HOLY COSMIC CONDENSATE OF ULTRALIGHT GRAVITONS WITH ELECTRIC DIPOLE MOMENT

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Abstract

Quantum modification of general relativity (Qmoger) is supported by cosmic data (without fitting). Qmoger equations consist of Einstein equations with two additional terms responsible for production/absorption of matter. In Qmoger cosmology there was no Big Bang and matter is continuously producing by the Vacuum. Particularly, production of the ultralight gravitons with possible tiny electric dipole moment was started about 284 billion years ago. Quantum effects dominate interaction of these particles and they form the quantum condensate. Under influence of gravitation, the condensate is forming galaxies and producing ordinary matter, including photons. As one important result of this activity, it recently created us, the people, and continues to support us. Particularly, our subjective experiences (qualia) are a result of an interaction between the background condensate and the neural system of the brain. The action potentials of neural system create traps and coherent dynamic patterns in the dipolar condensate. So, qualia are graviton-based, which can open new directions of research in biology and medicine. At the same time, a specialized study of qualia can open a new window into the dark sector of matter. The Qmoger theory explains why most of the ordinary particles are fermions, predicts the mass of neutrino (in accord with the experimental bound) and explained their oscillations (between three flavors) in terms of interaction with the background condensate. The achievements of the Standard Model and the Quantum Field Theory can be combined with the Qmoger theory.

Key words: cosmology with continuous production of energy, ultralight gravitons with tiny electric dipole moment, biophysics, qualia.

1. Introduction.

The level of a civilization, to a high degree, is determined by its cosmology. To the oldest question - Who we are?- this article, based on the described below quantum modification of general relativity (Qmoger), gives the answer: "We are creatures of the cosmic quantum condensate of ultralight dipolar gravitons - particles, which started to seep from the Vacuum about 284 billion years ago". How does it sound?

Let us take it slowly. First of all, in Qmoger the matter/energy is produced continuously. This is in contrast with the conventional Big Bang cosmology [1] with singular release of energy about 13.7 billion years ago. Some problems with Big Bang theory are described in Ref. 1, 2. Additional critical analysis of the old cosmology and main results of new cosmology, supported by cosmic data (without fitting, see below), were presented in Ref. 3, 4 and references there. In the new cosmology, our universe was quietly born in the infinite past (mathematically speaking). At those times there was nothing but the Vacuum with small quantum fluctuations. Than, about 327 billion years (*by*) ago an embryonic universe was born with size about Planck length $l_P = (G_* \hbar c)^{1/2} \sim 1.6 \times 10^{-37} cm$ ($G_* = Gc^{-4}$, G - gravitation constant, c - speed of light, $\hbar$ - Planck constant) and mass:

$$M_1 = \rho_0 l_P^3 \approx 10^{-128} gram, \tag{1}$$

where ρ_0 is the current averaged mass density of the universe. At this stage, one may naturally ask two questions: why 327 *by* and why ρ_0? Qmoger theory answer these and other questions (even more important).

2. Quantum modification of general relativity (Qmoger).

Qmoger equations are presented in the Appendix along with derivation of exact analytical solution:

$$a(\tau) = a_0 \exp[H_0 \tau - 2\pi(\tau/L_*)^2], \; L_* = (G_* \varepsilon_0)^{-1/2}, \; \tau = ct. \tag{2}$$

Here $a(\tau)$ is the time dependent averaged size of the universe (scale factor), subscript 0 indicate initial (current) value, $\varepsilon_0 = \rho_0 c^2$ is the energy density, H_0 is Hubble constant, divided by c - current value of $H(\tau) = \dot{a}/a$, where dot indicate differentiation with respect to τ. Solution (2) corresponds to constant energy density $\varepsilon(\tau) = \varepsilon_0$. That is why we have ρ_0 in (1). According to WMAP data [5], we use $\rho_0 \approx 2.6 \cdot 10^{-30} gram \cdot cm^{-3}$, which includes dark and ordinary matter, but not the so called dark energy, which we do not need in our theory.

