Homogeneity Scale of the Universe Through Large Scale Structure Survey

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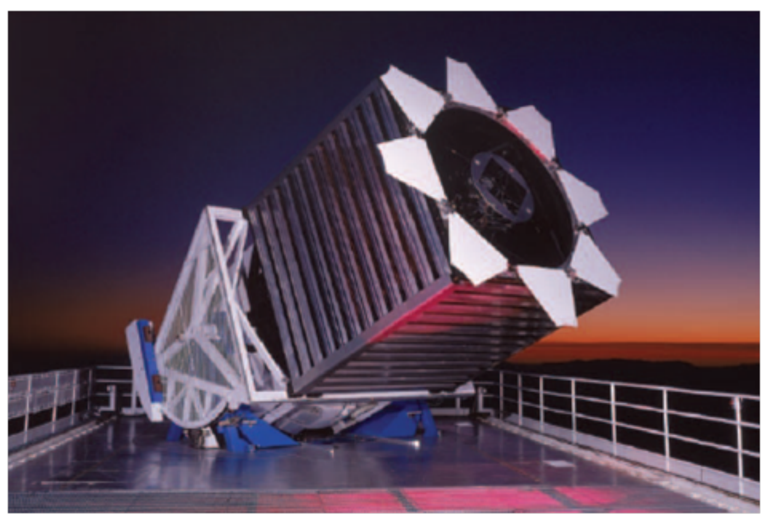
Introduction

The ΛCDM model is the most predominant model describing the Universe today and it is based on the Cosmological Principle. This Principle states that the universe is homogeneous and isotropic on scales large enough. The purpose of our research is to measure the scale at which the universe becomes homogeneous. One excellent spectroscopic survey is the Sloan Digital Sky Survey (SDSS) with the experiment Baryon Oscillation Spectroscopy Survey (BOSS).

SDSS-III Telescope

An APO telescope in New Mexico in U.S.A. Of 2.5 diameter:

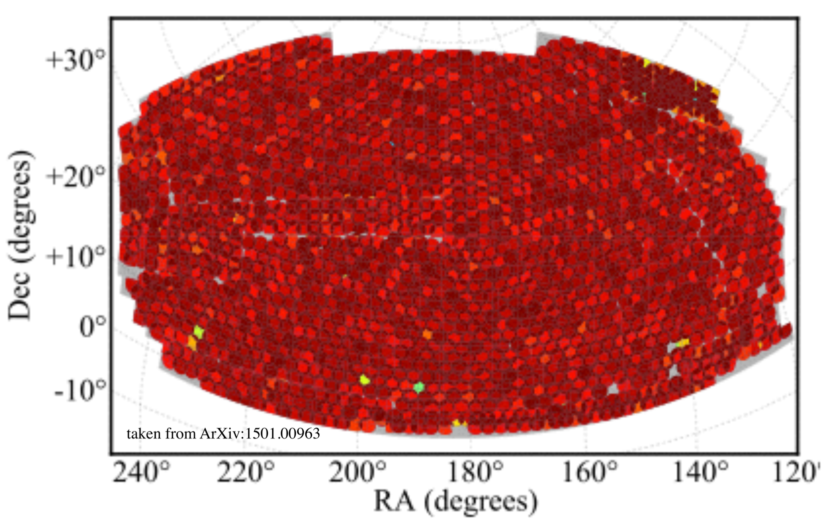


The spectroscopy survey of photometric targets uses a 2 two-arm spectographs in the wavelength range of 360 to 1000 nm providing:

