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Origin of the Expansive Homogeneous and Isotropic Relativistic-Quantum-Mechanical Universe

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Abstract

Physical properties of the universe unambiguously determine also the physical conditions and mechanism of its origin.

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1 Introduction

At present time we reliably know that the *universe has complementary relativistic and quantum-mechanical properties*.

A *relativistic–quantum-mechanical universe* is *expanding*, *homogeneous* and *isotropic*. It means that it originated before the finite time, under physical conditions that can be unambiguously identified by the reverse extrapolation of its expansive evolution.

According to the present observations the *age of our observed expansive homogeneous and isotropic relativistic–quantum-mechanical Universe* is approximately 13.7 Gyr [1, 2, 3].

The reverse extrapolation of the evolution of an *expansive homogeneous and isotropic relativistic–quantum-mechanical universe* leads to an *initial cosmological singularity* (i.e. to the most perfect geometric object: *point*), in which—assuming that it should have physical properties—all the physical parameters of the universe would have zero or infinite values. But this—neither from the standpoint of the *general theory of relativity*, nor from the standpoint of the *quantum mechanics*—in principle is not possible. Therefore, the initial cosmological singularity is not a physical object, but only an *abstract limit geometrical object*.

From the *quantum-mechanical standpoint* the reverse extrapolation of the evolution of the expansive homogeneous and isotropic relativistic–quantum-mechanical universe can be carried back only to the *Planck era*, when the universe had the following parameters [4]:

Planck length

$$l_P \cong 10^{-35}\ \mathrm{m}, \tag{1}$$

Planck time

$$t_P = \frac{l_P}{c} \cong 10^{-43}\ \mathrm{s}, \tag{2}$$

Planck mass

$$m_P \cong 10^{-8}\ \mathrm{kg}, \tag{3}$$

Planck mass density

$$\rho_P \cong 10^{96}\ \mathrm{kg\ m^{-3}}, \tag{4}$$

Planck temperature

$$T_P \cong 10^{32}\ \mathrm{K}. \tag{5}$$

2 Origin of an expansive homogeneous and isotropic relativistic–quantum-mechanical universe

Planckon, i.e. a matter-space-time non-differentiate physical object with the *Planck quantities* (1)-(5), is a limit quantum-mechanical object. Therefore, it cannot be created from something non-physical, by some kind of non-physical processes.

According to Stephen Hawking and Leonard Mlodinow: "... if we want to go back even further and understand the origin of the universe, we must combine what we know about general relativity with quantum theory." [5, p. 131].

From the complementarity between general theory of relativity and quantum mechanics results unambiguously that the matter-space-time non-differentiate planckon can originate only by the quantum-mechanical processes in the relativistic–quantum-mechanical environment.

We know only one global relativistic–quantum-mechanical environment: an expansive homogeneous and isotropic relativistic–quantum-mechanical universe, and only quantum-mechanical processes which may manifest an actualization and de-actualisation of quantum-mechanical objects: the *quantum-mechanical fluctuation origin and extinction of the particles and radiation*. Therefore: *The planckon—with limit relativistic and quantum-mechanical properties—can originate only by quantum-mechanical processes in the expansive homogeneous* *and isotropic relativistic–quantum-mechanical universe there, where appropriate conditions arise.*

The matter-space-time non-differentiate planckon has extreme relativistic–quantum-mechanical properties; therefore, it can originate only under very specific conditions.

From the first nontrivial exact solutions of the *Einstein field equations*, which were published in 1916 by Karl Schwarzschild [6], results that—according to the *Einstein general theory of relativity*—massive objects might exist from which neither the matter objects nor radiation cannot escape. For this property John A. Wheeler in 1967 gave to them the name *black holes*.

The dimensions of the black hole are determined by the *event horizon (Schwarzschild sphere)* with

critical (gravitational or *Schwarzschild) radius* [6]:

$$r_c = \frac{2Gm}{c^2}. \quad (6)$$

At the beginning of 1970's, British theoretical physicist Stephen W. Hawking—when he analysed *thermodynamic properties of black holes* from the quantum-mechanical point of view—came to an unexpected and surprising discovery, now known as *Hawking black hole evaporation* or *Hawking effect*.

