THE SMALL-SCALE PROJECTED CORRELATION FUNCTION FOR LRGs

ABSTRACT

1. INTRODUCTION

Galaxy clustering allows us to study the relation of galaxies to dark matter through the biased clustering of dark matter halos.(need reference)

massive galaxies are particularly interesting to study via clustering analyses because they tend to reside in massive dark matter halos (Sandage 1972; Hoessel et al. 1980; Schneider et al. 1983; Postman & Lauer 1995).

on large-scales two point correlation function is found to be very close to a power low(reference). this is expected as clustering of galaxies on large scales is expected to be the result of self-similar gravitational instabilities of small initial density fluctuations.

in contrast on sufficiently small-scales, one expects a variety of more complex processes to modify the galaxy clustering and thus presumably give rise to features in $\xi(r)$. Possibilities include dynamical friction, galaxy merger, tidal interactions and etc. (do i need reference for this?).

Gott & Turner(1979) measure the angular correlation function for angular separation that for the median redshift of their sample translates to scales of 10 to 100 kpc. their result suggests that the $\xi(r)$ power low extends down to scales of $\sim$ 10kpc. Thus they conclude that no process has changed the simple form of $\xi(r)$.

maller et al. (2005) measures the angular correlation function for 2MASS survey. for there median redshift they measure the angular correlation down to few kpc and find the same result, the power low continues to small-scales.

i guess i should add something about the halo model and how by merssuering the clutering at very small scales we are probing the dark matter halo profiles.

massive galaxies are particularly interesting to study via clustering analyses because they tend to reside in massive dark matter halos (Sandage 1972; Hoessel et al. 1980; Schneider et al. 1983; Postman & Lauer 1995). In addition massive galaxies are roughly passively evolving at low resdhifts(reference), so we should be able to interpret the redshift evolution of the clustering.

i dont know what else to say about clustering from here on it's about merger.

merger is a fundamental mode of stellar mass addition to galaxies. merger brings in new gas and creates gravitational disturbances that enhance star formation. gravitational forces on relatively large scales dominate merger dynamics which allows direct observations of the mechanism.

number of kinematic pairs is proportional to the volume integral at small scales or the two-point correlation function, ξ. so by measuring ξ we can calculate the merger rate.

why lrgs: well defined sample with a huge volume, so a higher pair count on small scales. highly clustered, candidates for dry mergers.

2. DATA

The SDSS (York et al. 2000; Stoughton et al. 2002; Abazajian et al. 2003; Abazajian et al. 2004) is conducting an imaging survey of 10^4 square degrees in 5 bandpasses u, g, r, i, and z (Fukugita et al. 1996; Gunn et al. 1998). Photometric monitoring (Hogg et al. 2001), image processing (Lupton et al. 2001; Stoughton et al. 2002; Pier et al. 2003), and good photometric calibration (Smith et al. 2002) allow one to select galaxies (Strauss et al. 2002; Eisenstein et al. 2001), quasars (Richards et al. 2002), and stars for follow-up spectroscopy with twin fiber-fed double-spectrographs. The spectra cover 3800Å to 9200Å with a resolution of 1800. Targets are assigned to plug plates with a tiling algorithm that ensures nearly complete samples (Blanton et al. 2003).

We focus here on the luminous red galaxy spectroscopic sample (Eisenstein et al. 2001). This uses color-magnitude cuts in g, r, and i to select galaxies that are likely to be luminous early-type galaxies at redshifts between 0.15 and 0.5. The selection is highly efficient and the redshift success rate is excellent. The sample is constructed so as to be close to volume-limited up to $z = 0.36$, with a dropoff in density towards $z = 0.5$. The comoving number density of the sample is close to that required to maximize the signal-to-noise ratio on the large-scale power spectrum.

