The Very Small Scale Clustering of SDSS-II and SDSS-III Galaxies

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Measuring $\omega(\theta)$ on Sloan Digital Sky Survey Galaxies

We measure the angular correlation in four volume-limited galaxy samples with absolute r-band magnitude thresholds of $M_r < -18$, $-19$, $-20$, $-21$, from the SDSS. Using the angular correlation function, we free us from the SDSS fiber collision limit, a technical aspect of the survey that causes incompleteness in the galaxy sample for angular separations less than 55". A power law fit was done for $0.002^\circ < \theta < 0.1^\circ$ using jackknife errors.

Fig. 1 (Left): The angular correlation function for the 4 volume limited SDSS samples with jackknife errors. Power law fits are in grey. The slope of the best fit is labeled.

Fig. 2. (Above): The probability density functions of the slope for different luminosities. The brightest sample (purple) is significantly steeper.

Fitting For The Halo-Galaxy Connection

The very small clustering of galaxies depends strongly on the number of satellites in a single halo. To quantify the relationship between host halos and satellite galaxies, we produce mock catalogues of galaxies using the Halo Occupation Distribution (HOD: Berlind & Weinberg 2002). Using the Zheng et al. 2007 parameterization, we vary the probability that halo of a given mass will host a satellite galaxy, as well as the spatial distribution of these galaxies within the halo. By comparing the parameter estimation of different galaxy classes, we can investigate how the spatial distribution of galaxies depends on luminosity.

Fig. 5 (Above): How the GNPW density profile parameter gamma depends on luminosity. A higher value of $\gamma$ corresponds to a steeper density profile. The two brighter samples differ from NFW with more than 99.7% confidence. The extent of the whiskers is the 99.7% CI.

Fig. 6 (Left): The joint probability distribution of HOD parameters for all four luminosity samples. Each parameter controls how galaxies are added to a halo.

Abstract

The very small scale clustering of galaxies can tell us about their spatial distribution within dark matter halos. To study the local universe, we measure the very small-scale angular clustering of galaxies in volume-limited luminosity samples drawn from the SDSS DR7. These angular scales correspond to 20 to 500 kpc at the median redshift of the Mr < -20 galaxy sample. We model this clustering using mock galaxy catalogues produced from the LasDamas simulations and the Halo Occupation Distribution (HOD) framework, assuming a flexible density profile of satellite galaxies within halos. We find that luminous galaxies have a steeper correlation function, and are thus more centrally concentrated in halos than the underlying dark matter. Lower luminosity galaxies, however, have a density profile that is consistent with that of dark matter. In order to see if this trend continues to higher redshift, we also measure the projected correlation function of SDSS-III BOSS CMASS galaxies on similar scales.

The Spatial Distribution of Galaxies:

How well do galaxies trace the dark matter distribution?

Not well! Figure 3 (below) shows the angular correlation function for the SDSS $M_r < -20$ sample compared to mock galaxy catalogues using a standard Navarro, Frenk and White density profile. The grey lines are $\omega(\theta)$ for each NFW mock. The upper axis describes the physical separation of the galaxies as if they were all located at the median redshift. The SDSS fiber collision limit of 55" is shown in the magenta line.

What Next? From this, we are motivated to introduce a Generalized NFW (GNFW) profile, with two additional parameters. The $f_g$ parameter (Eq. 1) allows galaxies to have a different concentration than the dark matter. The parameter $\gamma$ (Eq. 2) allows the inner slope of the density profile to be adjusted. A value of $\gamma = 1$ recovers the NFW profile of dark matter.

Measuring Clustering on BOSS CMASS Galaxies:

Is there Evolution in the Very Small Scale Clustering?

Next, we investigate whether there is an evolution in the density profile of one class of galaxy. We measure the projected correlation function, $w_p(r_p)$ for four different redshift bins. Figure 7 hints at a redshift evolution in CMASS galaxy clustering. We see a steepening in $w_p(r_p)$ towards lower redshift bins. It is possible that satellites which have not undergone enough dynamical times to be destroyed by the lowest z bin have not undergone enough dynamical times to be destroyed by the lowest z bin.

Fig. 7 (Right): The projected correlation function $w_p(r_p)$ of SDSS-III BOSS CMASS galaxies in four different redshift bins. Each measurement is done using a cross-correlation of imaging and spectroscopic galaxies. The errors are 140 jackknife resamplings of the data. The dotted line notes the scale of fiber collisions at the inner edge of each redshift bin.

Fig. 9: Evolution of the amplitude of the projected correlation function in four different redshift bins.