The Zeldovich Universe:
Genesis and Growth of the Cosmic Web
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Identification of Extremely Large Scale Structures in SDSS-III

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Abstract. We have initiated the search and detailed study of large scale structures present in the universe using galaxy redshift surveys. In this process, we take the volume-limited sample of galaxies from Sloan Digital Sky Survey III and find very large structures even beyond the redshift of 0.2. One of the structures is even greater than 600 Mpc which raises a question on the homogeneity scale of the universe. The shapes of voids-structures (adjacent to each other) seem to be correlated, which supports the physical existence of the observed structures. The other observational supports include galaxy clusters' and QSO distribution's correlation with the density peaks of the volume limited sample of galaxies.

Keywords. Cosmology: large scale structures

1. Introduction

It is very well known (from observations) that galaxies are distributed in the universe in the form of "cosmic web" (or cosmic network). The cosmic web consists of voids (regions of least density of galaxies), walls (slightly higher density planar regions of galaxies), filaments (regions of cross-sections of walls) and super-clusters (regions of intersections of filaments). Galaxy redshift surveys can be used to construct this three dimensional distribution. Comparison of these observations with the theoretical predictions decides to what extent the theory is correct. In this work, we examines the SDSS-III data and try to find extremely large coherent structures.

2. Data and Methods of Analysis

We made a volume limited sample of a region of space from the spectroscopic galaxy sample of SDSS III. The selected region spans 30^o in Right Ascension and 2.5^o in Declination. The redshift is choosen to be between 0.25 and 0.42. The final volume limited sample contains 4156 galaxies.

Since the distribution has a very small extent in declination, we neglect the declination axis and proceed with two dimensional analysis to find the coherent structures in this region. We have used two different methods to identify the clusters within this field. First, smoothed density using cloud in cells method, in which two dimensional galaxy distribution is first converted to density field on a grid. The mean density of the field is $\overline{\rho}$. Then density field is smoothened. Over-dense regions/cells are defined as the cells with densities $\rho > \overline{\rho}$ and voids as cells with densities $\rho \leqslant 0.2\overline{\rho}$. The friend-of-friend (FoF) algorithm is then applied to extract the clusters/groups.

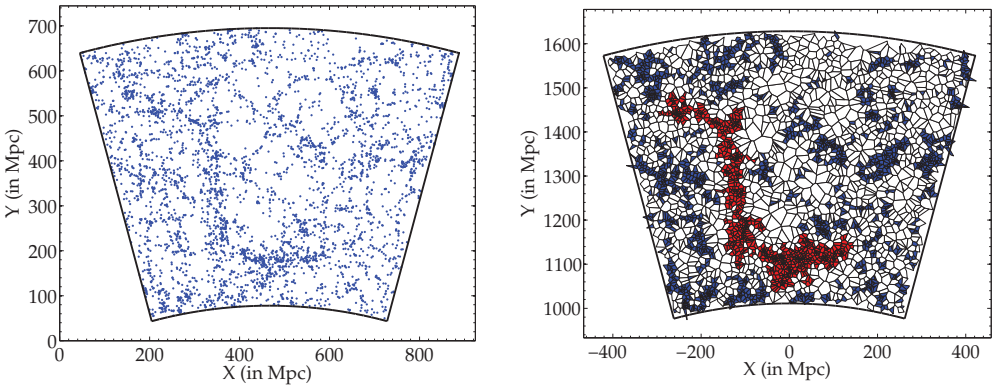

Figure 1. Left Panel: Volume limited sample of 4156 galaxies in comoving coordinates. Right Panel: Voronoi tessellation of the distribution of galaxies. Filled cells have $\rho > \overline{\rho}$. The largest structure's end to end length is $> 600 Mpc$.

The second method uses density distribution using Voronoi Tesselation, in which two dimensional galaxy distribution is first converted to density field using voronoi tessellation. The mean density of the field is $\overline{\rho}$. Over-dense regions/cells are defined as cells having densities, $\rho > \overline{\rho}$. The FoF algorithm is then applied to extract the clusters/groups.

3. Results, GMBCG Clusters and QSOs in the Field

After applying the two methods to extract coherent structures, we get an extremely large and linear structure which has an end to end linear length greater than 600 Mpc. Figure 1 shows the volume limited sample (left) and density field of Voronoi tesselation (right). The right panel shows the largest coherent structure, in an inverted S-shape.

We also compare the positions of the known clusters which have their spectroscopic redshifts available from GMBCG cluster catalog and the QSOs (from SDSS-III) in the field. A strong correlation between density peaks and cluster positions can be easily seen. The QSOs distribution also traces the largest structure very well. These correlations suggest that the largest structure found is composed of smaller clusters and is actually a physical structure.

4. Discussion and Conclusion

Two different methods give the same result - an extremely large structure of galaxies which has a length scale greater than 600 Mpc. The strong correlation of galaxy clusters with high density regions of the largest structure and the distribution of QSOs tracing the structure strongly suggest that this is an extremely dense structure. The size of this structure clearly raises the question on the homogeneity scale of the universe. There are other big structures near this extremely large structure. We will analyze those in our further studies.

References

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