He published it on 1 March 1974 in the article *Black hole explosions?* [7], and a year later, in more detail, in the article *Particle Creation by Black Holes* [8].

According to Hawking, black hole evaporation can be described in several ways, which at first sight may seem to be very different, but in fact they are equivalent. One from the description is based on the fact that the *uncertainty relations* allow particles fluctuation to transfer over a short distance at superluminal velocity. Therefore, particles and radiation can escape via fluctuation from the black hole. By escape (evaporation) of particles and radiation the black hole loses mass [9].

In his bestseller *A Brief History of Time* [10] Hawking described the final phase of the evaporation of black hole as follows: "As the black hole loses mass, the area of its event horizon gets smaller, but this decrease in the entropy of the black hole is more than compensated for by the entropy of the emitted radiation, so the second law is never violated.

Moreover, the lower the mass of the black hole, the higher its temperature. So as the black hole loses mass, its temperature and rate of emission increase, so it loses mass more quickly. What happens when the mass of the black hole eventually becomes extremely small is not quite clear, but the most reasonable guess is that it would disappear completely in a tremendous final burst of emission, equivalent to the explosion of millions of H-bombs." [10, p. 107].

Black holes can not evaporate (disappear) completely by the Hawking effect. The *Heisenberg uncertainty principle (relations)* [11] do not allow it.

After evaporation of the black hole a limit matter-space-time unstructured planckon remains with a relatively small, but non-zero mass. (The planckon has mass, determined by the relation (3), i.e. several hundred-thousandth of a gram.)

The planckon is a *limit ("residual") Schwarzschild undifferentiated in matter-space-time manner black hole*, which in this limit state can exist only in the frame of uncertainty relations. Therefore, in the shortest possible, i.e. Planck time t_P, determined by the relation (2), it is transformed by the fluctuation into object, which is structured in the matter-space-time manner.

Fluctuation differentiation of the planckon is realized under extreme conditions, with the maximum possible, i.e. Planck temperature T_P, determined by the relation (5), generating the maximum possible negative pressure of creating particles. Therefore, created particles are drifting apart at high velocities, and the event horizon is moving away from them at the maximum possible velocity of signal propagation c.

The relativistic–quantum-mechanical object, structured in matter-space-time manner, with the event horizon moving away at the velocity c, is space-time limit-singularly closed. A *"baby universe"*, i.e. new space-time limit-singularly closed *expansive homogeneous and isotropic relativistic–quantum-mechanical universe (EU)*, is created.

The EU during its whole expansive evolution expands at the boundary velocity of signal propagation c. Therefore, for its gauge factor a and the cosmological time (age of universe) t is valid the relation [12]:

$$a = ct. \tag{7}$$

If in the relation (6) instead of the critical radius r_c we put the gauge factor $a := r_c$, we receive:

$$a = \frac{2Gm}{c^2}. \tag{8}$$

The physical-mathematical foundations of the present *relativistic cosmology* are represented by the *Friedmann equations of the homogeneous and isotropic relativistic universe dynamics* [13, 14], which—using the *Robertson-Walker metrics* [15, 16, 17, 18]—can be expressed in the following form:

$$\dot{a}^2 = \frac{8\pi G\rho a^2}{3} - kc^2 + \frac{\Lambda a^2 c^2}{3}, \tag{9a}$$

$$2a\ddot{a} + \dot{a}^2 = -\frac{8\pi G p a^2}{c^2} - kc^2 + \Lambda a^2 c^2, \tag{9b}$$

$$p = w\varepsilon, \tag{9c}$$

where a is the gauge factor, ρ mass density, k curvature index, Λ cosmological constant, p pressure, w state equation constant, and $\varepsilon = \rho c^2$ energy density.

The *Friedmann-Robertson-Walker (FRW) equations of the homogeneous and isotropic relativistic universe dynamics* (9a), (9b) and (9c) fulfil the restrictive conditions, determined by the relations (7) and (8), only with $k = 0$, $\Lambda = 0$ and $w = -1/3$ [19].

