# 30 Years of Fractal Universe debate: Status and Perspectives

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About 30 years ago there was a prestigious conference at Princeton organized by Neil Turok with title: Critical Dialogues in Cosmology. The idea was to have exciting debates on the most important controversial topics in the field. The first debate was on the large scale structure of the universe, homogeneous or fractal. It was between Marc Davis (and Jim Peebles) and me. At that time the correlation length for galaxies, identifying the crossover to homogeneity, was supposed to be 5 Mpc but, curiously, for galaxy-clusters it was 25 Mpc. My argument was that these values did not refer to the real correlation properties, but were simply a fraction of the sample size, because the system consisted of a Fractal structure all the way through the sample (for details see Ref.). In fact the cluster sample was precisely 5 times deeper than the galaxy one, so this view also resolved this puzzling discrepancy, because clusters after all consist of galaxies and the idea that they become homogeneous at different scales is conceptually inconsistent. This debate was certified by a bet which is officially reported in the proceedings (see Ref.). According to D&P these two values, 5 and 25, should have been confirmed by future deeper distributions. I predicted instead that they would slide with the depth of the distributions because they have no real physical meaning, since the real properties are fractal correlations up to the sample limits. Today, even the most conservative people, would agree that the long sought homogeneity is not observable at least up to 100Mpc, and the preliminary results from DESI galaxies show fractal correlations up to the sample limits of 400 Mpc, so nobody talks any more about 5 and 25. Therefore the bet is over and we can safely conclude that the visible universe consists of a grandiose Fractal structure which should be considered as the basis for any realistic theory. What about the Cosmological Principle? Already Mandelbrot pointed out that one has just to be a bit more subtle and consider the "Conditional CP". This implies that all points of the fractal structure (galaxies) are statistically similar and the conditional average density decays similarly from each of them. So, in some sense, one can say that in a Fractal "everybody is at the center of the universe". We cannot use any more the Friedmann metric but, in this perspective, we could resort to the Lemaitre-Tolman-Bondi metric, which is probably a reasonable starting point. We conjecture that this more realistic consideration of the real properties of the observable universe could resolve a number of present puzzles and possibly reduce the need of so much dark matter and dark energy. Hopefully this will lead to the evolution of the present "dark age" of cosmology into a more brilliant situation.

Reference:

L. Pietronero et al, On the Fractal Structure of the Visible Universe, in Critical Dialogues in Cosmology, Ed. by Neil Turok, World Scientific p. 27 (1997)