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Automated Lens Parameter Estimation using Simulation-Based Inference Methods

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We present ongoing work to automate and accelerate parameter estimation of galaxy-galaxy lenses using simulation-based inference (SBI) and machine learning methods.

Current cosmological galaxy surveys, like the Dark Energy Survey (DES), are predicted to discover thousands of galaxy-scale strong lenses, while future surveys, like the Legacy Survey of Space and Time (LSST) will find hundreds of thousands. These large numbers will make strong lensing a highly competitive and complementary cosmic probe of dark energy and dark matter. Unfortunately, the traditional analysis of a single lens is highly computationally expensive, requiring up to a day of human-intensive work. To leverage the increased statistical power from these surveys, we will need highly automated lens analysis techniques.

We present an approach based on Simulation-Based Inference for lens parameter estimation of galaxy-galaxy lenses. In particular, we demonstrate the successful application of Sequential Neural Density Estimators (SNPE) to efficiently infer a 5-parameter lens mass model. We compare our SBI constraints to a Bayesian Neural Network (BNN) and find that it outperforms the BNN, often producing posteriors distributions that are both more accurate and more precise, in some cases predicting constraints on lens parameters that are several times smaller than that from the BNN. Being able to accurately estimate the lens parameters of a large sample of lenses will enable us to study the dark matter distribution across populations of lenses, as well as potentially constrain dark energy models.

Primary author: POH, Jason (University of Chicago)

Co-authors: SAMUDRE, Ashwin (EMBL Heidelberg);   CIPRIJANOVIC, Aleksandra (Fermi National Accelerator Laboratory);   NORD, Brian (Fermilab);   FRIEMAN, Joshua (Fermilab);   KHULLAR, Gourav (University of Chicago)

Presenter: POH, Jason (University of Chicago)

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