Cosmological fractal negative acceleration

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Abstract: It is shown that a free (not a member of gravitationally connected system) object which is moving inside fractal structure with a dimension $D = 2$ has an acceleration $a \cong Hc \cong 10^{-7}$ cm·s^{-2}. This results in appearance of a new term in equations of motions that is equal to $-Hc\cdot\mathbf{v}/|\mathbf{v}|$. Here H is the Hubble constant, c is the light speed, $\mathbf{v}$ is the object velocity. The local (anomalous decelerations of "Pioneer-10" and "Pioneer-11") and cosmological consequences of this effect are discussed.

1. Introduction

Beginning from the appearance of the theory of fractals (Mandelbrot, [1]), the application of this theory to the large-scale structure of the Universe is one of the most important. An interesting result was found by Baryshev [2]. It appeared that the Hubble law $z=Hr/c$ can be explained as a gravitational redshift inside the fractal structure with the dimension $D = 2$ for gravitating matter. For the photons

$$z_g = \frac{\Delta\varphi}{c^2} = \frac{4\pi}{3}\frac{G\rho_0 r_0}{c}\frac{r}{c} = \frac{H_g}{c} r \ ,$$

where ρ_0 and r_0 are the low cut-off of the fractal structure.

This explanation that is an alternative to the standard cosmological model was practically not discussed in the literature. Most of researchers were occupied in the dominating conception. Nevertheless, it is a puzzle why such a consideration was not carried out for a massive particle.

Indeed,

$$\frac{d\mathbf{v}}{dt} = -\nabla\varphi$$

And for $D = 2$ and $M \propto r^2$ $\varphi \propto r$,

$$\frac{dv}{dt} \sim G\rho_0 r_0 \ ,$$

and, if fractal structures propagate till Hubble scale then

$$\frac{dv}{dt} \sim \frac{GM_H}{R_H^2} \sim Hc$$

This situation is partly similar to the investigation of the gravitational field of the Earth. In this case, the acceleration

$$g_{Earth} = \frac{dv}{dt} = \frac{GM_{Earth}}{R_{Earth}^2}$$

was firstly discovered due to the Newton's apple (1687). But photon redshift

$$z_{Earth} = \frac{\Delta\nu}{\nu} = \frac{\Delta\varphi}{c^2} = \frac{g_{Earth} r}{c^2}$$

was investigated only 300 years after [3].

Finally the equation of motion inside fractal structure with $D = 2$ is as follows

$$\frac{d\mathbf{v}}{dt} = \mathbf{a}_{Holts} - \frac{\mathbf{v}}{v} H_g c$$

The consequences from these equations for extragalactic systems are discussed in [4].

Let's note that the density of energy of the gravitational field

$$\rho_G = \frac{(\nabla\varphi)^2}{8\pi G c^2} \sim \frac{(Hc)^2}{8\pi G c^2} = \frac{H^2}{8\pi G} \sim 3{\times}10^{-30} g{\cdot}cm^{-3}$$

gives in each point of fractal structure a scalar $\boldsymbol{a}^2$ that does not change in space. It seems that this fact is important for understanding the direction of thermodynamical evolution of self-gravitating systems because the massless component (field of gravitons) leads to homogeneity. Then the sources of gravitation tend to the fractal structure with $D = 2$ [5].

It is very interesting to note that besides the result of action of negative accelerations of extragalactic objects on cosmological time scales (see [4]), one can observe similar accelerations in the Solar system in on-line regime. This is possible due to high precision of measurements of the velocities of the spacecrafts Pioneer 10 and 11 (see Fig.1 taken from [6]). In this picture, we can see that the acceleration of order 10^{-7} cm/s^2 for Pioneer 11 appeared after its gravitational interaction with Saturn. After that the space craft has supplied an escape velocity and lost gravitational connection with the Solar system. This explains the fact that the gravitationally connected objects such as the planets, asteroids, satellites of planets etc. are not forced by the additional fractal acceleration, because it acts on the center of mass as a whole.

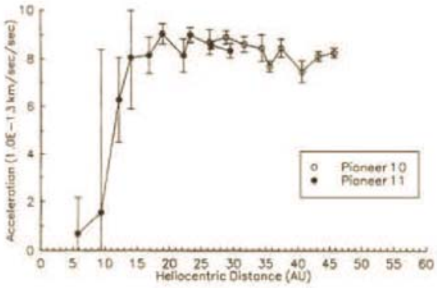

Fig. 1. The dependences of anomalous accelerations of the spacecrafts Pioneer 10 and Pioneer 11 on heliocentric distance [3].

Unlike fractal redshift, the fractal acceleration probably has essential consequences which can strongly change our views on structure and evolution of the Universe. These are comparable in order of magnitude with the effects on negative vacuum pressure. Fortunately, the modern data let us choose amongst these two scenarios.

References

1. Mandelbrot B.B. The fractal geometry of nature / NY. W.H. Freeman and Company (1977).
2. Baryshev Yu.V. // Izv. SAO. 14, 24 (1981).
3. Pound R.V., Rebka G.A. // Phys. Rev. Lett. 4, 337 (1960).
4. Raikov A.A., Orlov V.V. // Proceed. Intern. Conf. ``Dynamics of galaxies'', St. Petersburg, August, 6-10, 2007, in press (2008).
5. Raikov A.A. // Abstract of the talk in Interdisciplinary seminar on the time study. Moscow University (1997).
6. Nieto M.M., Turyshev S.G., Anderson J.D. // ArXiv: gr-qc/0411077v2 (2004).