KiDS-1000: A GRAVITATIONAL LENSING DATA SET

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KiDS-1000

The Kilo-Degree Survey (KiDS) is a multi-band optical imaging survey conducted with the 2.6m VLT Survey Telescope. KiDS measures the distortions, or 'shear', induced in galaxy shapes from *weak gravitational lensing*. The shear signal is used to place constraints on cosmological parameters: the mass energy density of the Universe Ω_m, and the amplitude of matter's clustering, σ_8.

The latest data release, KiDS-1000, consists of shear and redshift estimates for 21 million galaxies, spanning 1006 square degrees on the sky (see Fig. 1). In this work, we verify the robustness of the shear and redshift measurements in KiDS-1000, concluding that this data set is ready for scientific analysis.

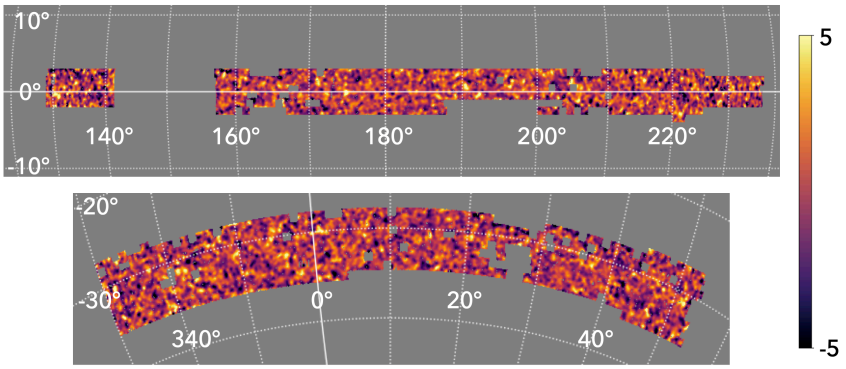

Fig. 1: Maps of the projected density of the Universe from the northern and southern fields of the KiDS-1000 footprint, as a function of (RA,Dec) and expressed in units of signal-to-noise.

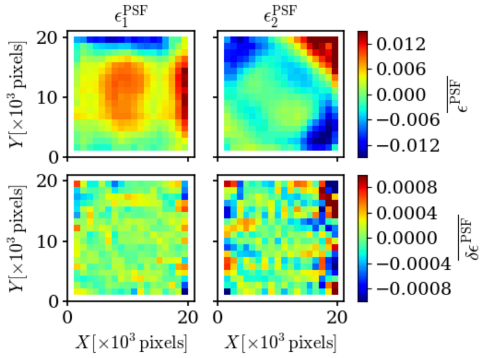

Fig. 2: The PSF distortions induced in galaxy shapes are summarised by two ellipticity components (left/right panels). Upper: the PSF pattern across the pixels in our camera. Lower: the residual after subtracting our model.

PSF Modelling

To robustly estimate shear from galaxy shapes, one must accurately model and remove the atmospheric and instrumental distortions summarised by the point-spread function (PSF; Fig. 2). We test multiple prescriptions for the impact of imperfect PSF modelling on our estimation of the cosmological clustering parameter $S_8=\sigma_8(\Omega_m/0.3)^{0.5}$. We find that the induced bias in S_8 is smaller than 0.1σ for all of the following potential PSF systematics:

- Imperfect modelling of the PSF shape and size (green line; Fig. 3)
- Instrumental defects in our camera (pink line).
- Imperfectly removing the PSF distortions from our images (orange line).

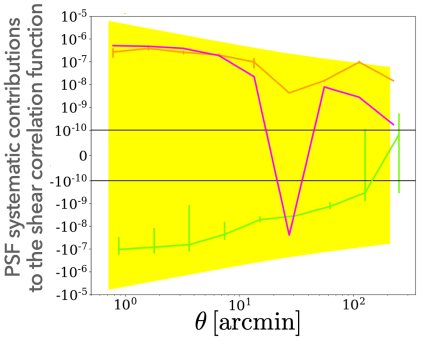

Fig. 3: The PSF systematic contributions to the angular shear correlation function – a measure of how correlated galaxy shapes are as a function of their angular separation – from imperfect PSF modelling (green), residual PSF contamination (orange) to instrumental defects (magenta). The yellow band depicts the maximum allowed amplitude of these biases tolerated by our analysis to constrain cosmological parameters.

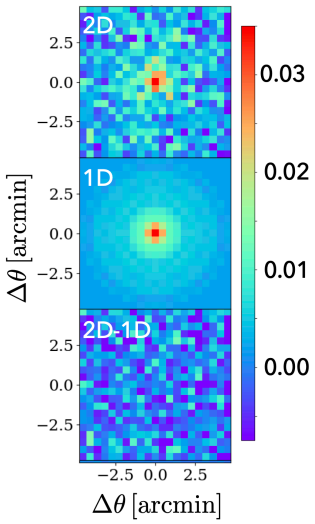

Fig. 4: The stacked KiDS-1000 tangential shear measured around the positions of foreground galaxies. The upper/middle panels show the 2D (cartesian)/1D (angular) signals respectively. The featureless residuals (lower) are a sign that no prominent additive systematic affects our shear measurement.

Galaxy-Galaxy Lensing Systematic Tests

The lensing of background galaxies by those in the foreground (known as galaxy-galaxy lensing) is measured via the tangential shear, γ_t, and is used to test the accuracy of our shear and galaxy redshift estimates. We compare the 2D (cartesian) and 1D (angular) tangential shear signals to eliminate the possibility of an additive bias in the shear (Fig. 4). We further verify the redshift distributions of our background galaxies with a comparison of the data signal to a theoretical prediction (Fig. 5).

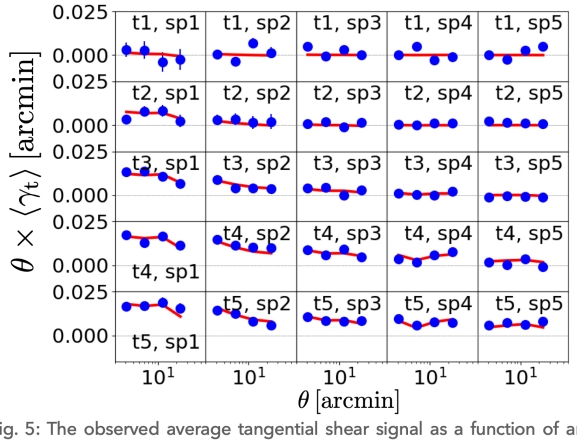

Fig. 5: The observed average tangential shear signal as a function of angular galaxy separation (blue points) binned by the redshifts of the background (t1-5) and foreground (s1-5) galaxies. The consistency of the measurement with the theoretical prediction (red lines) verifies the galaxy redshift estimation.

Conclusions

KiDS-1000 is a catalogue of weak gravitational lensing shears and galaxy redshifts derived from the imaging of the Kilo-Degree Survey. We have found that the low-level biases from PSF modelling have negligible impact on our cosmological constraints. The shear and redshift measurements are further validated with examination of the galaxy-galaxy lensing signal. We conclude that KiDS-1000 is robust and ready to be used in weak lensing analyses to measure the properties of our Universe.

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Please get in touch if you would like to use KiDS-1000.