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Population-level Dark Energy Constraints from Strong Gravitational Lensing using Simulation-Based Inference

In this work, we present a scalable approach for inferring the dark energy equation-of-state parameter (w) from a population of strong gravitational lens images using Simulation-Based Inference (SBI). Strong gravitational lensing offers crucial insights into cosmology, but traditional Monte Carlo methods for cosmological inference are computationally prohibitive and inadequate for processing the thousands of lenses anticipated from future cosmic surveys. New tools for inference, such as SBI using Neural Ratio Estimation (NRE), address this challenge effectively. By training a machine learning model on simulated data of strong lenses, we can learn the likelihood-to-evidence ratio for robust inference. Our scalable approach enables more constrained population-level inference of w compared to individual lens analysis, constraining w to within 1σ. Our model can be used to provide cosmological constraints from forthcoming strong lens surveys, such as the 4MOST Strong Lensing Spectroscopic Legacy Survey (4SLSLS), which is expected to observe 10,000 strong lenses.

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