BOSS galaxy voids: arXiv:1602.02771; 1602.06306

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Catalog

A COSMIC VOID CATALOG OF SDSS DR12 BOSS GALAXIES

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ABSTRACT

We present a cosmic void catalog using the large-scale structure galaxy catalog from the Baryon Oscillation Spectroscopic Survey (BOSS). This galaxy catalog is part of the Sloan Digital Sky Survey (SDSS) Data Release 12 and is the final catalog of SDSS-III. We take into account the survey boundaries, masks, and angular and radial selection functions, and apply the ZOBOV void finding algorithm to the galaxy catalog. We identify a total of 10,643 voids. After making quality cuts to ensure that the voids represent real underdense regions, we obtain 1,228 voids with effective radii spanning the range 20-100h^{-1}Mpc and with central densities that are, on average, 30% of the mean sample density. We release versions of the catalogs both with and without quality cuts. We discuss the basic statistics of voids, such as their size and redshift distributions, and measure the radial density profile of the voids via a stacking technique. In addition, we construct mock void catalogs from 1000 mock galaxy catalogs, and find that the properties of BOSS voids are in good agreement with those in the mock catalogs. We compare the stellar mass distribution of galaxies living inside and outside of the voids, and find no significant difference. These BOSS and mock void catalogs are useful for a number of cosmological and galaxy environment studies.

Subject headings: cosmological parameters – cosmology: observations – large-scale structure of Universe – methods: statistical – surveys

CMASS void map

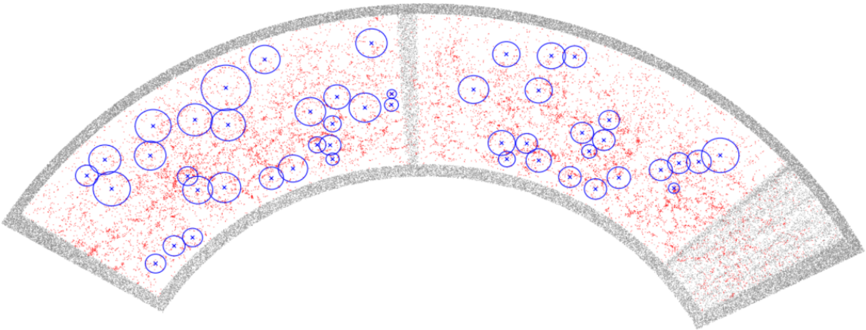

Figure 1. A thin slice of CMASS North galaxies (red) and random buffer particles (gray). The slice is centered on the celestial equator and is 2° thick in declination. Blue crosses show the central positions of the identified voids whose weighted centers are also located in the slice; the sizes of the blue circles indicate the effective radii of the voids.

Void sizes

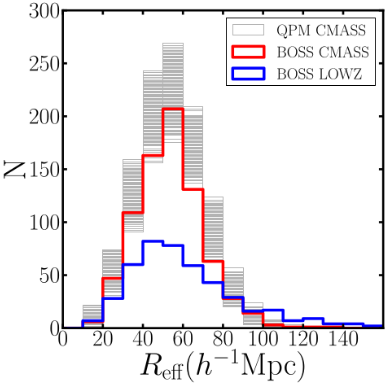

Figure 2. Distribution of void sizes. Each gray line represents the void effective radius distribution for one of the 1000 QPM CMASS (North + South) mock catalogs. Results for the CMASS (North + South) and LOWZ (North + South) samples are shown by the red and blue lines, respectively. Most voids have effective radii between 30 and $80h^{-1}$Mpc. The mock catalogs contain, on average, 10-20% more voids than found in the CMASS sample.

Void density profile

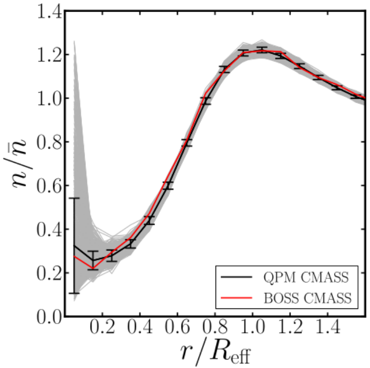

Figure 6. 1-Dimensional stacked density profile from the CMASS sample. The profile is measured by calculating the density profiles for each void individually in a set of shells around each void center, scaling the densities to the mean sample density and the radii to the void effective radii, and averaging over all the voids. Each gray line represents the result for one of the 1000 QPM mock catalogs. The peak at the center is an artifact due to the way we measure the profile. The black line indicates the mean of all the mocks and error bars show the standard deviation among the mocks. The red line is the measurement from the BOSS LSS catalog. CMASS voids have central densities that are $\sim 30\%$ of the mean sample density. Moreover, the density profiles of CMASS and mock galaxies are in excellent agreement with each other.