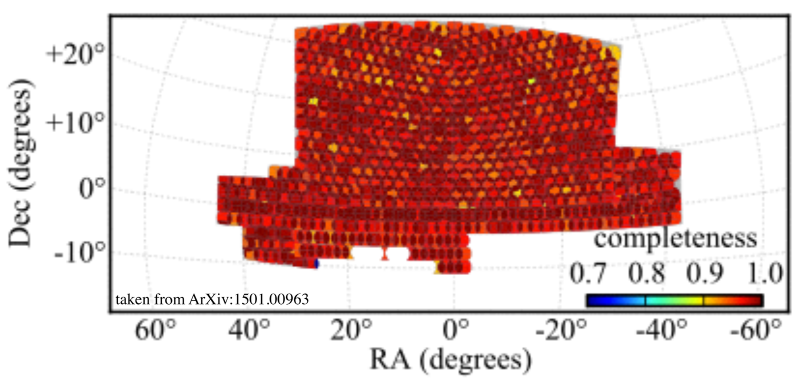
- 1.5 million LRGs at $z_{LRG} = 0.6$
- 150000 QSO, Ly-α at $z_{QSO} = 2.3$

Main objective of BOSS survey is to provide information about the cosmological parameters with high precision, using the Baryon Acoustic Oscillations as a standard ruler!

CMASS targets on north:



CMASS targets on south:



Different colours correspond to:

$$Completeness = \frac{Spectra}{Targets}$$

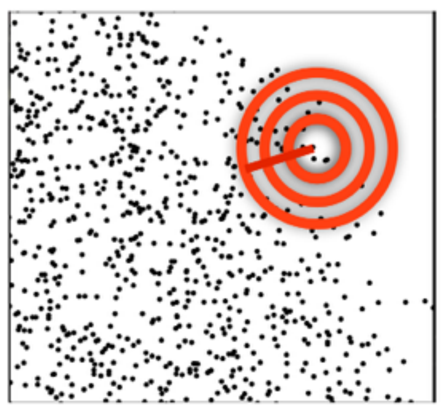
In order to account for the anisotropic efficiency of the survey. Several unisotropies are treated in order to get a homogeneous distribution, such as:

$$w_{tot}^{Data} = (w_{cp} + w_{zf} - 1)\, w_{fkp}\, w_{star}$$

Methodology

Average number of galaxies within a volume: N(r)
Fractal Correlation Dimension:

$$\mathcal{D}_2(r) = \frac{d\ ln\ N(r)}{d\ ln\ r}$$



- $\mathcal{D}_2(r) < 3$, inhomogeneous
- $\mathcal{D}_2(r) = 3$, homogeneous
- $\mathcal{D}_2(r) > 3$,super-homogeneous

The Homogeneity Scale is reached at the limit of:

$$\mathcal{D}_2(\mathcal{R}_H) \to 3\ at\ 1\%$$

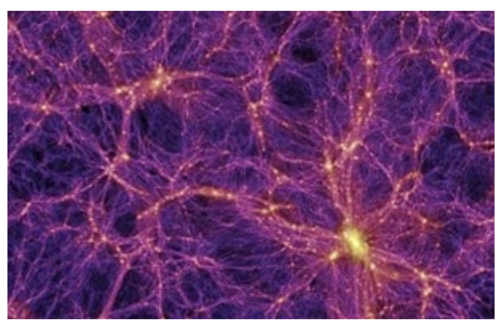
Mock Catalogues

Accurate realisations of the galaxy surveys:

- Generation of DM-particle field
- Identification Dark Matter Halos
- Population of Halos with Galaxies
- Apply survey characteristics

Usage:

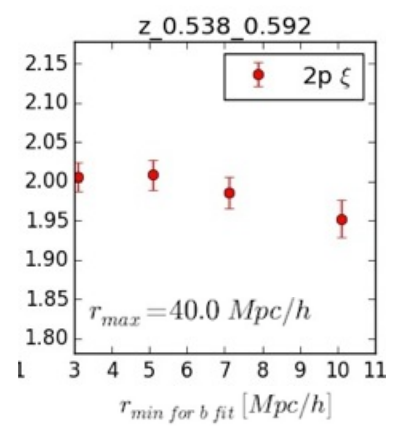
- Statistical Analysis
- Survey systematics
- Covariance Matrix
- Analysis Tests



Bias Calibration

In order our inferences account of the amount of fractality of the universe we need to convert our observable of the galaxy distribution to that of the matter distribution, by using:

