

Cosmology with galaxy surveys: from cosmic shear to 6x2pt

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Abstract: In 2000, cosmic shear, namely the gravitational lensing effect generated by the large-scale structure, was first measured by photometric galaxy surveys. Since then, it has been playing an increasingly important role in modern cosmology, providing tight constraints on the matter density parameter (Ω_m) and fluctuation amplitude parameter (S_8). With the improvement in image quality, sky coverage, and survey depth, tensions have emerged between the S_8 constraints from galaxy surveys and the CMB survey by the Planck satellite. Combined analysis of cosmic shear, galaxy-galaxy lensing, and galaxy clustering from recent "Stage-III" surveys (KiDS, DES, and HSC), namely the 3x2pt, has confirmed this tension to a significance of $\sim 3\sigma$.

The final cosmic shear results from the Kilo-Degree Survey (KiDS), however, show consistency with Planck (0.73σ), driven largely by improved redshift calibration. This highlights the critical role of redshift calibration in future surveys. To further improve precision, a 6×2 pt analysis has been proposed, combining correlations among galaxy positions and shapes from photometric surveys and galaxy positions from spectroscopic surveys. This approach strengthens cosmological constraints while mitigating redshift uncertainties through self-calibration. A key challenge for 6×2 pt analyses is the variable depth of photometric galaxy samples, caused by non-uniform selection effects. It introduces an additional correlation signal and bias in parameter constraints. By applying an unsupervised machine learning method, we can obtain "organized randoms" that can account for the selection effects.

In this talk, I will review the current status of cosmology with galaxy surveys, with an emphasis on cosmic shear and 6×2 pt analyses using KiDS-Legacy data. These efforts set the stage for upcoming Stage-IV surveys and promise to sharpen our understanding of the Universe.