FRACTAL STRUCTURE OF THE UNIVERSE

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1 Self-Reproducing Inflationary Universe

At present, the only theory of the evolution of the universe which is free from many defects of the standard Big Bang theory is inflationary cosmology [1]. The main idea of the inflationary scenario is that the universe at the very early stages of its evolution expanded exponentially (the stage of inflation) in a state with energy density dominated by the potential energy density $V(\phi)$ of some scalar field ϕ. This rapid expansion made the universe flat, homogeneous and isotropic. Later, the potential energy density of the scalar field transformed into thermal energy and still later, the universe was correctly described by the standard hot universe theory. This scenario solves about ten different problems of the standard Big-Bang theory; therefore, most cosmologists now believe that this scenario correctly describes our universe.

The most unexpected result which was obtained in the context of inflationary cosmology was that the universe containing at least one inflationary domain filled with a sufficiently big scalar field ϕ unceasingly produces inflationary domains of all possible types [2]. This effect is caused by long-wave quantum fluctuations of the field ϕ generated during inflation. The universe after inflation becomes divided into many exponentially large domains, inside which the laws of low energy physics and even the dimensionality of space-time may be different [1]. This means that the inflationary universe has a completely different global structure than that of the Friedmann universe. Instead of being a spherically symmetric expanding ball, our universe is a huge fractal consisting of an exponentially big (or infinitely big) number of such balls permanently producing new and new ones. This changes considerably the standard cosmological paradigm according to which all parts of our universe appear simultaneously in the Big Bang and (if the universe is closed) disappear in the Big Crunch. In inflationary cosmology there is no end (and there may be no unique beginning) of the evolution of the universe [1].

We are planning to perform a computer simulation of the processes of self-reproduction of the inflationary universe. Such an investigation would be very important, since it may give us information about the structure of the universe at the distances presently inaccessible by direct

astronomical observations. It may also provide the tools for the investigation of the previous evolution of the self-reproducing inflationary universe and of the future fate of the part of the universe where we live now.

We believe that the present status of inflationary cosmology can be understood not only by a few experts, but by a much wider community of people who traditionally have a strong interest in the origin of the universe and in properties of the outer space. However, after many years when it was believed that the universe was a big ball appearing in the Big Bang, it is psychologically difficult to switch to the new notion that the universe locally looks like a big ball but globally looks like a fractal, and that the properties of space-time in different parts of the universe may be different. Therefore it would be very important to develop some tools for a visual demonstration of the evolution and of the global structure of the inflationary universe, which could be used in the educational process. We hope that it can be done with the help of the computer simulation of stochastic processes in the inflationary universe which we are planning to perform. Our purpose is to obtain a series of images of the universe on a scale much bigger than the size of the part of the universe which can be seen with the help of any telescope. It may be compared with the possibility of looking at another side of the moon which cannot be seen from the earth. But another side of the moon is just a dull grey surface, whereas the universe on super large scale has a complicated fractal structure which may look very interesting and thought-provoking on a good color display. By zooming to the parts of the picture where the new domains of the universe are formed *right now* and to the parts where this process is already finished we will create a kind of "time machine" which will show us the beginning of the universe and the late stages of its evolution on the same screen! As a next stage of this project, we hope to make a video showing the process of self-reproduction of the universe and its fractal structure. Some preliminary results of this investigation have been already obtained, and the results of computer simulation of stochastic processes in the early universe were included into a recent preprint [3] containing 119 pp of text and 38 figures. However we feel that we are just in the beginning of an exciting investigation, and we need help of experts in computer calculations. We also need some assistance to represent our results in a form suitable for demonstration on TV and in teaching process. For these purposes we would like to engage the help of the Academic Software Development group.

References

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[3] A.D. Linde, D.A. Linde and A. Mezhlumian, FROM THE BIG BANG THEORY TO THE THEORY OF A STATIONARY UNIVERSE, SU-ITP-93-13, Jul 1993. 119pp. Bulletin Board: gr-qc@xxx.lanl.gov - 9306035.