The Zeldovich Universe:
Genesis and Growth of the Cosmic Web
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Galaxy and Mass Assembly (GAMA): galaxy pairwise velocity dispersion

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Abstract. We describe preliminary measurements of the pairwise velocity dispersion (PVD) of galaxies in the Galaxy and Mass Assembly (GAMA) survey as a function of projected separation and galaxy luminosity. Due to the faint magnitude limit ($r < 19.8$) and highly-complete spectroscopic sampling of the GAMA survey, we are able to measure the PVD to smaller scales and for lower-luminosity galaxies than previous SDSS-based work. We see no strong scale-dependence at most luminosities in the quasi-linear regime. We observe an apparent drop in PVD towards very small scales (below $\approx 0.1h^{-1}$ Mpc), but this could in part be due to a restriction of the streaming model employed. At intermediate scales, the PVD is highest (~ 500 km/s) at intermediate luminosities, dropping at both fainter and brighter luminosities.

Keywords. galaxies: kinematics and dynamics, galaxies: statistics

1. Introduction

The pairwise velocity dispersion of galaxies, PVD, or σ_{12}, is an important quantity for modeling the galaxy redshift space correlation function. It can be used to test predictions of galaxy formation and evolution models and of the cold dark matter paradigm in general. In addition, σ_{12} is a parameter that strongly affects cosmological parameter fits as it correlates with measurements of the growth rate of structure.

The Galaxy and Mass Assembly (GAMA) survey (Driver et al. 2011) is ideal for measuring the PVD due to (i) being two magnitudes fainter than the SDSS main galaxy sample, and (ii) having very high (> 98 per cent) spectroscopic completeness, even in high-density regions. In this contribution, we measure the PVD from the GAMA-II equatorial regions, covering a total area of 180 square degrees. Throughout, we assume a Hubble constant of $H_0 = 100h$ km s^{-1} Mpc^{-1} and an $\Omega_M = 0.3, \Omega_\Lambda = 0.7$ cosmology in calculating distances, co-moving volumes and luminosities.

2. Galaxy clustering measurements

Galaxy clustering is measured as a function of separation parallel ($r_\parallel$) and perpendicular ($r_\perp$) to the line of sight using the Landy & Szalay (1993) estimator,

$$\xi(r_\perp, r_\parallel) = \frac{DD - 2DR + RR}{RR}, \tag{2.1}$$

where DD, DR and RR are the normalised numbers of data-data, data-random and random-random pairs in a given $(r_\perp, r_\parallel)$ bin. The random catalogue is generated within the survey mask and with a radial distribution determined by replicating each galaxy a number of times within its observable redshift range while correcting for radial density fluctuations (Cole 2011; Loveday 2014). Two-dimensional correlation functions are shown for blue and red GAMA-II galaxies in Fig. 1

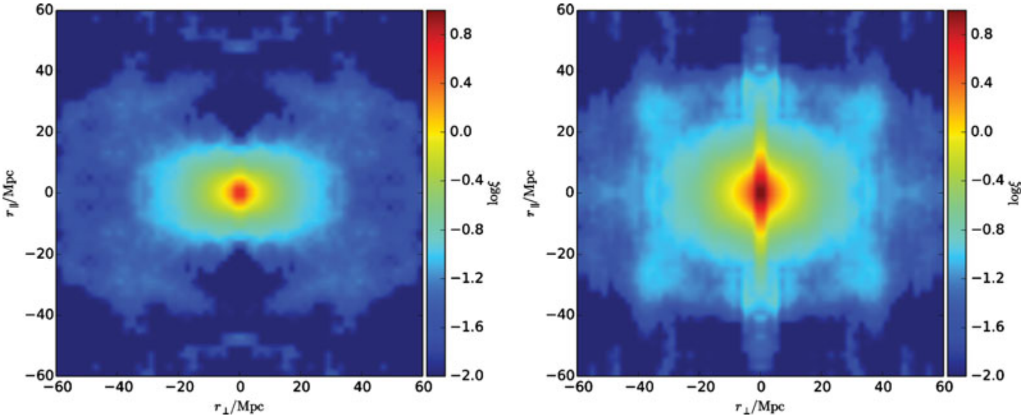

Figure 1. The two-dimensional correlation function $\xi(r_\perp, r_\parallel)$ for blue (left) and red (right) galaxies in GAMA-II. Elongation along the line of sight as small projected separations is clearly visible within the red galaxy sample. Large-scale infall is visible in both samples as a compression of the clustering signal along the line of sight (y-axis) at larger separations.

