ISENTHALPIC QUANTUM GRAVITY

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Abstract
New simple and exact analytical solutions of Einstein equations of general relativity (GR) and of Qmoger (quantum modification of GR) equations are obtained. These solutions corresponds to processes with invariant density of enthalpy (energy plus pressure). Interpretation of this solutions in terms of cosmic radiation and production of massive particles, as well as comparison with cosmic data (without fitting), are presented. It is suggested, that isenthalpic processes can be relevant also to excessive radiation from Jupiter and Saturn. Similar processes potentially can be used as a new source of energy on Earth.

In recent papers [1, 2] it is suggested that "ordinary matter" was synthesized from the dipolar background gravitons in local bangs (LB) during formation of galaxies. This concept is based on the quantum modification of general relativity (Qmoger), which was introduced in Ref. 3 and developed in Ref. 4-6, 1, 2. These works were presided by invention of new type of fluid, namely, dynamics of distributed sources-sinks [7, 8], which in turn was presided by the exact general analytical solution for the (1+1) dimensional Newtonian gravitation [9]. This solution, particularly, describes local gravitational collapses, leading to LB.

Critical analysis of the conventional Big Bang theory [which is based on solution of Einstein equations with the cosmological constant (CC) and hypothesis of inflation], was presented in Ref. 2. The Qmoger equations differ from the Einstein equations by two additional terms, which takes into account production/absorption of gravitons. Exact analytical solution of the Qmoger equations for the scale factor in the homogeneous and isotropic universe [4-6, 1, 2] shows that there was no Big Bang at the beginning. Qmoger theory also eliminates other major controversies [critical density of the universe, dark energy (CC) and inflation]. The indicated solution has no fitting parameters and is in good quantitative agreement with cosmic data (see below). As a big bonus, Qmoger theory also explain our subjective experiences (qualia) in terms of interaction between background dipolar gravitons and neuron system [10].

In his letter we provide new simple solutions of the Einstein and Qmoger equations, which shed some light on evolution of galaxies and LB and open some other applications.

[One can skip complicated equations (1, 2), read notations below and go directly to ordinary differential equations (3, 4)].

Qmoger equations have the form [3]:

$$R_i^k - \frac{1}{2}\delta_i^k R = 8\pi G_* T_i^k + \lambda_N \delta_i^k,\ T_i^k = w u_i u^k - \delta_i^k p,\ w = \varepsilon + p, \qquad (1)$$

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

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 CC, which we will put zero, σ is the covariant divergency, g is the determinant of the metric tensor. For homogeneous and isotropic universe we can consider β and γ as nondimensional constants. But, if we wont to deal with formation of galaxies and LB, these parameters may become dynamical (see below).

With $\beta = \gamma = 0$ we recover the classical equation of general relativity (GR). Let us note that curvature terms in lhs of (1) 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 (5) below) or changing slowly, than the σ-effect is, certainly, very important in quantum cosmology.

Some exact analytical solutions of equations (1,2) where obtained in Ref. 3. 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 (1,2) reproduce Newtonian gravitation in the nonrelativistic asymptotic, but gravitational waves can propagate with speed, which is not necessary equal to speed of light [4]. This give us a hint that gravitons may have finite mass [1, 2].

In the case $\beta = 2\gamma$ equations (1,2) can be derived from the variational principle by simply replacing the cosmological constant λ_0 (in the Lagrangian) by $\lambda = \lambda_0 - \gamma\sigma^2$[4].