In fact, problems with dark energy (ridiculously small cosmological constant) were a major motivation for the Qmoger theory, presented originally in Ref. 6. This work was presided by invention of new type of fluid, namely, dynamics of distributed sources/sinks [7,8], which in turn where presided by exact analytical solution of the (1+1)-dimensional Newtonian gravitation [9]. I love to simplify things and to get analytical solutions (second motivation for Qmoger). In Ref. 9 it was shown, particularly, that Newtonian gravitation leads to singularities in spacial dimensions 1 and 2. So, the third motivation for Qmoger was to get rid of singularities, particularly, from Big Bang - see, how smooth is function (2).

Solution (2) formally gives beginning of the universe at infinite past with $a(-\infty) = 0$. But, (2) is the solution of the differential equations for the time-space metric, which is supposed to be smooth. So, in frame of the Qmoger theory, it seems natural to start with size l_P, when we can expect formation of smooth spacetime metric. Putting $a(\tau) = l_P$ in (2), we get equation for τ. Solution of this equation, corresponding to the past, gives 327 *by* [10, 4].

According to (2), evolution of the universe is determined by characteristic physical scale $L_* \approx 76$ billion light years (*bly*), which is comparable with the size of the visible universe $a_0 \approx 46.5$ *bly*. Remarkably, $H_0 L_* \approx 2.6$. The temporal scale H_0^{-1} and the eternal scale L_* are of the same order because currently $a(\tau)$ is relatively close to its maximum. Indeed, after reaching maximum $a_{\max} \approx$

$1,32a_0$ at $t_{\max} \approx 12.6by$ from now, $a(\tau)$ decreases and $a(\infty) = 0$ (see details in Ref. 4).

It seems natural to assume that mass m_0 of the dark matter particles (DMP), which fill out the universe, is determined by condition that the relativistic uncertainty of partial position [11] (or Compton wavelength) $\hbar/m_0 c$ is of order of L_*. This gives:

$$m_0 = \hbar(G_* \rho_0)^{1/2} \sim 5 \cdot 10^{-67} gram. \tag{3}$$

These particles we call gravitons, because only gravity field was used in the theory. In this paper we will not compare such definition with many definitions and use of gravitons in the literature [12]. Let us only stress, that Qmoger theory is not Hamiltonian (see also Appendix). Gravitons in this theory are not virtual, but real particles with small, but finite mass (3) [compare with electron mass $m_e \sim 9 \cdot 10^{-29} gram$] and, possibly, with some electromagnetic properties (see below).

Concentration of gravitons n and characteristic scale l (averaged distance between them) are:

$$n = \rho_0/m_0 \sim 0.5 \cdot 10^{37} cm^{-3}, \; l = n^{-1/3} \sim 0,27 \cdot 10^{-12} cm. \tag{4}$$

The mass of the embryonic universe (1) indicates, that there are particles (or quasiparticles) with masses smaller than the mass of graviton m_0. We will call such particles vacumos (see also below). It seems that a metrical part of the Vacuum is feeding the universe with vacumos, not unlike an ovary is feeding a fruit, and becomes a part of it. The supply of vacumos may come from an external part of the Vacuum, which do not need to be equipped with a metric. To determine when universe started to produce gravitons, we put $a(\tau) = l$ into (2), solve equation for τ and got the result: 284 *by* ago [10, 4]. So, it took 43 *by* of "incubation" to accommodate universe for production of gravitons.

Formula (2) does not have any fitting parameters and shows good quantitative agreement with cosmological observations (SnIa, SDSS-BAO and reduction of acceleration of the expanding Universe [13]). Comparison with observational data was made in Refs. 14, 15, 3 , see also Fig.1 below. We can not expect better agreement of a global solution with data obtained from particular galaxies, evolution of which does not have to be synchronized. Effect of local bangs in galaxies on scale factor is described in terms of isenthalpic process ($w \equiv \rho c^2 + p = w_0$, where p is pressure) [16]. Let us stress, solution (2) avoids major longtime controversies [critical density of the universe, dark energy (ridiculously small cosmological constant) and inflation].