In the "streaming" model (Peebles 1980; Davis & Peebles 1983; Zehavi et al. 2002), the two-dimensional correlation function $\xi(r_\perp, r_\parallel)$ is given by a convolution of the isotropic real-space correlation function $\xi_r(r)$ with the pairwise velocity distribution $f(v)$:

$$1 + \xi(r_\perp, r_\parallel) = H_0 \int_{-\infty}^{\infty} \left[1 + \xi_r\left(\sqrt{r_\perp^2 + y^2}\right)\right] f(v) dy. \tag{2.2}$$

The pairwise velocity distribution is assumed to follow an exponential distribution

$$f(v) = \frac{1}{\sqrt{2}\sigma_{12}} \exp\left(-\frac{\sqrt{2}|v|}{\sigma_{12}}\right), \tag{2.3}$$

$$v \equiv H_0(r_\parallel - y) + \bar{v}_{12}(r), \tag{2.4}$$

where $\bar{v}_{12}(r)$ is the mean radial pairwise velocity at separation r; we use the expression given by Juszkiewicz et al. (1999, equation 6).

The real-space correlation function $\xi_r(r)$ may be estimated by first integrating $\xi(r_\perp, r_\parallel)$ along the line of sight direction $r_\parallel$ to obtain the projected correlation function

$$w_p(r_\perp) = 2 \int_0^{r_{\max}} \xi(r_\perp, r_\parallel) dr_\parallel, \tag{2.5}$$

and then performing the inversion

$$\xi(r) = -\frac{1}{\pi} \int_r^{r_{\max}} w_p(r_\perp)(r_\perp^2 - r^2)^{-1/2} dr_\perp. \tag{2.6}$$

This integral is evaluated by linearly interpolating between the binned $w_p(r_\perp)$ values (Saunders et al. 1992).

3. Results

In Fig. 2 we show the PVD σ_{12} as a function of projected separation in bins of absolute magnitude. The data from Li et al. (2006) provide only an approximate comparison with previous results, since Li *et al.* calculate σ_{12} as a function of the amplitude of the total

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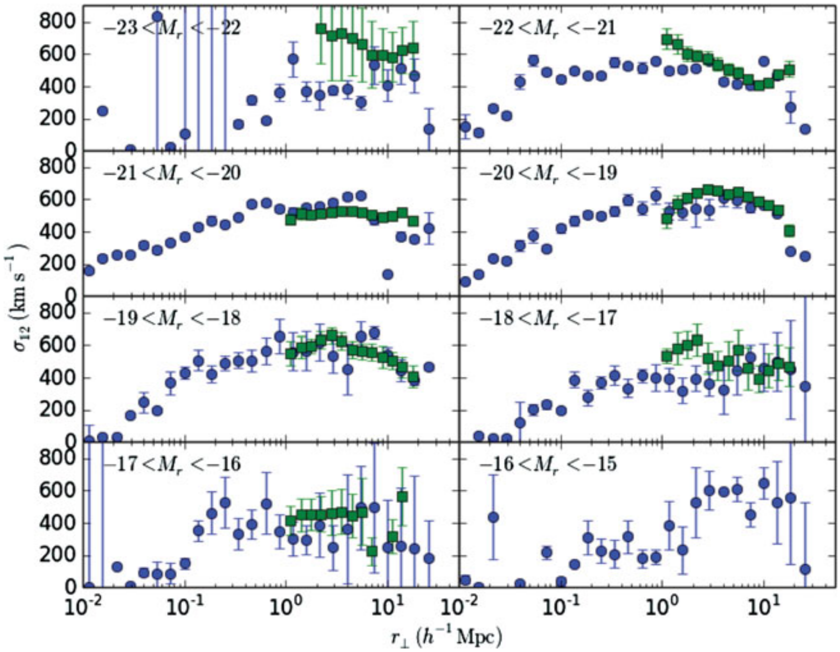