The sample we use here is drawn from NYU LSS `sample14` (Blanton et al. 2004) and covers 3,836 square degrees containing 55,000 LRGs between redshift of 0.16 and 0.47. The subsample of LRGs used in this paper has an absolute g-band magnitude range of $-23.2 < \mathrm{M_g} < -21.2$, including k-corrections and passive evolution to $z = 0.3$ and redshift range of

$0.16 < z < 0.36$. This subsample is chosen to maximize our use of the LRG spectroscopy for the volume-limited portion of the sample. this subsample is the same as the first subsample used in Zehavi et al. (2004). The details of the radial and angular selection functions are described in Zehavi et al. (2004). The radial modeling of the expected number of galaxies as a function of redshift is based closely on the observed distribution.

We create large catalogs of randomly distributed points based on these angular and radial models. These catalogs match the distribution of the LRGs in redshift and are isotropic within the survey region. These catalogs allow us to check the survey completeness of any given volume and provide a homogeneous baseline (e.g., expected numbers) for the tests that follow.

3. METHOD & RESULTS

3.1. Projected Correlation Function

To calculate the real space correlation function, customary one estimates the correlation function on a two dimentional grid of pair seperations parallel (π) and perpendecular (r_p) to the line of sight, termed $\xi(r_p, \pi)$. This can be turned in to projected correlation function

$$w_p(r_p) = 2 \int_0^\infty d\pi \xi(r_p, \pi). \tag{1}$$

Using this method Zehavi et al.(2004) calculates $w_p(r_p)$ for LRG sample in the range $0.5h^{-1}\text{Mpc} \lesssim r_p \lesssim 30\text{Mpc}$.

LRGs in Slone can fail to receive a spectra if they fall within $55''$, "fiber collision radius", of another target. This limits the uses of euation 1 to r_p larger than $\sim 0.3h{-}1\text{Mpc}$ the equvalence of $55''$ angular separation for the redshift of LRG sample.

We overcome the fiber collision problem by cross correlating the spectroscopic sample with imaging sample. To do this we use above explained subsample of LRGs as our spectroscopic sample (data spectroscopy, D_s), and all LRG targets as our imaging sample regardless of the fact that they did receive a spectra or not(data imaging,D_i). For each LRG from the spectroscopic sample, we treat the nearby imaging LRGs (whether they have spectrum or not) as if they are at the same redshift as the spectroscopic. This allows us to calculated a g-band absolute magnitude (M_g) for them in the same manner as LRGs with spectra and chose the ones which make it to the sample limits (e.g., $-23.2 < \text{M}_\text{g} < -21.2$). This will turn our cross-correlation into an auto-correlation. In addition, Assuming this given redshift we can bin the pairs chosen, according to their comoving projected separation.

This method depends soully on the fact that correlation function becomes much larger than unity as one probes scales smaller than few Mpc. On these scales about half of the apparent close pairs (close pairs in angular seperation) are actuall close pairs (kinematic close pairs). Using this we make random spectroscopic sample $(R - s)$ with the same redshift distribution as LRG spectroscopic sample and cross-correlation this sample with the imaging LRG sample we can statisticly calculate substract the interlopers from our data-data correlation.

Using this method we calculate $w_p(r_p)$:

$$n * w_p(r_p) = \frac{\mathrm{D_sD_i}}{\mathrm{D_sR_i}} - \frac{\mathrm{R_sD_i}}{\mathrm{R_sR_i}}$$

where n is the average comoving density for the spectroscopic sample. $\mathrm{R_s}$ and $\mathrm{R_i}$ are the random spectroscopic and random imaging samples. The first term is the usual estimator, and the second term deals with the interlopers. In details :

$$\mathrm{D_sD_i} = \frac{\sum\limits_{i \in D_s D_i \mathrm{pairs}} p_i}{\sum\limits_{i \in D_s} p_i} \quad ,$$

where p_i refers to the wight given to each spectroscopic galaxy i, which is the number of the objects in the collision group it belongs to over the number of object in that collision group that got spectrum.

$$\mathrm{D_sR_i} = \frac{\sum\limits_{i \in D_s R_i \mathrm{pairs}} p_i}{\sum\limits_{i \in D_s} p_i \left(\frac{\mathrm{d}\Omega}{\mathrm{d}A}\right)_i \frac{\mathrm{d}N}{\mathrm{d}\Omega}} \quad ,$$

where $\left(\frac{\mathrm{d}\Omega}{\mathrm{d}A}\right)_i \frac{\mathrm{d}N}{\mathrm{d}\Omega}$ is the number density of the random imaging objects per unit comoving area around each spectroscopic galaxy.

