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MULTI-FRACTAL AND LACUNARITY SPECTRUM ANALYSIS OF THE GALAXY DISTRIBUTION IN THE SDSS 9TH DATA RELEASE

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We develop a statistical analysis of the large-scale clustering of galaxies in the Universe from the fractal point of view using galaxies from the Ninth Sloan Digital Sky Survey Data Release.

The cosmological principle states that the cosmos is homogeneous and isotropic, such that the observed inhomogeneities are only perceived locally and should vanish on sufficiently large scales. In modern cosmology the cosmological principle is one of the fundamental hypotheses from which the observations and theoretical developments are contrasted and interpreted. Thus, it is important to investigate if the cosmological principle is supported by the observations of galaxies in the most recent catalogues and, in the affirmative case, what is the distance scale at which the transition to homogeneity is observed. Some researchers report that astrophysical objects are grouped in highly structured hierarchical patterns that exhibit properties of self-similarity and a fractal dimension smaller than the physical space dimension (i.e., no transition to homogeneity) (Kobayashi et al. 2011), while other authors claim to have found the scale of transition to homogeneity (Hogg et al. 2005; Sarkar et al. 2009)

We develop a statistical analysis of the large-scale clustering of matter in the universe from the fractal point of view using galaxies from the SDSS–DR9. From the total set of galaxies, a galaxy sample with redshifts in the range $0 < z < 0.25$ is created. The sample covers the largest completely connected area of the celestial sphere within the catalogue, with limits in right ascension of $120° < \alpha < 240°$ and declination $0° < \delta < 60°$, which is a region that includes the largest galactic samples that have been studied from the fractal viewpoint to date. From this initial sample which contains 296,465 galaxies we create four volume-limited samples in order to avoid radial incompleteness that would create a spurious detection of clustering up to the largest scales analyzed.

We use the sliding-window technique to determine the multi-fractal dimension (Blumenfeld & Mandelbrot, 1997), the lacunarity spectrum and its dependence on radial distance from the centers for the four volume limited samples used. Using these statistical tools, we find that the clustering of galaxies shows a fractal behavior, that is function of the radial distance, for all calculated quantities. A transition to homogeneity is not observed in the complete multi-fractal dimension set; instead, the galaxies exhibit a persistent multi-fractal behavior with a dimensional spectrum that does not reach the physical space dimension for all values of the structure parameter analyzed (see Figure 1), at least for radial distances up to 140 Mpc/h from each available center within the four volume-limited samples.

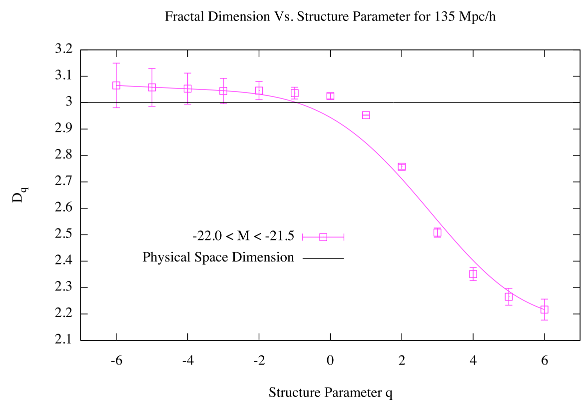

Fig. 1. Multi-fractal dimension spectrum Dq(r) of the galaxy clustering as a function of the structure parameter q in the range [6,6]. The solid line indicates the Bézier interpolation curve.

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