The ultralight gravitons have huge concentration (4). The "ordinary" matter (OM) in this theory was synthesized from dark matter in galaxies [3, 4]. Averaged concentration (4) is not only enormous, but also constant. It means, that these particles somehow communicate with each other and polarize vacuum in order to maintain averaged distance l (4). Remember, that we are dealing with unusual fluid [7, 8]. The thermal de Brogle wavelength [17] for the temperature of the universe $T \approx 2.73K$ is many orders bigger than l: $\hbar c(l k_B T)^{-1} \approx 3 \cdot 10^{11}$

(k_B - Boltzmann constant). This estimate is for massless particles. For non-relativistic gravitons with mass m_0 the relation is $\hbar l^{-1}(m_0 k_B T)^{-1/2} \approx 7 \cdot 10^{13}$. So, the quantum effects, such as Bose-Einstein condensate, can dominate, even for high temperature.

In the areas of gravitational condensation (future galaxies) the density was much higher than (4). With certain critical density, we can expect local bangs (recall Ref. 9) with multiple collisions and formation of new particles in some sort of "natural selection". During the steady and stable expansion of the universe, the ordinary matter (OM) was synthesized in this way, probably, starting with light particles. Particularly, the production of neutrinos from the background gravitons and the oscillation (between the three flavors) are described recently [18, 19] in frames of Qmoger. The estimated mass $m_* = \rho_0^{1/4} (\hbar/c)^{3/4} \approx 3.13 \cdot 10^{-36} gram \approx 1.76 \cdot 10^{-3} eV/c^2$ [18, 19] corresponds to the experimental bound [20]. The neutrino oscillations are example of an interface between dark and ordinary matter (Idom). Another and possibly related example of Idom is our subjective experiences (see below). The introduced above vacumos could be expected to participate in both these phenomena.

The background condensate of gravitons, being under pressure in galaxies, is forming new particles and expels them from the hot places. This explains why most of the ordinary particles are fermions, obeying the Pauly exclusion principle. This also can lead to an additional acceleration of ordinary matter relative to the background condensate, which will be considered in detail in future work. These processes were accompanied by radiation, which is reflected in cosmic microwave background (CMB). The eqilibrium character of CMB and the small global curvature of the universe are naturally explained by the large amount of time available for the evolution. Some peculiarities of CMB can be associated with synthesis of various particles in expanding universe. Particularly, the observed anisotropy of CMB can be connected with nonsynchronous processes in galaxies.

In context of the type of evolution, which is described by exact solution (2), what we call ordinary matter is, in fact, an exotic matter, which was synthesized from gravitons and, so far, constitute about 15% of the total mass of the universe (standard 4% corresponds to inclusion of dark energy). Taking into account the history of the universe, the vacumos (see above), the indicated below spectrum of mass and mediators between gravitons and OM (perhaps, connected with vacumos), we can not be sure that graviton is elementary particle. Moreover, we can not be sure that gravitons obeys all the rules of the conventional quantum theory. It is possible, that gravitons and mediators produce some quantum effects for "ordinary" matter (see new interpretation of quantum theory [21]).

3. Electric dipole moment of gravitons.

The baryonic asymmetry of the universe (prevalence of matter over antimatter) can be explained if gravitons have nonzero electric dipole moment (EDM). Indeed, EDM of primary particles can break the reflection symmetry and give advantage to matter over antimatter. It will also help to explain synthesis of some particles from the dipolar quantum condensate. Additionally, EDM of gravitons helps to explain qualia [22] and brightens the dark sector of matter (see also next section and Appendix). In a mean time, simple estimation can be made in frame of Qmoger. From mass m_0 (3), l_P and c we have unique expression for EDM:

$$d \sim m_0^{1/2} l_P^{3/2} c \sim 2 \times 10^{-72} gram^{1/2} cm^{5/2} \sec^{-1} \tag{5}$$

There is also scale $l_0 = m_0 G c^{-2} \sim 4 \cdot 10^{-95} cm$, which is much smaller than l_P. So, we have small nondimensional parameter $\nu = l_0/l_P \sim 2.5 \cdot 10^{-62}$ and more general formula $d = m_0^{1/2} l_P^{3/2} c N(\nu)$. We will get (5), assuming that $N(0)$ is finite. Using ν, we have spectrum of mass: $m(\alpha) = m_0 \nu^{\alpha}$. Scale l_0 and vacumos (for $\alpha > 0$) can be related not only to the early evolution, including indicated above "incubation" period, but also to mediators. Vacumos and mediators are potentially observable, particularly, in connection with the neutrino oscillations [18, 19] and qualia.