$$\mathrm{R_sD_i} = \frac{\displaystyle\sum_{i\in R_s D_i \mathrm{pairs}} f_i}{\displaystyle\sum_{i\in \mathrm{R_s}} f_i} \quad ,$$

where f_i is the FGOT value for the random spectroscopic galaxy i.

$$\mathrm{R_sR_i} = \frac{\displaystyle\sum_{i\in R_s R_i \mathrm{pairs}} f_i}{\displaystyle\sum_{i\in R_s} f_i \left(\frac{\mathrm{d}\Omega}{\mathrm{d}A}\right)_i \frac{\mathrm{d}N}{\mathrm{d}\Omega}}$$

Figure 2 shows our result as well as the result from Zehavi et al. (2004) results, the agreement on the scales in common is remarkable.

In addition, we inspected all the pairs bellow 20 kpc and they are all real pairs, but there might be more pairs at these separations that are lost due to deblending issues, which means that the result at small scales is a lower limit to the ac tual correlation function.

3.2. Real-Space Correlation Function

It is possible to directly invert $w_p(r_p)$ to get $\xi(r)$. This is done by

$$\xi(r) = -\frac{1}{\pi}\int_r^\infty dr_p \frac{dw_p(r_p)}{dr_p}(r_p^2 - r^2)^{-1/2}$$

(e.g., Davis & Peebles 1983). We calculate this integral by interpolating $w_p(r_p)$, This estimate is only accurate to few percents level, due to the inaccuracy of the interpolation. Figure **??** shows the real-space correlation function, obtained in this pashion, combined with the results for $\xi(r)$ on other slaces from Zehavi et al.(2004) and Eisenstein et al.(2005).

4. MOCK

5. DISCUSSIONS

how we can constrain halo model: can we fit it with in the frame work of NFW or do we need to tweak that? basically the small-scale correlation is the convolution of the halo profile with itself.

how can we explain the result in terms of dynamical friction. can this result chose between very elongated orbits and circular ones.

is there a selection effect? could it be that galaxies become LRGs as they get very close to one another.

REFERENCES

Abazajian, K. et al. 2003, AJ, 126, 2081

Abazajian, K. et al. 2004, AJ, 128, 502

Blanton, M. R., Lin, H., Lupton, R. H., Maley, F. M., Young, N., Zehavi, I., & Loveday, J. 2003, AJ, 125, 2276

Blanton, M. R. et al. 2004, AJ, in press (astro-ph/0410166)

Eisenstein, D. J. et al. 2001, AJ, 122, 2267

Fukugita, M., Ichikawa, T., Gunn, J. E., Doi, M., Shimasaku, K., & Schneider, D. P. 1996, AJ, 111, 1748

Gunn, J. E., Carr, M. A., Rockosi, C. M., Sekiguchi, M., et al. 1998, AJ, 116, 3040

Hogg, D. W., Finkbeiner, D. P., Schlegel, D. J., & Gunn, J. E. 2001, AJ, 122, 2129

Lupton, R. H., Gunn, J. E., Ivezić, Z., Knapp, G. R., Kent, S., & Yasuda, N. 2001, in ASP Conf. Ser. 238: Astronomical Data Analysis Software and Systems X, Vol. 10, 269

Pier, J. R., Munn, J. A., Hindsley, R. B., Hennessy, G. S., Kent, S. M., Lupton, R. H., & Ivezić, Ž. 2003, AJ, 125, 1559

Richards, G. et al. 2002, AJ, 123, 2945

Smith, J. A., Tucker, D. L., et al. 2002, AJ, 123, 2121

Stoughton, C. et al. 2002, AJ, 123, 485

Strauss, M. A. et al. 2002, AJ, 124, 1810

York, D. et al. 2000, AJ, 120, 1579

Zehavi, I. et al. 2004, ApJ, submitted (astro-ph/0408569)