Let us consider equations for the scale factor $a(\tau)$ in homogeneous isotropic universe (Eq. (8,9) in Ref. 3):

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

$$-\beta\frac{\ddot{a}}{a} + (1 + \beta - 3\gamma)(\frac{\dot{a}}{a})^2 + \frac{k}{a^2} - \frac{\lambda_0}{3} = \frac{8\pi}{3} G_* \varepsilon. \tag{4}$$

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 [3] unique choice $\beta = 2\gamma = 2/3$, these equations take simple form:

$$\frac{k}{a^2} = \lambda_0 - 8\pi G_* p, \tag{3*}$$

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

From (3*) 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 (3-4) have been indicated [3]: 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 (3*) is identity and from (4*) we have exact analytical Gaussian solution:

$$a(\tau) = a_0 \exp[H_0\tau - 2\pi(\tau/L_*)^2],\ L_* = (G_*\varepsilon_0)^{-1/2} \tag{5}$$

Here subscript 0 indicate present epoch ($\tau = 0$) and H_0 is the Hubble constant. In analogous solution, obtained in [4], instead of ε_0 was $w_0 = \varepsilon_0 + \lambda_0/8\pi G_*$, for generality. Other solutions of system (3)-(4) are obtained [6, 2] for various ranges of parameters, below we will present new additional solutions.

Formula (5) corresponds to continuous and metric-affecting production of dark matter (DM) particles (gravitons) 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. Formula (5) does not have any fitting parameters (no CC /dark matter, no inflation) and shows good quantitative agreement with cosmological observations (SnIa, SDSS-BAO and reduction of acceleration of the expanding Universe [11]) [4, 5]. See also below the Figure: comparison of (5) with two observational projects and with some parametric models, details in Ref. 4, 5.

During the epoch of local bangs (ELB), the dust approximation may not be adequate and choice of parameters (β, γ) can depend on the equation of state. For modeling of this situation, we rewrite (3, 4) with $\lambda_0 = 0, k = 0$ in the form:

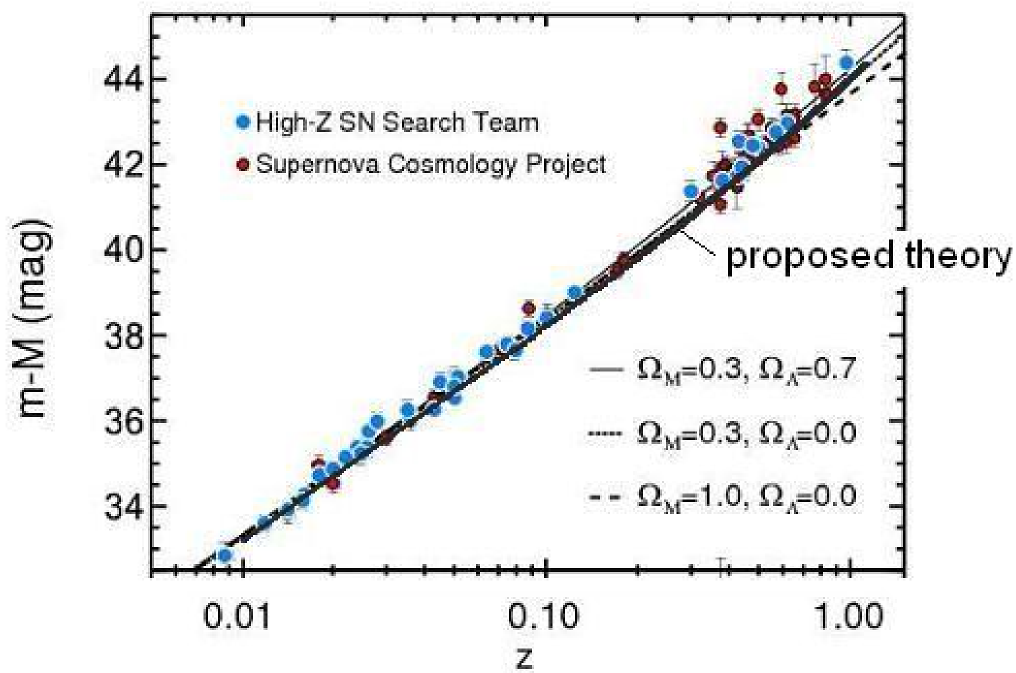
$$\dot{H} = -4\pi G_* w \tag{6}$$

$$4\pi G_*(2 - 3\beta)w + 3(3\gamma - 1)H^2 = 8\pi G_* p,\ \varepsilon = w - p. \tag{7}$$