Figure 2. Pairwise velocity dispersion for GAMA-II (this work, blue circles) and SDSS (Li et al. 2006, green squares) as a function of projected separation $r_\perp$, in absolute magnitude bins is labeled.

wave-vector k rather than just the projected component. We assume when plotting their data points that $r_\perp = \sqrt{2}\pi/k$. Given the uncertainties, our results are broadly consistent with those of Li *et al.* where we overlap. Due to the high spectroscopic completeness of GAMA, we are able to estimate σ_{12} to much smaller scales, as small as 10 h^{-1} kpc, with reasonable random errors for most luminosity subsamples. However, we caution that the apparent strong decline of σ_{12} to the smallest scales may be due at least in part to a breakdown of the streaming model on extremely non-linear scales. We plan to test this issue in the near future using N-body simulations.

In Fig. 3 we show the PVD σ_{12} as a function of absolute magnitude in bins of projected separation. At intermediate scales, 0.1–3.0 h^{-1} Mpc, σ_{12} is highest (around 400–600 km s^{-1}) at intermediate luminosities, $-22 \lesssim M_r \lesssim -18$ mag, decreasing at both faint and bright ends. Unlike Li *et al.*, we see no increase in σ_{12} in the highest luminosity bin. We note that in Fig. 6 of Li *et al.*, the error bars for the most luminous galaxies are very large, and so this apparent increase in σ_{12} is not very significant.

In future, we plan to compare estimates of the PVD obtained in Fourier space using the "damped Kaiser" model (Peacock & Dodds 1993; Li et al. 2006) and to investigate the dependence of the PVD on location within the cosmic web, on stellar mass and on redshift.

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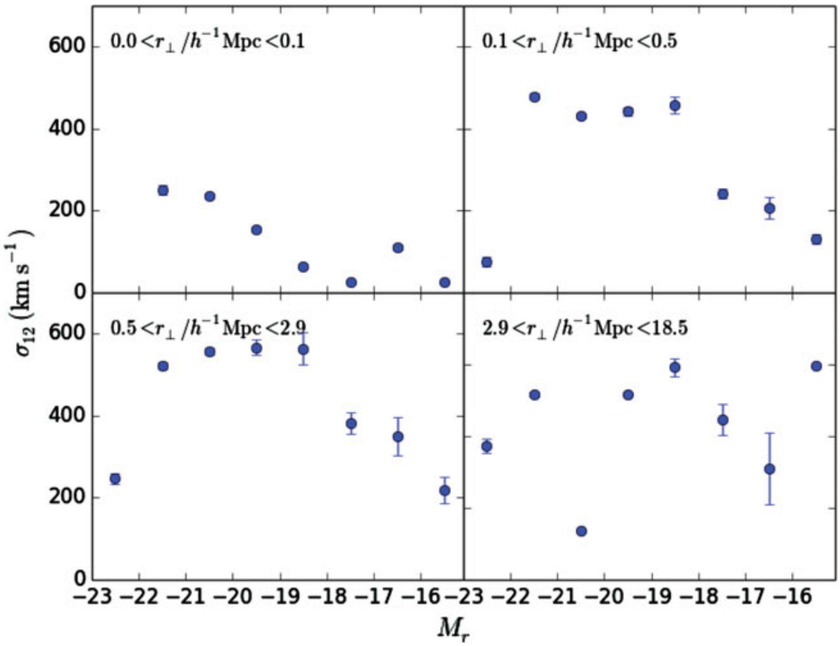

Figure 3. GAMA-II pairwise velocity dispersion as a function of absolute magnitude in bins of projected separation $r_\perp$.

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