NEW EXACT SOLUTIONS OF EINSTEIN AND QMOGER EQUATIONS AS ALTERNATIVE TO BIG BANG

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Abstract
New exact analytical solutions of Einstein and Qmoger (quantum modification of general relativity) equations are obtained in the context an alternative to the Big Bang theory.

In recent papers [1, 2] it is suggested that "ordinary matter" was synthesized from the background gravitons (with estimated tiny electric dipole moment [1, 2]) in local bangs (LB) during formation of galaxies. This concept is based on the quantum modification of general relativity (Qmoger), with 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 of the (1+1) dimensional Newtonian gravitation [9]. This solution, particularly, describes local gravitational collapses, leading to LB.

Critique of the conventional Big Bang theory, based on solution of Einstein equations with the cosmological constant (CC), 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. This solution has no fitting parameters and is in good quantitative agreement with cosmic data (see below). However, formation of galaxies and LB could lead to some local deviations from the scale factor obtained for homogeneous and isotropic universe. Particularly, formation of galaxies can locally slow down expansion and LB can have opposite effect. In his letter we provide some new solutions of the Einstein and Qmoger equations, which can shed light on evolution of galaxies and LB.

Qmoger equations have the form [3]:

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

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

Here R_i^k is the curvature tensor, p, ε and w are pressure, energy density and heat function, 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 CC, which we will put zero, σ is the covariant divergency, β and γ are nondimensional constants and g is the determinant of the metric tensor. 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. 2):

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

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

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 [10]) [4, 5], see also 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. In order to model 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 $w = \varepsilon + p = const$. From (6) we have:

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

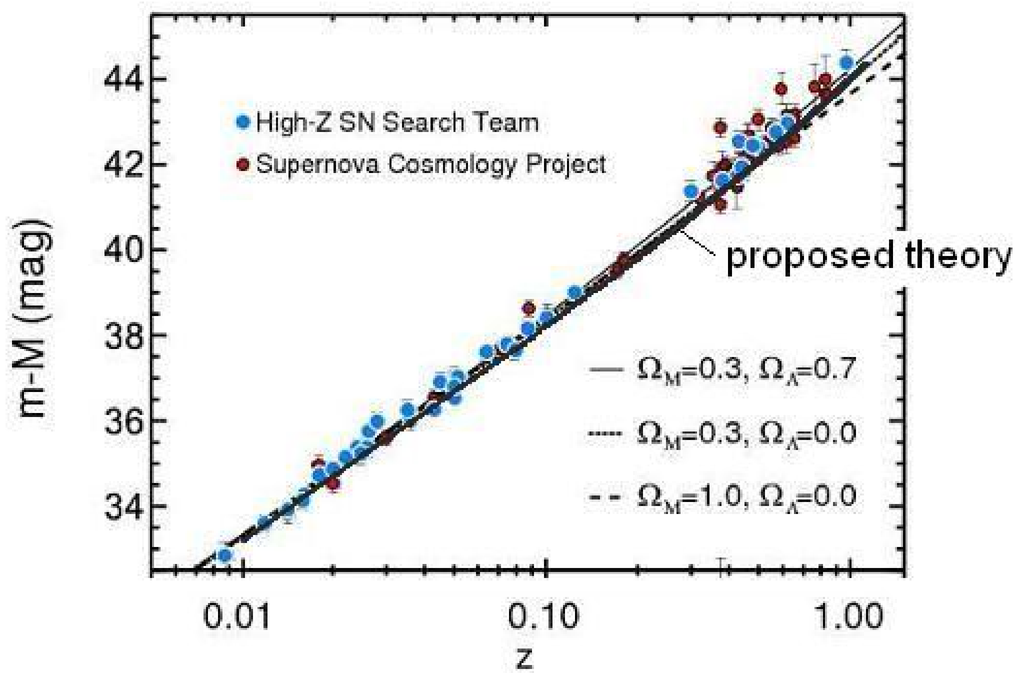
So, with constant heat function w, the scale factor $a(\tau)$ remains of the form (5) with $L_w = (G_* w)^{-1/2}$ instead of L_*:

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

According to (7, 8), with $\gamma \neq 1/3$, 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.



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

A matching of obtained in this letter new exact solutions (7 - 9) with (5) and comparison with observational data requires an additional work and will be presented elsewhere.

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