Voids are spherical on average ⇒ AP test

COSMIC VOIDS IN THE SDSS DR12 BOSS GALAXY SAMPLE: THE ALCOCK-PACZYŃSKI TEST

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ABSTRACT

We apply the Alcock-Paczyński (AP) test to the stacked voids identified using the large-scale structure galaxy catalog from the Baryon Oscillation Spectroscopic Survey (BOSS). This galaxy catalog is part of the Sloan Digital Sky Survey Data Release 12 and is the final catalog of SDSS-III. We also use 1000 mock galaxy catalogs that match the geometry, density, and clustering properties of the BOSS sample in order to characterize the statistical uncertainties of our measurements and take into account systematic errors such as redshift space distortions. For both BOSS data and mock catalogs, we use the ZOBOV algorithm to identify voids, we stack together all voids with effective radii of $30 - 100h^{-1}$Mpc in the redshift range $0.43 - 0.7$, and we accurately measure the shape of the stacked voids. Our tests with the mock catalogs show that we measure the stacked void ellipticity with a statistical precision of 2.6%. The stacked voids in redshift space are slightly squashed along the line of sight, which is consistent with previous studies. We repeat this measurement of stacked void shape in the BOSS data assuming several values of $\Omega_{\rm m}$ within the flat ΛCDM model, and we compare to the mock catalogs in redshift space in order to perform the AP test. We obtain a constraint of $\Omega_{\rm m} = 0.38^{+0.18}_{-0.15}$ at the 68% confidence level from the AP test. We discuss the various sources of statistical and systematic noise that affect the constraining power of this method. In particular, we find that the measured ellipticity of stacked voids scales more weakly with cosmology than the standard AP prediction, leading to significantly weaker constraints. We discuss how AP constraints will improve in future surveys with larger volumes and densities.

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Aspect ratio in real and redshift space

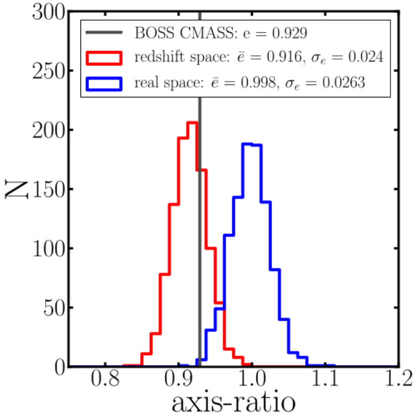

Figure 4. Shape measurements for the BOSS CMASS stacked voids, compared to the 1000 QPM mock catalogs, when the fiducial cosmology of $\Omega_{\rm m} = 0.29$ is assumed to convert redshifts to comoving distances. The distribution of mock void shapes is shown in real space (blue histogram) and redshift space (red histogram). Also displayed is the shape measurement from the BOSS data (vertical black line). The BOSS void axis ratio, as well as the mean and standard deviation of the mock void axis ratios, are listed in the panel. Mock voids in real space are spherical, as expected, while in redshift space they are slightly squashed along the line of sight. The shape of the BOSS voids is consistent with the distribution of mock shapes in redshift space.

We next measure the shapes of stacked voids in the 1000 mock catalogs in redshift space, using the same cosmology. This result shows the effects of redshift space distortions on void shapes and it also provides relevant predictions that can be directly compared to measurements from the BOSS CMASS data. The bottom panel of Figure 3 shows the $e/e_{\rm cut}$ as a function of $e_{\rm cut}$ measurements and the red histogram in Figure 4 presents the distribution of stacked void shapes for the 1000 mocks. These results reveal that redshift space distortions cause a slight squashing of voids along the line of sight, with a mean void axis ratio of 0.916. This result is opposite from what we expect from linear theory, where voids are expanding in comoving space and should thus be elongated in redshift space, and it demonstrates that the dynamics of galaxies within the region we consider are non-linear. Other recent studies using the same void-finding algorithm also find a squashing, although the magnitude of

Expected axis ratio vs Ω_M

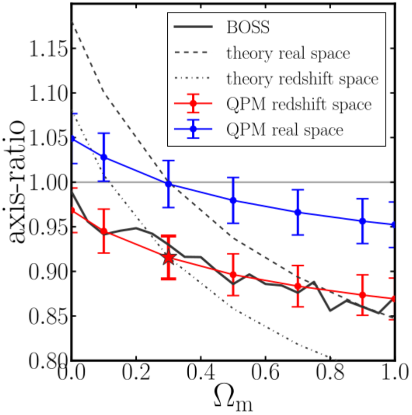

Figure 5. Shape measurements of the stacked voids assuming different values of $\Omega_{\rm m}$. Blue and red lines show the mean measurements from 1000 QPM mock catalogs in real space and redshift space, respectively, with error bars showing the standard deviation of the 1000 measurements. The black line shows the measurements from the BOSS CMASS galaxy catalog. The red point at $\Omega_{\rm m} = 0.29$ is highlighted with a star to indicate that this is the shape of the stacked voids when assuming the correct cosmology and including redshift space distortion effects. The dashed line shows the ideal theoretical prediction in real space given by equation 6, and the dash-dotted line is the theoretical prediction in redshift space obtained by simply scaling the dashed line by the value of the red star point.

Ω_m (flat universe)

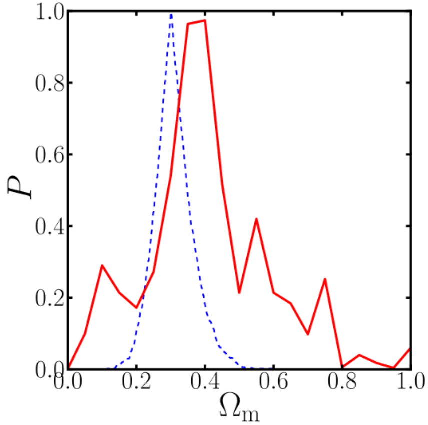

Figure 6. The probability distribution of Ω_m (red curve) calculated by comparing the shape measurements of the CMASS data (shown by the black line in Fig. 5) to the expected distribution measured from the mock catalogs in redshift space and assuming the correct cosmological model (shown by the red histogram in Fig. 4). Specifically, the probability is given by the fraction of such mock catalogs that have a higher stacked void ellipticity than that measured from CMASS. The blue dashed curve indicates the optimal constraint by replacing the CMASS measurement with the theoretical AP prediction (dash-dotted curve in figure 5). The probability distribution of Ω_m resulting from this analysis is not Gaussian, but has a narrow peaked shape.