Stochastic Self-Similar and Fractal Universe

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Abstract

The structures formation of the Universe appears as if it were a classically self-similar random process at all astrophysical scales. An agreement is demonstrated for the present hypotheses of segregation with a size of astrophysical structures by using a comparison between quantum quantities and astrophysical ones. We present the observed segregated Universe as the result of a fundamental self-similar law, which generalizes the Compton wavelength relation. It appears that the Universe has a memory of its quantum origin as suggested by R. Penrose with respect to quasi-crystal. A more accurate analysis shows that the present theory can be extended from the astrophysical to the nuclear scale by using generalized (stochastically) self-similar random process. This transition is connected to the relevant presence of the electromagnetic and nuclear interactions inside the matter. In this sense, the presented rule is correct from a subatomic scale to an astrophysical one. We discuss the near full agreement at organic cell scale and human scale too. Consequently the Universe, with its structures at all scales (atomic nucleus, organic cell, human, planet, solar system, galaxy, clusters of galaxy, super clusters of galaxy), could have a fundamental quantum reason. In conclusion, we analyze the spatial dimensions of the objects in the Universe as well as spacetime dimensions.
The result is that it seems we live in an El Naschie’s E infinity Cantorian spacetime; so we must seriously start considering fractal geometry as the geometry of nature, a type of arena where the laws of physics appear at each scale in a self-similar way as advocated long ago by the Swedish school of astrophysics.

1 Introduction

What is the geometry of the universe? Has the universe a memory of its quantum and relativistic origin?

In 1965 Sakharov indicated that quantum primordial fluctuations should have expanded towards the present epoch leading first to classical energy-density perturbations and, after the decoupling from the cosmological background, to the observed galaxies, clusters and superclusters of galaxies [399].

A relevant contribution was given by L.Nottale starting from 1993. In many papers he extends Einstein’s principle of relativity to scale transformations in the framework of the theory of scale relativity. In particular, he showed that a continuous but non differentiable space-time is necessarily fractal [399], [404], [405], [406]. In this work, we present a complementary approach starting from the well-known Random Walk equation or Brownian motion relation that was firstly used by Eddington [407], [408], [409]. Following this line we arrive at a self-similar universe; which was firstly considered by the Swedish Astronomers Charlier [410].

The idea, that a rule can exist among the fundamental constants, was presented by Dirac and by Eddington–Weinberg, but these rules were exact at Universe scale or subatomic scale. Here, a scale invariant rule is presented. Thanks to this relation the Universe appears self similar and its self similarity is governed by fundamental quantum quantities, like the Plank constant $h$, and relativistic constants, like the speed of light $c$.

Actually, there are some theories of gravity which are obtained from the Einstein-Hilbert gravitational action by adding scalar fields or curvature invariants of the form $\phi^2 R$, $R^2$, $R_{\mu\nu}R^{\mu\nu}$, $R\Box R$ [311], [312], [313]. However, in the weak-limit approximation, all these theories fit very well with the experiments of Einstein’s general relativity (tested only in this limit) [314]. Moreover, the observations show a structure of Universe with scaling rules, where we can see globular clusters, single clusters or superclusters of galaxies, in which stars can be treated as massive point-like constituents of a universe mad of dust.

Why does the Universe appear with fixed scales, where matter can be clustered? The right question is not the previous one, but the following one: does the Universe have quantum nature at all scales? It appears that the Universe has a memory of its quantum origin like as suggested by R.Penrose with respect to quasi-crystal [315]. Particularly, it is related to Penrose tiling and thus to $e^{(\infty)}$ theory (Cantorian spacetime theory) as proposed by M.S. El Naschie [316], [317] as