Dark Substructure Sensitivity in the Euclid Survey with Machine Learning

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Abstract

Gravitational imaging is a technique for finding dark substructures in the haloes of strong lensing galaxies. Constraints on the number and mass distribution of subhaloes from this analysis can constrain the subhalo mass function, and by extension, the underlying dark matter model. The Euclid survey will increase the number of known strong gravitational lenses by many orders of magnitude and provide a wealth of data for future gravitational imaging studies. In this work we combine machine learning and realistic simulations of large strong lensing datasets to determine the constraining power of the Euclid survey for different dark matter models.
Traditional methods for determining substructure sensitivity of lensing data are resource intensive, both in terms of computation and investigator time. It would be infeasible to analyse any large number of Euclid images in this way. Rather, we use a convolutional neural network, trained on millions of realistic Euclid images, to determine the smallest mass subhalo that could reliably be detected in a Euclid image. This then fixes a range of subhalo masses in which different dark matter models can be tested. We create multiple datasets drawn from different mass functions and, from the output of the trained network, find the range of mass functions which could reliably be distinguished from CDM in a complete Euclid dataset.

Slides: in PDF
Video: https://youtu.be/NJr76kTCbws

Keywords: Euclid, dark matter, substructure, mass function, CNNs, CDM

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