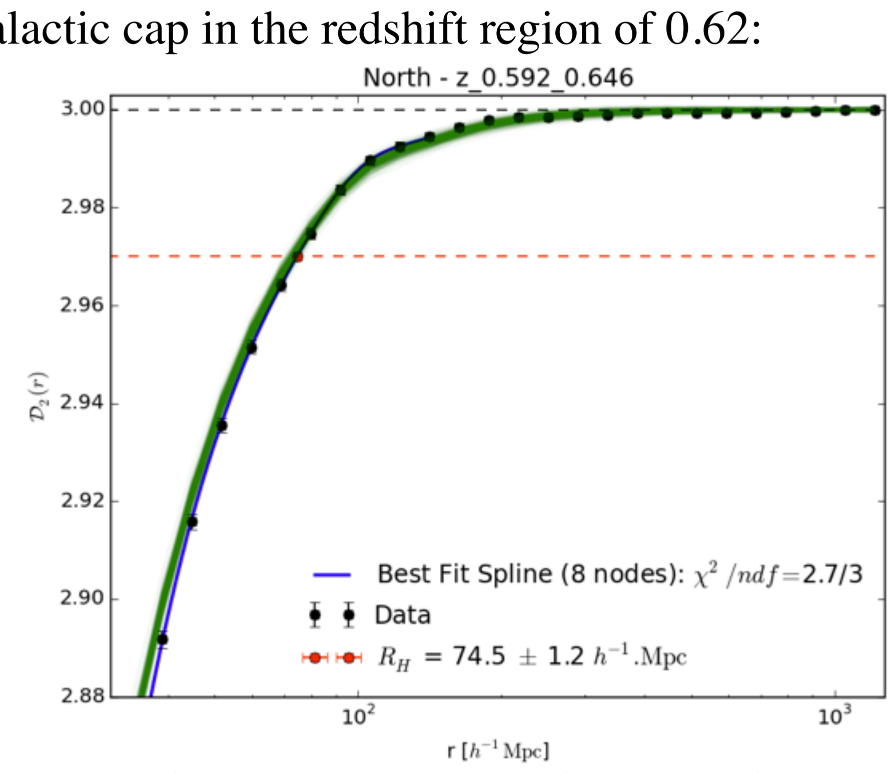
$$b^2(r) = \frac{\xi_{gal}(r)}{\xi_m(r)}$$



From our observations we show that bias is independent of scale using a constant line fitting with $\chi^2_{b=2.0} = 2.72/2$

Results

The fractal correlation dimension versus the radius of the count-spheres of the DR12 data of the North galactic cap in the redshift region of 0.62:

