

## FEEDING THE UNIVERSE, QUANTUM SCALING AND STABLE NEUTRINOS

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### Abstract

Based on the quantum modification of the general relativity (Qmoger), it is shown, that the Vacuum is continuously feeding the universe with ultralight particles (vacumo). Vacuumos are transforming into more heavy (but still ultralight) gravitons, which form quantum condensate even for high temperature. The condensate, under gravitational pressure in galaxies, produces and expels from the hot places the first generation of "ordinary" massive fermions, which are identified with neutrinos. It explains the stability of all three neutrinos, which was a puzzle in the Standard Model. The mass of neutrino, estimated in terms of a new scaling in Qmoger, satisfies the experimental bound. The oscillations of neutrino are explained in terms of interaction with the background condensate of gravitons. The electric dipole moment of neutrino is also estimated. The situation with neutrinos is an example of interface between dark and ordinary matter (Idom), introduced before in explanation of the phenomena of subjectivity.

In the quantum modification of the general relativity (Qmoger), in contrast with the conventional Big Bang theory (BB) [1], the matter (energy) is continuously produced by the Vacuum. The Qmoger equations differs from the Einstein equations of the general relativity by two additional terms, responsible for production (absorption) of matter [2-4]. These works were presided by invention of a new type of fluid, namely the dynamics of distributed sources-sinks [5, 6], which, in turn was presided by exact analytical solution of the (1+1)-dimensional Newtonian gravitation [7]. Qmoger theory was motivated by many deficiencies of BB [1-4, 8]. The additional terms in Qmoger equations take into account the space-time divergency (stretching), the effect of which is comparable with the effect of the space-time curvature in the Einstein theory. The additional motivation of Qmoger is that the Standard Model [9], principally, can not predict absolute values of masses for observable particles, while Qmoger can do this (see below).

The simplest situation with continuous production of matter from the Vacuum is when the averaged density of matter is constant:  $\rho = \rho_0$ . In more general situation [10] the averaged density of enthalpy is constant:  $w = \varepsilon + p = w_0$ , where  $\varepsilon = \rho c^2$  is the energy density,  $p$  is the pressure and  $c$  is the speed of light. The pressure can be high in stars. But the averaged pressure in the universe is small and the dust approximation ( $p = 0$ ) is useful in many situations. In this case, the main parameters in the Qmoger theory are: the gravitational constant  $G$ ,  $c$  and  $\rho_0$ . From these parameters we have unique length scale:

$$L_* = c(G\rho_0)^{-1/2} \quad (1)$$

We use value  $\rho_0 \approx 2.6 \cdot 10^{-30} \text{ gcm}^{-3}$ , which, according to WMAP, includes ordinary and dark matter. We do not include the dark energy, which does not exist in Qmoger (see below). (1) gives  $L_* \approx 76$  billion light years (*bly*) [3, 4], which is comparable with the current size of the visible universe  $a_0 \approx 46.5 \text{ bly}$ . Qmoger equations have corresponding exact analytical solution [11, 3, 4] for the scale factor  $a$  in homogeneous and isotropic universe:

$$a(\tau) = a_0 \exp[H_0\tau - 2\pi(\tau/L_*)^2], \quad \tau = ct, \quad (2)$$

where  $H_0$  is the Hubble constant, divided by  $c$ , which is the current value of function  $H(\tau) = d(\ln a)/d\tau$ . Remarkably,  $L_*H_0 \approx 2.6$ . 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 (see below). In the isenthalpic case ( $w = w_0$ ), which takes into account radiation [10], Qmoger equations have the same solution (2) with  $L_w = c^2(Gw_0)^{-1/2}$  instead of  $L_*$ . These two scales are very close because averaged pressure is small.

Solution (2) does not have any fitting parameters and is in good quantitative agreement with cosmic data [11, 3]. This solution eliminates major controversies - critical density of the universe, dark energy (cosmological constant) and inflation.

In nonrelativistic regime, Qmoger reproduces Newtonian dynamics, but the speed of the gravitational waves can be different from  $c$  [11]. This give us a hint, that gravitons have mass (unlike photon). With scale (1) we associate gravitons with mass  $m_0 = \hbar/(cL_*) \sim 0.5 \cdot 10^{-66} \text{ gram}$  and electric dipole moment (EDM)  $d_0 \sim m_0^{1/2} l_P^{3/2} c \sim 2 \cdot 10^{-72} \text{ gram}^{1/2} \text{ cm}^{1/2} \text{ s}^{-1}$  [3, 4], where  $l_P = (\hbar G/c^3)^{1/2} \approx 1.6 \cdot 10^{-37} \text{ cm}$  is the Planck scale. EDM of background gravitons can explain the baryon asymmetry of the universe (prevalence of particles over antiparticles) in terms of breaking the reflection symmetry. It is shown [3, 4], that such particles form quantum condensate even for high temperature. The concentration of particles  $n$  and characteristic scale are:

$$n = \rho_0/m_0 \approx 5 \cdot 10^{36}, \quad l = n^{-1/3} \approx 2.7 \cdot 10^{-13} \text{ cm}. \quad (3)$$

