Strong gravitational lensing with Euclid, Rubin and Herschel

Stephen Serjeant, 11 November 2021

Motivation

Both Rubin LSST and Euclid's Wide and Deep optical/near-infrared imaging and grism surveys will be transformative for the discovery of strong gravitational lenses, increasing the known number by two orders of magnitude. Lensed systems at z>6 will be the premier high-z lensing systems in Euclid/LSST and prime targets for JWST, illuminating at high angular resolution the physical processes that drive the earliest stellar mass assembly at z>6. However Euclid and LSST are very far from having an algorithm for the reliable discovery of these very rare z>6 strongly lensed galaxies (e.g. Marchetti+17 MNRAS 470, 5007). Over all redshifts, Euclid and LSST are expected to find more than 10^5 strong gravitational lens systems, including many rare and exotic populations such as compound lenses, but these 10^5 systems will be interspersed among much larger catalogues of around 10^9 galaxies. The z>6 rare population is therefore a "needle in a haystack in a huge field of haystacks" data mining problem. This volume of data is too much for visual inspection by volunteers alone to be feasible and gravitational lenses will only appear in a small fraction of these data which could cause a large amount of false positives. Machine learning is one obvious approach to finding a solution. We have developed Convolutional Neural Networks to identify strong gravitational lenses in large imaging data sets (Wilde+21 in prep.), and interpretability tools to understand whether it will detect or select out rare populations such as z>6 galaxies or compound lenses.

Activities and Expected Outcomes

Dr Lucia Marchetti (UCT) has obtained HST data on large numbers of submm-selected lenses so we seek visitor funding to try the HST imaging of these lenses through our lens-detecting convolutional neural net. Our suspicion is that submm-selected lenses will not fare as well as simulated Euclid lenses, because they are optically quite faint, so this will be a useful salutary lesson in LSST and Euclid's false-negative detection rate. We will seek additional UK funding from the visitors' line in our STFC Consolidated Grant and other sources.

Aims / Goals

- Produce gravitational lens postage stamps from Dr Marchetti's HST data on submm-selected lensing systems
- Test the completeness of the convolutional neural network when classifying these submm-selected lensing systems
- Determine recommendations for the future Euclid mission for improving the recall and purity of lensing systems discovered through machine learning
- Apply any modified CNN to existing high quality imaging data sets such as COSMOS HST data to find lensed galaxies that are atypical of current training sets for Euclid and LSST, e.g. missing populations of lensed dust-obscured galaxies or candidate lensed systems at very high redshifts