In order to let averaged pressure change during ELB , we can assume $w = \varepsilon + p = const$. Note, that in Qmoger, as well as in classical GR, the absolute value of enthalpy density is important, in contrast with the nonrelativistic thermodynamics, where only changes of enthalpy are essential. From (6) we have:

$$H(\tau) = H_0 - 4\pi G_* w\tau. \tag{8}$$

So, with constant w, the scale factor $a(\tau)$ remains of the form (5) with $L_w = (G_* w)^{-1/2}$ instead of L_*:


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

$$a(\tau) = a_0 \exp[H_0\tau - 2\pi(\tau/L_w)^2] \tag{9}$$

According to (7, 8), if β and γ are constants and $\gamma \neq 1/3$, than p and ε are now quadratic functions of τ. This is a new class of solutions (for various β and γ) of Qmoger equations, in addition to solutions presented in Ref.2. Particularly, with $\beta = \gamma = 0$, from (7, 8) we have:

$$\varepsilon = \frac{3}{8\pi G_*}\left(H_0 - 4\pi G_* w\tau\right)^2, \; p = w - \varepsilon. \tag{10}$$

As far as we know, (9, 10) give a new solution of the Einstein equations.

During formation of galaxies and LB, parameters β and γ are, generally, no longer constant. For isenthalpic processes we can assume them to be functions of p/w. Taking into account that vacuum can produce and absorb matter, it seems natural to consider even functions. The simplest model for deviation from used above values $\beta = 2/3$, $\gamma = 1/3$, has the form:

$$\beta = \frac{2}{3}[1 - b(\frac{p}{w})^2], \; \gamma = \frac{1}{3}[1 + k(\frac{p}{w})^2], \tag{11}$$

where b and k are positive constants. Substitution of (11) into (7) gives nontrivial solution:

$$\frac{p}{w} = \frac{8\pi G_* w}{8\pi G_* w b + kH^2(\tau)}, \; \varepsilon = w - p. \tag{12}$$

Taking into account (8), we see that the averaged pressure goes from 0 at $\tau = -\infty$, riches maximum $p_m = w/b$ at $\tau_m = H_0/(4\pi G_* w)$ and goes again to 0 at $\tau = \infty$. Averaged energy density starts with $\varepsilon = w$ at $\tau = -\infty$, decreases to minimum $w(1 - 1/b)$ at τ_m and then return to the original value w. Such behavior of averaged pressure and energy seems physically reasonable. Part of the energy, radiated during formation of galaxies and LB, absorbs in contraction. Positivity of energy ($\varepsilon > 0$) gives restriction on parameter $b > 1$.

Choice of isenthalpic process is dictated by the form of Einstein and Qmoger equations and leads to simple Gaussian solution (9). We can speculate that such processes are wide spread in Nature and wait to be discovered (see below) [12].

Note, that solution of Einstein equations (with $\beta = \gamma = 0$) and solution of Qmoger equation give the same scale factor (9) corresponding to cosmic data with $w \approx \varepsilon_0$ (see Figure). But unlimited increase of energy in solution of Einstein equation (10) with $\tau \to \pm\infty$ looks unphysical.

Formulas (11) can be used also for local calculation of galaxies formation and LB with Qmoger equations. More details can be obtained by inclusion electromagnetic terms into Qmoger equations. Isenthalpic processes of dipolar gravitons can produce radiation and magnetic field not only in stars, but also in a planet core. Excessive radiation of Jupiter and Saturn [13] could be connected with this phenomena. Similar isenthalpic processes potentially can be used as a new source of energy on Earth. Indeed, dipolar gravitons, which are seeping from the vacuum, are ultralight and they did not loose yet energy to cosmic radiation. It is a primary ("organic") fuel. In combination with the effect of quantum entanglement, which is inversely proportional to particle mass [14], such source can be made energy efficient.

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