According to (2), the universe was born in the infinite past ( $a(-\infty) = 0$ ) from small fluctuation. But, formula (2) is solution of Qmoger differential equations for the space-time metric, which is assumed to be smooth. The smooth metric we can expect only starting with condition  $a = l_P$ . It is natural to associate this condition with the beginning of the universe in frame of the Qmoger theory. From that condition, using (2), we get time [3, 4]:  $t_1 \approx -327$  billion years. The mass of the embryonic universe can be estimated by  $M_1 = \rho_0 l_P^3 \approx 10^{-128} \text{ gram}$ . This result suggest existence of particles (or quasiparticles) with much smaller mass than  $m_0$  (see also below). Any such particle we will call vacumo. It seems reasonable to suggest, that Vacuum is feeding universe with vacumos.

The next important step in the evolution of the universe is the production of gravitons with indicated above mass  $m_0$ . The corresponding condition is:  $a = l$ . In this case, (2) gives [4] :  $t_2 \approx -284$  billion years. So, it took about 43 billion years of nurturing the universe to accommodate it for production of gravitons. It seems natural, that the feeding comes from an external part of the Vacuum, which do not have to be equipped with a metric. The mature universe transforms vacuum into gravitons, which form the background quantum condensate. Size of the universe (2) reaches the maximum  $a_{\max} \approx 1.32 a_0$  at time  $t_{\max} = (L_*^2 H_0)/(4\pi c) \approx 12.6$  billion years. It was shown [11], that universe is globally stable during expansion ( $-\infty < t < t_{\max}$ ). But, after that it becomes unstable and additional investigation is needed for evolution of the universe at  $t > t_{\max}$ .

During formation of galaxies (in a manner described in Ref. 7), in stars and in hot planets (Jupiter, Saturn), the local density of matter becomes large and new "ordinary" particles (including photons) are synthesized. In these processes, instead of  $G$ , the Planck constant  $\hbar$  becomes important. Note, that in the Standard Model [9], from parameters  $\hbar$  and  $c$  one can not construct a mass, a length scale or such characteristics as EDM. So, Standard Model, principally, can not predict absolute values of masses for observable particles and corresponding scales. In Qmoger, from  $c$ ,  $\hbar$  and  $\rho_0$ , we now have unique scale:

$$l_* = \hbar^{1/4} (c\rho_0)^{-1/4} \approx 10^{-2} cm. \quad (4)$$

We can rewrite (3) in the form:

$$l_* = \frac{\hbar}{cm_*}, \quad m_* = \rho_0 l_*^3 = \rho_0^{1/4} (\hbar/c)^{3/4} \approx 3.1326 \times 10^{-36} gram \approx 1.76 \cdot 10^{-3} eV/c^2. \quad (5)$$

So, scale  $l_*$  corresponds to the Compton wavelength of a particle with mass of background matter occupying volume of size  $l_*$ . This indicates a mechanism of formation new particles from background gravitons. Mass  $m_*$  is determined uniquely by the new scaling. Apparently, it is a typical mass of the first generation of "ordinary" massive particles, produced by indicated mechanism from the background condensate. It is easy to expel such particles from the hot places if they are fermions, obeying the Pauli exclusion principle. Among the experimentally observed particles, neutrino is the best candidate for being produced in this way. Indeed, mass  $m_*$  corresponds to experimental bound for the mass of neutrino [12]. The time scale:

$$t_* = (\hbar/\rho_0)^{1/4} c^{-5/4} \approx 3.3 \cdot 10^{-13} s \quad (6)$$

could be associated with formation and acceleration ( $c/t_* \sim 8.46 \cdot 10^{22} cms^{-2}$ ) of neutrino, as well to the neutrino oscillations [12]. The physics of these oscillations can be related to interaction of neutrino with the background condensate of described above ultralight dipolar gravitons. The averaged number of gravitons interacting with such neutrino can be estimated by  $N_* = m_*/m_0 \sim 10^{30}$ .

During a flight, neutrino can temporary carry along a coherent group of gravitons (perhaps, in a form of vortex ring). This can influence the effective mass and the flavor of neutrino [12]. The stability of all three neutrinos was unexplainable in frames of Standard Model. But, in frames of Qmoger, the stability seems natural for the first generation of particles, produced by the background gravitons. The new scaling also predict EDM for neutrino or similar particles:

$$d_* = \hbar^{3/2} c^{1/2} \rho_0^{-1/2} \approx 5.8 \cdot 10^{-11} \text{gram}^{1/2} \text{cm}^{5/2} \text{s}^{-1}, \quad (7)$$

which is much bigger than indicated above EDM of graviton. Note, that Qmoger with its seeping gravitons could also correct some deficiencies of the quantum field theory, such as inequivalent representations [13]. Indeed, the active background can eliminate unstable representation of reality.

The situation with neutrino is an example of interface between dark and ordinary matter (Idom), which was introduced in Ref. 14 in explanation of the phenomena of qualia ( subjective experiences). In future, we can combine the achievements of the Standard Model and the quantum field theory with Qmoger and new scaling. This will open new directions of research in physics and biology.

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