

Measuring the VIPERS galaxy power spectrum at $z \sim 1$

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Abstract. The VIMOS Public Extragalactic Redshift Survey [VIPERS, Guzzo *et al.* (2014)] is using the VIMOS spectrograph at the ESO VLT to measure redshifts for $\sim 100,000$ galaxies with $I_{AB} < 22.5$ and $0.5 < z < 1.2$, over an area of 24 deg^2 (split over the W1 and W4 fields of CFHTLS). VIPERS currently provides, at such redshifts, the best compromise between volume, number of galaxies and dense spatial sampling. We present here the first estimate of the power spectrum of the galaxy distribution, $P(k)$, at redshifts $z \sim 0.75$ and $z \sim 1$, obtained from the $\sim 55,000$ redshifts of the PDR-1 data release. We discuss first constraints on cosmological quantities, as the matter density and the baryonic fraction, obtained for the first time at an epoch when the Universe was about half its current age.

1. Overview

In the estimation of the galaxy power spectrum, the survey shape and volume play a dominant role. The observed power P_{obs} is, in fact, a convolution of the true one, P_t , with a window function (WF), W , that depends on the geometry of the survey:

$$P_{\text{obs}}(\mathbf{k}) = \int \frac{d^3k'}{(2\pi)^3} P_t(\mathbf{k}') |W(\mathbf{k} - \mathbf{k}')|^2 \quad (1.1)$$

The narrower is the dimension of a survey along a given direction, the broader is the WF in Fourier space, leading to a strong mixing of modes through equation 1.1. The effect of the WF on the recovered power is a strong suppression on small- k modes (large scales). These effects are particularly severe in the case of VIPERS, which has a relatively small angular aperture along the declination, even more so at the current stage, with the PDR-1 public release covering $\sim 65\%$ of the final sample. To understand and overcome the impact of the WF, we have used a suite of 26 mock samples accurately reproducing the VIPERS selection function and footprint, built from the MultiDark simulation [Prada *et al.* (2012)] and described in de la Torre *et al.* (2013). A series of accurate tests have been performed, including the VIPERS sampling strategy and other subtleties (Rota *et al.*, 2015, in preparation). The results of this work convincingly demonstrate that we are able to correctly model the effects of sampling and survey geometry, such that unbiased cosmological information can be extracted from the measured $P(k)$. Briefly, this is obtained by matching the model power spectrum to the observed P_{obs} , after the former has been brought to redshift space and then convolved with the WF (see Rota *et al.* 2015 for details). Particular care has been taken in including the effect of redshift-space distortions (RSD). This has been done *before* performing the convolution with the WF, an approach usually avoided due to the time-consuming nature of the required 3D convolution.

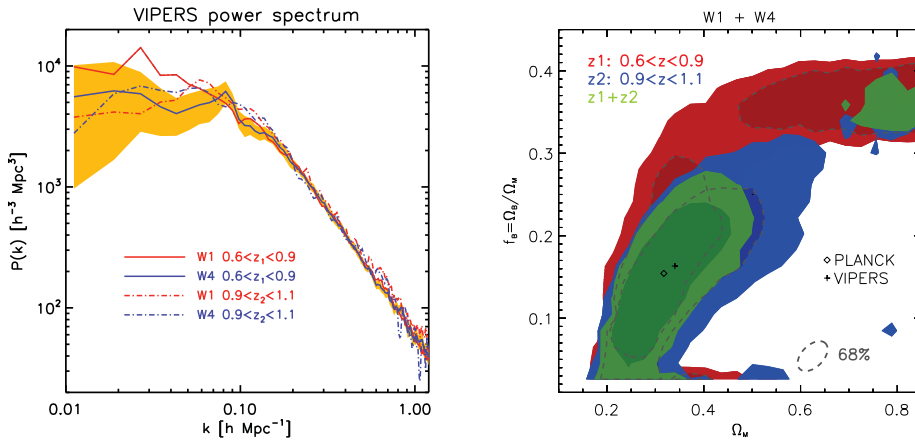


Figure 1. *Left:* measured power spectrum in the two redshift bins, $[0.6-0.9]$ and $[0.9-1.1]$ from the two independent W1 and W4 fields of VIPERS. *Right:* chi-square contours on the $f_B - \Omega_M$ plane for the two redshift bins (low redshift red contours, high redshift blue contours). The green region corresponds to a joint likelihood between z_1 and z_2 .

To test the robustness of our approach, the measured power spectrum from each of the 26 VIPERS mock catalogues is fitted with the model, using the standard chi-square technique including an estimate of the covariance matrix (obtained from a larger suite of 200 mock surveys, built using the Pinocchio code [Monaco *et al.* (2002)], and then re-normalized to match the variance of the “primary” mocks). The averaged redshift-space power spectrum from the 26 mocks is measured separately for the W1 and W4 areas, each split in turn into two redshift bins, $0.6 < z_1 < 0.9$ and $0.9 < z_2 < 1.1$. We vary the matter density parameter and the bias factor (assumed to be linear and scale independent), and fix all the other parameters to the known MultiDark values. In all cases we recover the true value Ω_M of the MultiDark simulation within statistical errors.

2. Results

We split the VIPERS data as done with the mocks, building four independent samples. These four data sets are characterised by two slightly different bias values and growth factors (at different redshifts) and two slightly different window functions (W1 and W4). We can handle these differences at best by treating each of them separately. As shown in the left panel of Figure 1, at $k > 0.1 \text{ h}^{-1} \text{ Mpc}$, where the effect of the WF is negligible, the combined effect of bias/growth is visible, with a slightly larger amplitude for the two higher- z samples (higher bias due to larger mean luminosity). When accounting for this, on large scales ($k < 0.1 \text{ h}^{-1} \text{ Mpc}$) the four power spectra are all compatible to each other within statistical errors, showing that small differences between the four WFs are smaller than statistical fluctuations.

Finally, in the right panel we show the results of a first model fit to the VIPERS measured power spectra in the range $0.01 < k < 0.3 \text{ h Mpc}^{-1}$. In analogy with the measurement at $z \sim 0$ from the 2dFGRS [Percival *et al.* (2001), Cole *et al.* (2005)], we impose flat priors on the baryonic fraction, $f_B = \Omega_B / \Omega_M$, the matter density, Ω_M and the bias, while fix the other cosmological parameters to Planck values [Planck Collaboration *et al.* (2014)]. In order to estimate the marginalised (over the bias) posterior likelihood distribution, we run a MCMC on the combined W1 and W4 measurements (accounting for the different WF), but treating separately the two redshift bins, given the different

bias parameters (blue and red contours). The green contours show the joint likelihood between z_1 and z_2 . **The best-fit values correspond to $f_B = 0.16^{+0.08}_{-0.12}$ and $\Omega_M = 0.34^{+0.11}_{-0.14}$.** These values agree well with the Planck ones, **although they are not completely independent.**

References

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