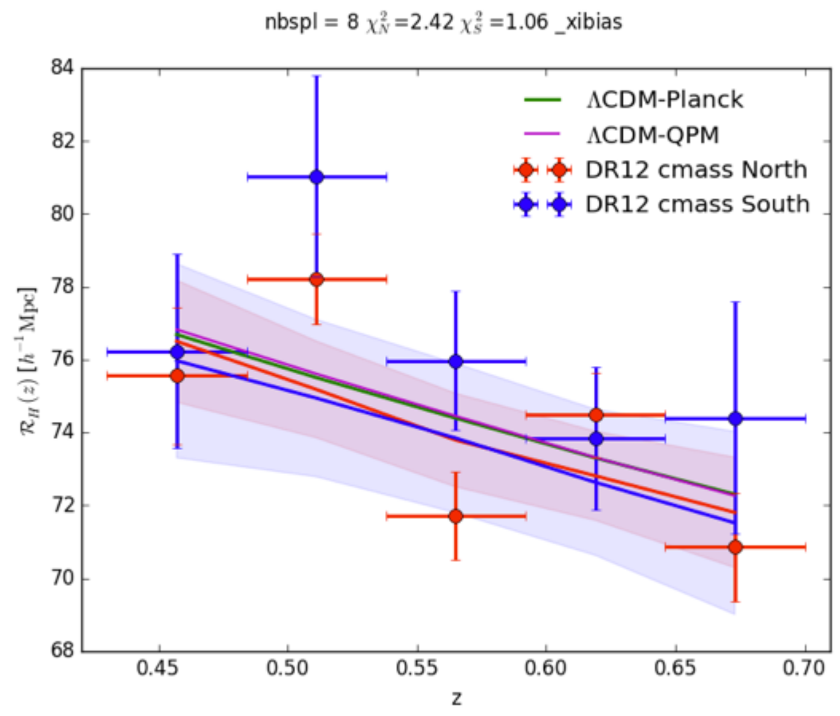


The green lines are the curve of the correlation dimension of the 1000 *QPM Mock* catalogues. The transition to a homogeneous universe on large scales is evident at scale $\mathcal{R}_H = 74.5 \pm 1.2 h^{-1}Mpc$ which is consistent with the ΛCDM model which can predict a scale of $\mathcal{R}_H^{\Lambda CDM} = 73.3 h^{-1} Mpc$ given the cosmological parameters:

$$(\Omega_m, \Omega_\Lambda, \Omega_b, h, n_s, ln[10^{10}A_s]) = (0.32, 0.68, 0.01, 0.67, 0.97, 3.09)$$

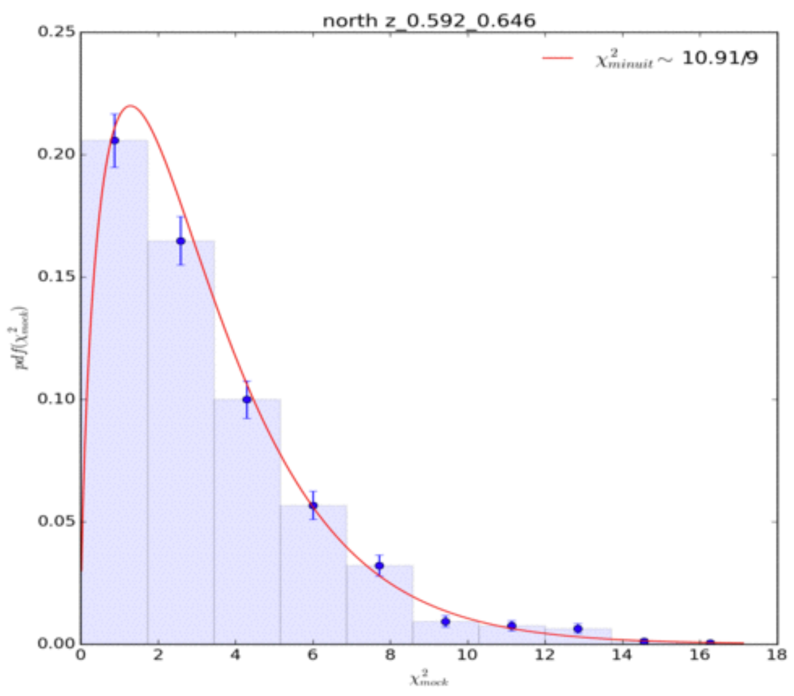
Results

The homogeneity scale is decreasing as the redshift is increasing which is another confirmation of the prediction of the ΛCDM Model.



What is shown with red and blue lines are the average values of the mock catalogues with 1σ shaded region.

Robustness



The distribution of the χ 2 of the mock-catalogues with 9 degrees of freedom are fitted quite satisfactory with the χ 2 distribution showing the robusteness of our analysis.

Outlook

The results show that there exists a homogeneity scale, $R_{H,cmass}^{DR12} = 74.43 \pm 1.55 h^{-1} Mpc$ at z=0.57 which is consistent with Cosmological Principle and with predictions of the ΛCDM model.

Furthermore, we need to study these results with the next release of the eBOSS survey, as well as with new realises of Mock Catalogues.

In addition, we are going to investigate how to extract information about the homogeneity scale from future projects such as the Large Synoptic Survey Telescope and EUCLID space telescope.

References

- M. I. Scrimgeour et al. ArXiv:1205.6812v2
- S. Alam et al. ArXiv:1501.00963v3

Acknowledgements

- J.C. Hamilton D.R. Apc Paris 7
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