Let us note, that presented calculations of mass (3) and EDM (5), actually, do not require the full acceptance of the Qmoger theory. It is sufficient to accept, that ρ_0 is an important parameter.

4. Conclusions.

In the described theory we got that gravitons constitute omnipresent background in the universe. As a result of gravitation, from that background emerged OM. The indicated above mediators can be produced spontaneously, or during collisions. The "plasma" of gravitons and mediators produces ordinary matter, including photons. So, we got interface between dark and ordinary matter (Idom). Such interface very likely exists not only in cosmos, but everywhere, including our body and our brain[1)]. A model of Idom is described in Ref. 22. From that model it follows that our subjective experiences (qualia) are manifestations of Idom and can be used as a natural detector of interaction between gravitons and ordinary matter. The typical action potentials (say, $30mV$) [23] of neural system can easily create traps and coherent dynamic patterns in the dipolar condensate with obtained above values of particle mass (3) and EDM (5). The necessary for qualia enormous number of degrees of freedom is supplied by huge concentration of gravitons (4). So, our subjective experiences are graviton-based. This can open new directions of research in biology and medicine. It also justify the given above answer to the big question: Who we are? - at the present level of understanding.

That answer suggest a specialized study of qualia, which can shed some light on the nature of the dipolar condensate of gravitons. The EDM (5) is small and existing telescopes do not see gravitons (dark matter). It seems also difficult to observe gravitons in the supercollider and in other high-energy machines. But we actually see the collective effects (condensate) of gravitons in qualia. By manipulating with action potentials of the neuron system and quantifying qualia responses, we can open a new window into the dark sector of matter. The neutrino oscillations are also connected to Idom [18, 19] and investigation of both phenomena (experimentally and in terms of Qmoger) can be mutually beneficial.

Appendix: Qmoger equations.

Qmoger equations, introduced in Ref. 6 and discussed in more detail in Ref. 4, differ from the Einstein equations by two additional terms responsible for production/absorption of matter by the vacuum:

$$R_i^k - \frac{1}{2}\delta_i^k R = 8\pi G_* T_i^k + \lambda_N \delta_i^k,\ T_i^k = wu_i u^k - \delta_i^k p,\ w = \varepsilon + p, \tag{A1}$$

$$\lambda_N = \lambda_0 + \beta\frac{d\sigma}{ds} + \gamma\sigma^2,\ \sigma = \frac{\partial u^k}{\partial x^k} + \frac{1}{2g}\frac{dg}{ds},\ \frac{d}{ds} = u^k\frac{\partial}{\partial x^k} \tag{A2}$$

Here R_i^k is the curvature tensor, p, ε and w are pressure, energy density and enthalpy density, respectively, $G_* = Gc^{-4}$(G- gravitational constant, c- speed of light), u^k - components of velocity (summation over repeated indexes is assumed from 0 to 3, $x^0 = \tau = ct$), λ_0 is the cosmological constant (which we will put zero), σ is the covariant divergency, β and γ are nondimensional parameters (with particular choice $\beta = 2\gamma = 2/3$, see below) and g is the determinant of the metric tensor. With $\beta = \gamma = 0$ we recover the classical equations of GR. Let us note that curvature terms in lhs of (A1) and additional terms $d\sigma/ds$ and σ^2 all contain second order (or square of first order) derivatives of metric tensor, which make these terms compatible. The importance of σ also follows from the fact that it is the only dynamic characteristic of media, which enters into the balance of the proper number density of particles $n : dn/ds + \sigma n = q$, where q is the rate of particle production (or absorption) by the vacuum. So, if n is constant (see the exact analytical solution (A7) below) or changing slowly, than the σ-effect is, certainly, very important in quantum cosmology. The σ-terms were introduces [6] with such physical argumentation on base of previous works [7-9]. Later, in the case $\beta = 2\gamma$, equations (A1, A2) were derived from the variational principle by simply replacing the cosmological constant λ_0 (in the Lagrangian) by $\lambda = \lambda_0 - \gamma\sigma^2$[14]. Indeed, the variation of $\int d^4x\,(-g)^{1/2}\,\sigma^2$ with respect to the metric tensor produces the two σ-terms in (A1, A2) [14]. But, the system is not Hamiltonian, the vacuum is feeding the universe, so, the standard approach is not appropriate[2)]. Parameters (β, γ), generally, depend on the equation of state [16].

