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Measuring individal dark matter halos in strong lenses with truncated marginal neural ratio estimation

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Strong lensing is a unique gravitational probe of low-mass dark matter (DM) halos, whose characteristics are connected to the unknown fundamental properties of DM. However, measuring the properties of individual halos in lensing observations with likelihood-based techniques is extremely difficult since it requires marginalizing over the numerous parameters describing configuration of the lens, source and low-mass halo population. In this talk I introduce an approach that addresses this challenge using a form of simulation-based inference called truncated marginal neural ratio estimation (TMNRE). TMNRE enables marginal posterior inference for the properties of an individual subhalo directly from a lensing image using a neural network, trained on data tailored to the image over a series of rounds. Using high-resolution mock observations generated with parametric lens and source models, I first show that TMNRE can infer a subhalo's properties in scenarios where likelihood-based methods are applicable. I then show that TMNRE makes it possible to extend this analysis to further marginalize over the properties of a population of low-mass halos, where likelihood-based methods are intractable. This paves the way towards robust marginal inference of individual subhalos in real lensing images, and compliments efforts to directly measure the DM halo mass function from images.

Auteurs principaux: COOGAN, Adam (Université de Montréal and Mila); ANAU MONTEL, Noemi (GRAPPA Institute (University of Amsterdam)); CORREA, Camila; KARCHEV, Konstantin (SISSA / GRAPPA); WENIGER, Christoph (University of Amsterdam)

Orateur: COOGAN, Adam (Université de Montréal and Mila)

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