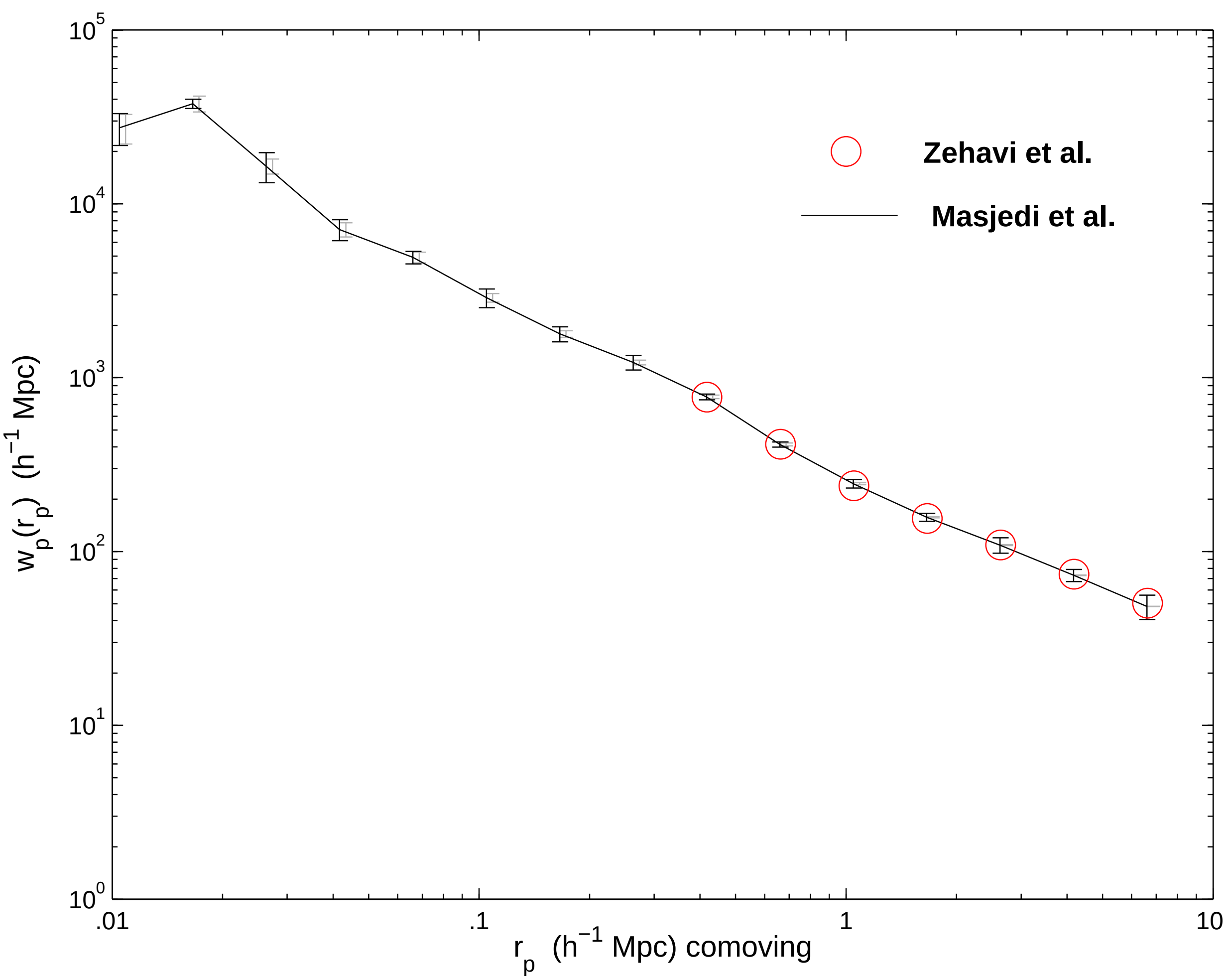

Fig. 1.— This is the projected correlation function $w_p(r_p)$ for the LRG sample ($-23.2 < M_g < -21.2$ & $0.16 < z < 0.36$) calculated as described in the text. The gray error-bars (on the right)are the Poisson error coming form the number of the pairs in each bin and The black error-bars (on the left) are coming form the scatter in the result after dividing the data into 4 disconnected chunks. The circles show result for the same sample from Zehavi et al.(2004)

