Introduction

Strong Gravitational Lensing are well-established observational probes of Dark Matter and Dark Energy.

- Future surveys (e.g., LSST) are predicted to discover potentially hundreds of thousands of new lenses. Conventional modeling techniques cannot scale to this volume of data. This necessitates the development of automated lens modeling techniques.
- Lens Modeling - reconstructing the observed lensed image by simultaneously modeling the source light in the source plane and the lens mass in the lens plane.
- We leverage SBI methods to recover lens parameter posteriors from simulated ground-based imaging data in an amortized way.

Dataset

We simulate ground-based galaxy-galaxy lenses using Deeplenstronomy (Morgan et al. 2021). Lenses are approximated by a singular isothermal ellipsoid (SIE) lens model and an Sersic source light profile. We add external shear to emulate the effect of environmental masses.

- 12 Parameters in total.
- Images emulate Dark Energy Survey (DES) observing conditions (image pixel scale, sky brightness, atmospheric blurring, CCD noise).
- Training set: 800,000 galaxy-galaxy Strong Lensing system. DES-like single band images with lens light subtracted. Image size = 32x32 pixels
- Wide uniform priors to encompass large parameter range

Experimental Details

NPE: Masked Autoregressive Flow (MAF; 400 hidden units, 20 transformations and 48 output features). We used an embedding network to learn summary statistics and use it as input for NPE (6 convolutional layers and 1 fully connected layer)

BNN: VGG-like network. Evidence Lower Bound (ELBO) loss (negative log-likelihood loss and the Kullback-Leibler divergence). AdaDelta optimizer with an initial learning rate of 0.1. Trained for 550 epochs.

Results

1. Uncertainty Calibration: Posterior Coverage Plots for NPE (left) and BNN (right) for the regular test set.

2. Ensemble Statistics of the Best-fit Values

Conclusions

- Both NPE and BNN methods are several orders of magnitude faster than conventional MCMC analysis.
- For the same training set and computational costs, NPE performs better than BNN.
- BNN might be improved with post-hoc calibration techniques.
- Future analysis on real DES lens candidates.