Using the FRW equations (9a) and (9b) with $k = 0$ and $\Lambda = 0$ and *total zero energy state equation*

$$p = -\frac{1}{3}\varepsilon, \tag{10}$$

we can determine the parameters of the *model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe (EU model)*, which describes the EU in the linear approximation, in which we abstract from its relativistic and quantum-mechanical properties [19]:

$$a = ct = \frac{c}{H} = \frac{2Gm}{c^2} = \frac{2GE}{c^4} = \sqrt{\frac{3c^2}{8\pi G\rho}} = \sqrt{\frac{3c^4}{8\pi G\varepsilon}}, \tag{11}$$

where H is the Hubble "constant" (parameter, coefficient), and E energy.

From the relations (11) results

increase of universe mass

$$\Delta m = \frac{c^3}{2G}\Delta t = 2.01849\times10^{35}\ \text{kg s}^{-1}. \tag{12}$$

Hawking in his—above mentioned—bestseller *A Brief History of Time* wrote: "… in quantum theory, particles can be created out of energy in the form of particle/antiparticle pairs. But that just raises the question of where the energy came from. The answer is that the total energy of the universe is exactly zero. The matter in the universe is made out of positive energy. However, the matter is all attracting itself by gravity. Two pieces of matter that are close to each other have less energy than the same two pieces a long way apart, because you have to expend energy to separate them against the gravitational force that is pulling them together. Thus, in a sense, the gravitational field has negative energy. In the case of a universe that is approximately uniform in space, one can show that this negative gravitational energy exactly cancels the positive energy represented by the matter. So the total energy of the universe is zero.

Now twice zero is also zero. Thus the universe can double the amount of positive matter energy and also double the negative gravitational energy without violation of the conservation of energy." [10, p. 129].

In the EU model, determined by the FRW equations (9a), (9b) and (9c) with $k = 0$, $\Lambda = 0$ and $w = -1/3$, the *Euclid geometry* is valid.

According to the *Einstein general relativity*, for the total mass m_{tot} of the Euclidean homogeneous matter sphere is valid the relation:

$$m_{tot} = \frac{4}{3}\pi r^3\left(\rho + \frac{3p}{c^2}\right). \tag{13}$$

For the total mass of the EU in the linear approximation m_{tot}—with the non-zero values of the gauge factor $a := r$, the mass density ρ and the pressure p—can be valid:

$$m_{tot} = \frac{4}{3}\pi a^3\left(\rho + \frac{3p}{c^2}\right) = 0 \tag{14}$$

only on the condition [20]:

$$\rho + \frac{3p}{c^2} = 0. \tag{15}$$

For the mass density ρ and the energy density ε is valid the relation:

$$\varepsilon = \rho c^2, \tag{16}$$

therefore, the relation (15)—using the relation (16)—can be rewritten into the form:

$$\varepsilon + 3p = 0. \tag{17}$$

If in the relation (17) we express the value of pressure *p*, we receive the total zero energy state equation, mentioned above as the relation (10).

From the above mentioned unambiguously results: *The EU model is only one non-formal universe model of the expansive homogeneous and isotropic relativistic–quantum-mechanical universe in the linear approximation with the total zero and local non-zero mass (energy).*

The EU model is the only one model of the expansive homogeneous and isotropic relativistic Universe, which—in the frame of measurement uncertainty—corresponds with the results of the present observations [21, 22, 23, 24].

Note: The model and physical properties of the EU are analysed in more detail in the article: *The model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe in the light of the general relativity, quantum mechanics, and observations* [23].

3 Conclusions

From the analysis given above it results unambiguously that after the evaporation of black hole by Hawking effect, it remains matter-space-time undifferentiated planckon, which in the frame of Heisenberg uncertainty relations is transformed by fluctuation into a new space-time limit-singular closed expansive homogeneous and isotropic relativistic–quantum-mechanical universe with the total zero and local non-zero mass (energy).

