Galaxy-galaxy lensing in the FORS Deep Field

Stella Seitz[1], Thomas Erben[2], Ralf Bender[1], and FDF-Team[3]

[1] Munich University Observatory (USM), Scheinerstr. 1, 81679 München
[2] Institut f. Astrophysik und Extraterrestrische Forschung, Bonn
[3] Landessternwarte Heidelberg, Universitätssternwarte Göttingen, Universitätssternwarte München

Abstract. We demonstrate the presence of a galaxy-galaxy lensing signal of $z = 0.5 - 1.0$ foreground galaxies by analyzing the distortion of $z = 2.5 - 4.5$ background galaxies in the FORS Deep Field. The signal decreases when fainter foreground galaxies are considered in agreement with expectations. Also, the lensing signal of the faintest foreground sample agrees with that found in the HDF by [5] for $z < 0.85$ foreground galaxies with $< z >= 0.6$.

1 Introduction and earlier results

Galaxy-galaxy lensing is a powerful tool to determine the halo-parameters (mass, size and flattening) of field and cluster galaxies [3]. However, with unknown individual galaxy distances, a large number of foreground-background pairs (and thus a large area) is necessary to constrain the halo parameters (eg., compare [2] to [5]). For the investigation of medium redshift galaxy-halos – where the data have to be deep to obtain reliable shapes and measure the distortions for the background galaxies, and therefore fields are still small – the photometric redshift technique is most appropriate for selecting foreground objects (irrespective of their SED and morphology) and background objects. Hudson et al. ([8]) have demonstrated this for the HDFN-data, they have constrained the size and rotational-velocity of L_*-galaxies at redshift $z \approx 0.6$ and compared that to the Tully-Fisher relation at the same redshift. The fairly large error bars are caused by the small field size of the HDF-N, which yields only about 700 galaxies with shape an phot-z measurements, (208 of them are forgreound with $z < 0.85$ and $< z > \approx 0.6$.)

2 Galaxy-galaxy lensing in the FORS Deep Field

The FORS-team (*FDF is a common project of the Landessternwarte Heidelberg and the University Observatories in Göttingen and Munich*) has carried out deep imaging in the U-, B-, g-, R- and I-broad-band and z-narrow-band filters using FORS1&2 at the VLT and in the J- and K'-filters using SOFI at NTT. The Data are shallower than the HDF's but exceed their area by a factor of 8, which is essential for the measurement of the galaxy-galaxy lensing signal on larger scales where the halo size of field galaxies can possibly be measured. For details concerning filters, field position, integration times, FWHM and depth of the

FDF data see [6]. The data-reduction, including correction of the field distortion of FORS, are described in more detail in [7] Object detection was performed with SExtractor, and about 7000 objects were detected in the I-band image with 6.8h total integration time and a coadded seeing of about $< .55''$. The colors of these objects were used for photometric redshifts estimates similar as described in [1]. The photometric redshifts proved to be accurate to an rms of $[z_{spec} - z_{phot}]/(1 + z_{spec}) < 0.05$ as a comparison to the roughly 300 sepctra obtained in this field up to now shows.

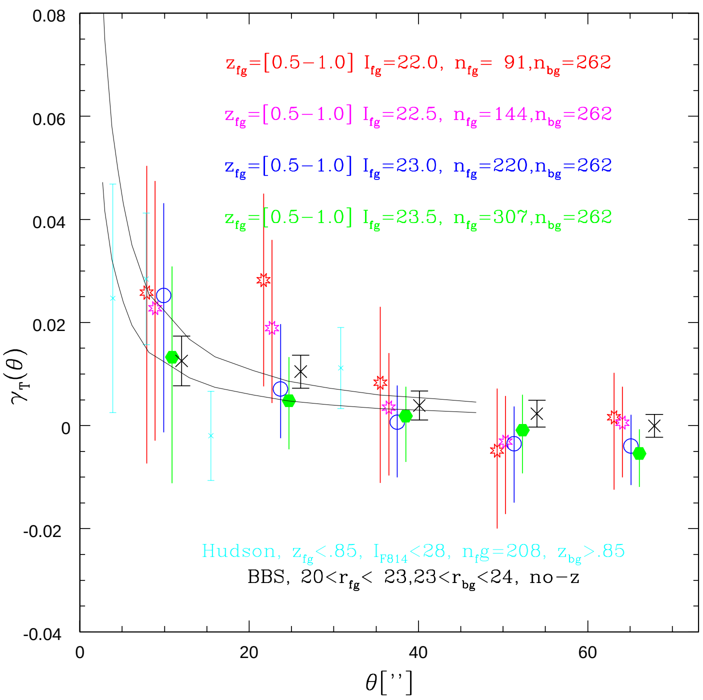

Fig. 1. Tangential shear of background galaxies with $z = 2.5{-}4.5$ relative to foreground galaxies at $z = 0.5 - 1.0$ as a function of foreground-background separation. The faint-magnitude cut-off of the foreground galaxies is increased from $I = 22$ to $I = 23.5$. (these data points are shifted by 1 arcsecond horizontally for clarity). We have obtained our errorbars from bootstrapping of the background galaxies. The number of background and foreground objects in indicated by n_{fg} and n_{bg}, respectively. For comparison we also add the tangential shear of '$r = 23 - 24$ background' galaxies relative to $r < 23$, more local foreground galaxies obtained by BBS (black data points). The results from Hudson et al in the HDFN are shwon as cyan data points.

Shape analysis, PSF-smearing and anisotropy correction of the background objects were carried out on the I-band image with the seeing of about $< 0.55''$

using the IMCAT software (and modifications) analogously to [4]. Then the photometric redshift catalog (containing roughly 7000 objects) and the shape catalog were merged. Stars were excluded conservatively using half-light radius, stellar classification and comparison to stellar SED-templates.

For this proceedings we discuss only the tangential shear signal in the FDF caused by galaxies with $z = 0.5 - 1.0$ and different apparent brightness limits in the I-band. As background galaxies we define all galaxies with $z = 2.5 - 4.5$ with sufficient S/N to allow shape determination. The number of galaxies in every foreground sample and in the background sample can be seen in the Figure. The tangential shear of the background galaxies follows the expected functional form (roughly $\propto 1/\theta$). The signal is largest for foreground galaxies with $I < 22$ and decreases down to $I < 23.5$ when less luminous and thus less massive galaxies enter the foreground sample.

We have included the data points of Hudson et al.[8] in the Figure (cyan color). Their foreground sample is similar to ours with $I < 23.5$.

The tangential shear of isothermal spheres at $z \approx 0.5$ with rotational velocities of 210km/s (which fits the Hudson data best) and one with 380 km/s are shown as solid lines to guide the eye. We conclude that the rotational velocity $v \propto \sqrt{\gamma_T}$ of the halos of the brightest subsample is about 1.8 higher than that of the faintest sample. This is in excellent agreement with the upper limit of 2 obtained from the magnitude difference and the Tully-Fisher/Faber-Jackson relation.

A maximimum-likelihood analyis of the galaxy-galaxy-lensing signal in the FDF that of will be presented in the near future.

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