Contribution ID: **16** Type: **not specified**

KiDS-SBI: Simulation-Based Inference Analysis of KiDS-1000 Cosmic Shear

Monday 13 May 2024 11:20 (20 minutes)

Cosmic shear, the weak gravitational lensing effect on distant galaxies due to matter in the foreground, is a powerful tool to study the distribution of matter, to probe its large-scale structure, and infer the cosmological model of the Universe. Standard analyses are typically based on the assumption of a Gaussian likelihood with a parameter-independent covariance, but these assumptions may not hold for all observables, scales and/or all systematics. Simulation-based inference (SBI) addresses this by evaluating an effective likelihood from forward-simulations which map parameters to data vectors. To this end, I will present a novel application of SBI to a cosmic shear analysis of the Kilo-Degree Survey's KiDS-1000 data release. The forward model is based on lognormal random fields which take into consideration systematics which are typically not modelled in standard inference, such as variable depth, point-spread function variations, shear biases, etc. I will also describe how the simulated galaxy catalogues are compressed to shear-shear angular two-point statistics which are further compressed using score compression. I will show how we train a 12-dimensional neural likelihood estimation to obtain a converged and unbiased posterior of the cosmological parameters within LambdaCDM. We achieve this with only 10,000 model evaluations which run in a time comparable to a standard MCMC. We find that our constraints on the weak lensing parameter, S8, are similar to constraints from previous analyses of KiDS-1000. We note a non-negligible parameter-dependence in the learnt likelihood which is consistent with cosmic variance. At the same time, we find that systematics such as variable depth can have significant impacts on the posterior estimates. Lastly, I will highlight how these findings and SBI will help address the modelling/inference challenges facing upcoming stage IV galaxy surveys.

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