Some exact analytical solutions of equations (A1, A2) where obtained in Ref. 6. On the basis of these solutions, it was concluded that the effect of spacetime stretching (σ) explains the accelerated expansion of the universe and for negative σ (collapse) the same effect can prevent formation of singularity. Equations (A1, A2) reproduce Newtonian gravitation in the nonrelativistic asymptotic, but gravitational waves can propagate with speed, which is not necessary equal to speed of light [14]. This give us a hint that gravitons may have finite mass.

The natural next step was quantitative comparison with cosmological data and choice of parameters β and γ. Let us consider equations for the scale factor $a(\tau)$ in homogeneous isotropic universe, derived from (A1, A2) by standard procedure [Eq. (8,9) in Ref. 6, or Eq. (3, 4) in Ref. 4]:

$$(2-3\beta)\frac{\ddot{a}}{a}+(1+3\beta-9\gamma)(\frac{\dot{a}}{a})^2+\frac{k}{a^2}-\lambda_0=-8\pi G_* p, \tag{A3}$$

$$-\beta\frac{\ddot{a}}{a}+(1+\beta-3\gamma)(\frac{\dot{a}}{a})^2+\frac{k}{a^2}-\frac{\lambda_0}{3}=\frac{8\pi}{3}G_*\varepsilon. \tag{A4}$$

Here points indicate differentiation over τ, the discrete curvature parameter $k = 0, +1, -1$ corresponds to flat, closed and open universe, respectively.

With indicated in Ref. 6 unique choice $\beta = 2\gamma = 2/3$, these equations take simple form:

$$\frac{k}{a^2}=\lambda_0-8\pi G_* p, \tag{A5}$$

$$\dot{H}=\frac{3k}{2a^2}-\frac{\lambda_0}{2}-4\pi G_*\varepsilon,\ H\equiv\frac{\dot{a}}{a} \tag{A6}$$

From (A5) with $\lambda_0 = 0$, we see that sign of curvature is opposite to sign of pressure. From observations we know that global curvature is close to zero. So, the dust approximation ($p = 0$) is natural for this theory with $\lambda_0 = 0$ and $\beta = 2\gamma = 2/3$.

In the dust approximation with $\lambda_0 = 0, k = 0$, two special cases for system (A3, A4) have been indicated [6]: 1) for $\beta = 2/3$ and $\gamma \neq 1/3$ stationary solution exist; 2) for $\beta = 2\gamma$ the global energy is conserved, except for $\beta = 2\gamma = 2/3$. The choice $\beta = 2\gamma = 2/3$ is exceptional and in the dust approximation with $\lambda_0 = 0, k = 0$, equation (A5) is identity and from (A6) we have exact analytical Gaussian solution:

$$a(\tau)=a_0\exp[H_0\tau-2\pi(\tau/L_*)^2],\ L_*=(G_*\varepsilon_0)^{-1/2} \tag{A7}$$

Here subscript 0 indicate present epoch ($\tau = 0$) and H_0 is the Hubble constant. In the analogous solution, obtained in [14], instead of ε_0 was $\varepsilon_0+\lambda_0/8\pi G_*$, for generality.

Solution (A7) corresponds to continuous and metric-affecting production of dark matter (DM) particles out of vacuum, with its density $\rho_0 = \varepsilon_0 c^{-2}$ being retain constant during the expansion of spatially flat universe. In this solution there is no critical density of the universe, which is a kind of relief.

The solution (A7) is shown [14] to be globally stable in the regime of cosmological expansion until $t_{\max}$ about 12.6 billion years from now. After that time, the solution becomes unstable and characterizes the inverse process of dark matter particle absorption by the vacuum in the regime of contraction of the universe. More general class of solutions of Qmoger equations is presented in Ref. 4, 16.

