Cosmological parameter estimation with weak gravitational lensing

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Abstract
The European Space Agency's (ESA) *Euclid* satellite, launched on July 1st 2023, aims to shed light on the nature of the dark universe by studying dark matter and dark energy. A key probe to achieve the goals of Euclid is *weak gravitational lensing*, which occurs when the gravity from massive structures bend the paths of photons, causing distortion in the images of galaxies. On large scales these distortions are described by *cosmic shear*, which is used to study dark matter and dark energy, done by constraining cosmological parameters such as Ω_m (matter density), Ω_Λ (dark energy density), and σ_8 (clustering amplitude).

Since cosmic shear arises from the gravitational influence of cosmic structures, it's very sensitive to both the amount of matter and how it is clustered. Cosmic shear's dependence on the redshifts of the source galaxies also makes it a useful tool in the study of dark energy.

Commonly, cosmic shear information is captured by its two-point correlation functions $\xi_\pm$. However, the cosmic shear signal contains both the true cosmological signal (E-modes) and contaminants (B-modes) from e.g. systematic effects. For cosmological analysis, it's important to separate the true signal from contaminants, which is done with *Complete Orthogonal Sets of E- and B-mode Integrals* (COSEBIs) to cleanly separate E- and B-modes while preserving the full cosmological information contained in $\xi_\pm$. Thus, COSEBIs provide an efficient method of estimating cosmological parameters from weak lensing observables.

This work of simple cosmological parameter estimation uses data from a single simulation, developed by *Marenostrum Institut de Ciencies de l'Espai* (MICE). The methods for cosmological parameter estimation include the use of Bayesian statistics, maximum likelihood estimation and Markov Chain Monte Carlo (MCMC) sampling. These methods are applied by utilizing *Cosmosis* to calculate the model predictions of E-modes given a set of model cosmological parameter values, and then comparing them to the data E-modes, and outputting the parameter estimation results.

The results suggest that COSEBIs accurately estimate cosmological parameters and efficiently constrain the matter-energy content of the Universe. Therefore COSEBIs remain a powerful tool for studying of dark matter, dark energy, and the Universe's evolution and should be used in analyzing the abundant, high-quality weak lensing data the Euclid satellite will provide in the coming years.