From observations, physical and model properties of our observed Universe it results unambiguously that the expansive homogeneous and isotropic relativistic–quantum-mechanical universe with the total zero and local non-zero mass (energy), is the only one possible universe, in which physical properties unambiguously determine also both the physical conditions and the mechanism of its physical, i.e. relativistic–quantum-mechanical origin.

References

[1] C. L. Bennett et al., First Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Preliminary Maps and Basic Results, Astrophysical Journal Supplement Series, 148 (2003), 1-27.
[2] G. Hinshaw et al., Five-year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Data processing, sky maps, and basic results, Astrophysical Journal Supplement Series, 180 (2009), 225-245.
[3] N. Jarosik et al., Seven-year Wilkinson Microwave Anisotropy Probe (WMAP) observations: Sky maps, systematic errors, and basic results, Astrophysical Journal Supplement Series, 192 (2011), 14-55.
[4] M. Planck, Über irreversible Strahlungsvorgänge, Fünfte Mittheilung (Schluss), Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften, 26 (1899), 440-480.
[5] S. Hawking and L. Mlodinow, The Grand Design. New Answers to the Ultimate Questions of Life, Bantam Press, London (2010).
[6] K. Schwarzschild, Über das Gravitationsfeld eines Massenpunktes nach der Einsteinschen Theorie, Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften, 189-196 (1916).
[7] S. W. Hawking, Black hole explosions? Nature, 242 (1974), 30-31.
[8] S. W. Hawking, Particle Creation by Black Holes, Communications in Mathematical Physics, 43 (1975), 199-220.
[9] S. Hawking, Black Holes and Baby Universes and Other Essays, Bantam Books, New York (1993).
[10] S. W. Hawking, A Brief History of Time. From the Big Bang to Black Holes, Bantam Books, New York (1988).
[11] W. Heisenberg, Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik, Zeitschrift für Physik, 43 (1927), 172-198.
[12] V. Skalský, Cosmological considerations and the special theory of relativity, Astrophysics and Space Science, 158 (1989), 145-151.
[13] A. Friedmann, Über die Krümmung des Raumes, Zeitschrift für Physik, 10 (1922), 377-386.
[14] A. Friedmann, Über die Möglichkeit einer Welt mit konstanter negativer Krümmung des Raumes, Zeitschrift für Physik, 21 (1924), 326-332.
[15] H. P. Robertson, Kinematics and World Structure, I, Astrophysical Journal, 82 (1935), 284-301.
[16] H. P. Robertson, Kinematics and World Structure, II, Astrophysical Journal, 83 (1936a), 187-201.
[17] H. P. Robertson, Kinematics and World Structure, III, Astrophysical Journal, 83 (1936b), 257-271.
[18] A. G. Walker, On Milne's Theory of World-Structure, Proceedings of the London Mathematical Society, 42 (1936), 90-127.

[19] V. Skalský, A note of the problem of choosing a model of the Universe, IV, Astrophysics and Space Science, 176 (1991), 313-322. (Corrigendum: V. Skalský: Astrophysics and Space Science, 187 (1992), 163.)
[20] V. Skalský, Vesmír ako fluktuácia vákua (in Slovak), (The universe as a vacuum fluctuation), Slovak University of Technology Press, Bratislava (2002).
[21] V. Skalský, The Wilkinson Microwave Anisotropy Probe (WMAP) confirmed the model of our observed relativistic Universe, Astrophysics and Space Science, 295 (2004), 485-492.
[22] V. Skalský, The model of a flat (Euclidean) expansive homogeneous and isotropic relativistic Universe in the light of the Wilkinson Microwave Anisotropy Probe (WMAP) observations, Astrophysics and Space Science, 321 (2009), 1-4.
[23] V. Skalský, The model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe in the light of the general relativity, quantum mechanics, and observations, Astrophysics and Space Science, 330 (2010), 373-398. This article is also available via the article-id: arXiv:1012.5427v1, or the link: http://arxiv.org/ftp/arxiv/papers/1012/1012.5427.pdf
[24] V. Skalský, The model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe and the Wilkinson Microwave Anisotropy Probe (WMAP) observations, Advanced Studies in Theoretical Physics, 5 (2011), 269-274.

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