In Qmoger equations we can have some extra terms (Qmoger+) to account for electromagnetic (EM) and other fields, but the presented above σ-terms seems to be unique. Inclusion of EM field in Qmoger is needed for problem of graviton-induced radiation from stars and hot planets (such as Jupiter and Saturn) [16], as well as for investigation of qualia [22]. At the same time, Qmoger with its seeping gravitons could lead to correction of some deficiencies in the Quantum Field Theory, particularly, the inequivalent representations [24]. Indeed, the active background can eliminate unstable representations of reality. In future, we can combine the achievements of the Standard model and the Quantum Field Theory with Qmoger. This will definitely open new directions of research in physics.

[1)] It did not escape my attention, that this approach has important philosophical consequences. Particularly, nonmaterial entities can be considered as interfaces (or collections of interfaces) between different types of matter. Also, the approach can be imbedded in a mathematical structure, similar to the category theory [25], with morphisms (see Ref. 22) and formalized interfaces, but that is another story.

[2)]Note, that Newton and Einstein did not use the Lagrangian and the variational principle. Unfortunately, these days the physical and common sense are often replaced by the variational principle. We can blame textbooks, which are convenient to base on the variational principle. In my opinion, it can lead theoretical physics astray.

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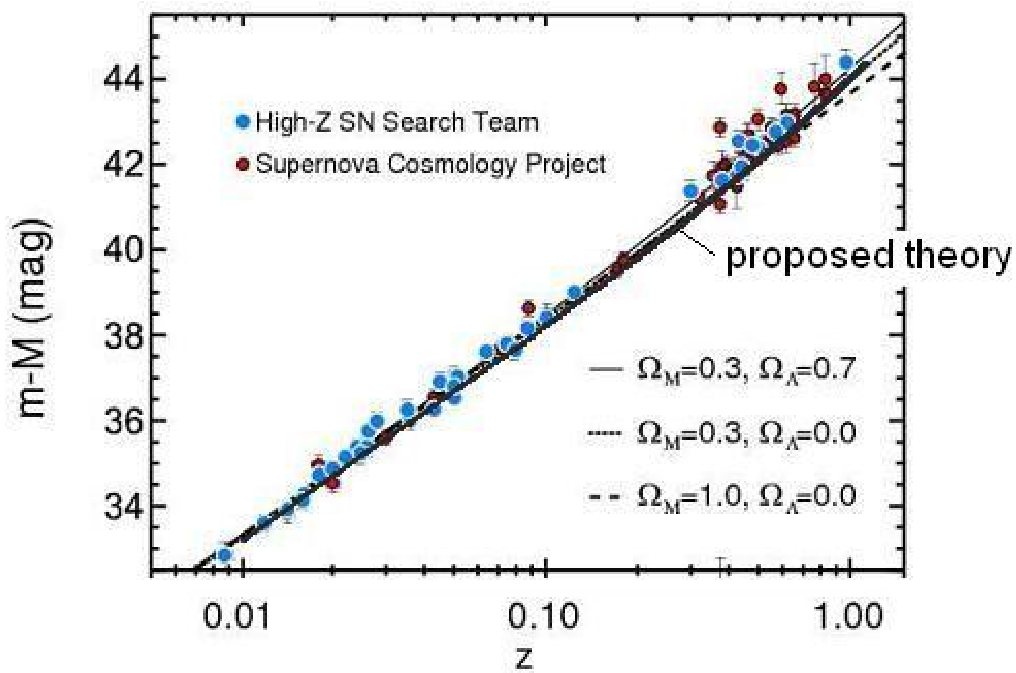
Fig.1. Comparison of exact analytical solution (2) with results of two observational projects and with some parametric models (details in Ref. 14, 15). Here $z = a_0/a - 1$ is the redshift, $m - M$ is the distance module as function of z, m and M are apparent and absolute magnitudes of the source correspondingly. The observations are model-independent.



High-Z SN Search Team
Supernova Cosmology Project
proposed theory
Ω_M=0.3, Ω_Λ=0.7
Ω_M=0.3, Ω_Λ=0.0
Ω_M=1.0, Ω_Λ=0.0
m-M (mag)
z
0.01
0.10
1.00
34
36
38
40
42
44