark-matter mass (Harvey et al. 2019), or the mass-ratio between cluster member galaxies. However, we have yet to fully explore the ability of observations to constrain such properties using current modelling techniques.

The student will work with simulated galaxy clusters, and produce mass density maps. These maps will be used to simulate observing constraints for strong lensing. The student will learn how to model a cluster using gravitational lensing, and use these models to robustly estimate how well cluster modelling can actually recover dark matter properties and assess the possibility of testing it with observations. This project can lead to a publication in a peer-review journal. Minimal python coding skills are necessary and the ability to navigate and run commands in a terminal is appreciated.

How to apply
You must apply through the University's applicant portal

You will need to:

- State 'ASTRO and Testing different flavours of dark matter with gravitational lensing in the 'Field of Study' section.
- On the funding tab select 'yes' you are applying for a scholarship, select 'Other' write DOW234 in the name of the scholarship, and select 1st October 2023 as the start date
- attach a covering letter and CV
- attach degree transcripts and certificates and, if English is not your first language, a copy of your English language qualifications.
- provide 2 referee contact details (specifically email addresses) who we will contact directly.

Contact
For enquiries please contact Prof Mathilde Jauzac mathilde.jauzac@durham.ac.uk