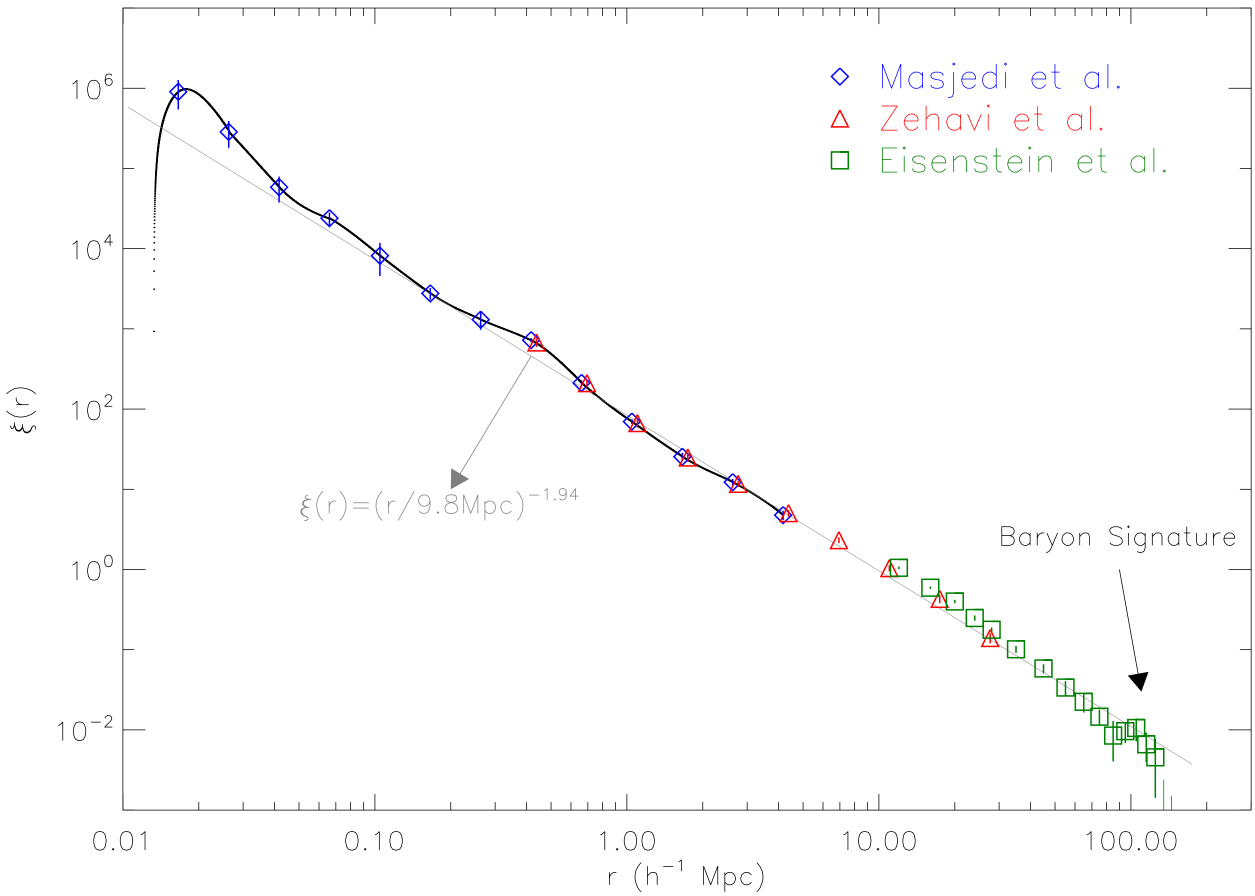

Fig. 2.— This is the real-sapce correlation function $\xi(r)$ for the LRG sample($-23.2 < \mathrm{M_g} < -21.2$ and $0.16 < z < 0.36$) calculated as described in the text on small scales, combined with results on larger scales from Zehavi et al. (2004) and Eisenstein et al. (2005).