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# Correction of Standard Model in View of Improved Gravity Equation

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**Abstract** In the framework of general relativity, systematically deal with the problems of galaxy formation and evolution. Einstein's equation of gravitational field is first improved, space-time is proved to be infinite and its expansion and contraction are in circles, the singular point of big bang didn't exist, Besides, it is disclosed that galaxies or celestial bodies form from unceasing growth but not the assemblage of existent matter after big bang, new matter continuously creates in the interior of celestial bodies depending on the work done by the negative pressure, and in the same time celestial bodies, galaxies and space synchronously enlarge in accordance with Hubble expansion, cosmic density and pressure keep unchanged.

***Keywords:*** *background coordinate system, convex lens effect of space-time expansion, negative pressure*

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## 1. Introduction

Though general relativity has gotten quite success, some significant fundamental problems such as the problem of singular point, the problem of horizon, the problem of distribution and existence of dark matter and dark energy, the problem of the formation of celestial bodies and galaxies, always are not solved satisfactorily. And besides, physicists in the course of dealing with gravitation often can not be in a consistent manner, for example the inflation, as it is demanded to explained horizon difficulty it had to exist and today it must be thrown away due to not being demanded. Another similar question is so-called cosmic constant, as people research the motion in a central field it is dumped from gravitational field equation and as people research the big scope space-time structure it is picked back to gravitational field equation, obviously in order to explain a certain facts so subjective choice is never scientific manner. In a word, the prolonged existence of these problems exposes that our fundamental theory needs further improvement. In the paper we get these problems well solved by improving Einstein' s equation.

## 2. Correction of Einstein's Field Equation and Removing of Cosmological Difficulties

### 2.1. Correction of Einstein's Gravitational Field Equation

Einstein's gravitational field equation [1,2], which decides space-time metric, is the following equation

$$R_{\mu\nu} = \gamma(T_{\mu\nu} - \frac{1}{2}Tg_{\mu\nu}) \tag{1.1}$$

where $\gamma$ is the coupling coefficient, $T_{\mu\nu} \equiv (\rho + p)U_\mu U_\nu + pg_{\mu\nu}$ is the energy-pressure tensor of ideal fluid.

In the paragraph we find out the more rational weak field approximate solution of the static spherical symmetry and in the same time reconfirm the coupling coefficient $\gamma$ and pressure inside gravitational source. Unlike previous work that in advance pressure within gravitational source was assumed zero, now the pressure will be solved together with metric.Our discussion is still in natural unit (light speed $c$=1) and in Cartesian right-angle coordinate system $x^\mu = (x^0, x^1, x^2, x^3) = (t, x, y, z)$. In the coordinate system, Minkowski metric is appoint as

$$\eta_{\mu\nu} = \begin{pmatrix} \eta_{00} & \eta_{01} & \eta_{02} & \eta_{03} \\ \eta_{10} & \eta_{11} & \eta_{12} & \eta_{13} \\ \eta_{20} & \eta_{21} & \eta_{22} & \eta_{23} \\ \eta_{30} & \eta_{31} & \eta_{32} & \eta_{33} \end{pmatrix} = \begin{pmatrix} -1 & & & \\ & 1 & & \\ & & 1 & \\ & & & 1 \end{pmatrix}$$

line element $ds^2 \equiv -d\tau^2 = g_{\mu\nu}dx^\mu dx^\nu$, here $s = i\tau$, $\tau$ is proper time. $U^\mu \equiv dx^\mu / d\tau$, $U_\mu \equiv g_{\mu\nu}U^\nu$, then $U_\mu U^\mu \equiv g_{\mu\nu}U^\nu U^\mu = -1$,

$$\begin{aligned} T &= g^{\mu\nu}(\rho + p)U_\mu U_\nu + pg^{\mu\nu}g_{\mu\nu} \\ &= (\rho + p)U_\mu U^\mu + 4p = 3p - \rho. \end{aligned}$$

And for weak field, $g_{\mu\nu} = h_{\mu\nu} + \eta_{\mu\nu}$, $|h_{\mu\nu}| << 1$,

$$\Gamma^\mu_{\alpha\beta} = \frac{1}{2}\eta^{\mu\rho}(\frac{\partial g_{\rho\alpha}}{\partial x^\beta} + \frac{\partial g_{\rho\beta}}{\partial x^\alpha} - \frac{\partial g_{\alpha\beta}}{\partial x^\rho}), \qquad h^\mu_\beta = \eta^{\mu\rho}h_{\rho\beta},$$

$h = h^{\mu}_{\mu} = \eta^{\mu\rho} h_{\mu\rho}$. Omitting smaller than $o(h^2)$ Ricci tensor becomes

$$R_{\mu\nu} = \Gamma^{\sigma}_{\mu\sigma},_{\nu} - \Gamma^{\sigma}_{\mu\nu},_{\sigma}$$
$$= \frac{1}{2}\eta^{\sigma\lambda} h_{\mu\nu,\lambda,\sigma} + \frac{1}{2}(h_{,\mu,\nu} - h^{\lambda}_{\mu,\lambda,\nu} - h^{\sigma}_{\nu,\sigma,\mu}).$$

Note that here semicolons stand for co-variant derivative with respect to corresponding coordinate and commas stand for common derivative, and repeated indexes up and low imply Einstein's summation, and for weak field indexes go up or down through $\eta^{\mu\nu}$ or $\eta_{\mu\nu}$. In order to solve easily, may as well assume ( harmonic condition)

$$2h^{\sigma}_{\mu},_{\sigma} = h_{,\mu}. \tag{1.2}$$

Here four dimension indexes $\alpha, \beta, \lambda, \sigma, \mu, \nu = 0,1,2,3$. Take (1.2) derivative with respect to $x^{\nu}$, we have $2h^{\sigma}_{\mu},_{\sigma},_{\nu} = h_{,\mu,\nu}$ and likewise $2h^{\sigma}_{\nu},_{\sigma},_{\mu} = h_{,\nu,\mu}$. And for $h,_{\nu},_{\mu} = h,_{\mu},_{\nu}$ then

$$h,_{\mu},_{\nu} - h^{\lambda}_{\mu},_{\lambda},_{\nu} - h^{\sigma}_{\nu},_{\sigma},_{\mu} = 0$$

which means field equation (1.1) is decomposed into (1.2) and the following equation:

$$\nabla^2 h_{\mu\nu} - \frac{\partial^2 h_{\mu\nu}}{\partial t^2} = 2\gamma(T_{\mu\nu} - \frac{1}{2}T\eta_{\mu\nu})$$
$$= 2\gamma[(\rho + p)U_{\mu}U_{\nu} + \frac{\rho - p}{2}\eta_{\mu\nu}],$$

whose diagonal elements have delay solution $h_{\lambda\lambda} = -\frac{\gamma}{4\pi}\int \frac{2(\rho+p)U^2_{\lambda} + (\rho - p)\eta_{\lambda\lambda}}{\xi} dx'dy'dz'$, here $\xi = \sqrt{(x-x')^2 + (y-y')^2 + (z-z')^2}$, the integral is in full space. For static state $U^j = 0$, $U^0 = 1$, $U_0 = \eta_{0\mu}U^{\mu} = -1$, $U_j = \eta_{j\mu}U^{\mu} = 0$, space index $j = 1,2,3$. In order to make sure the external metric components $g_{00} = -1 + \frac{2GM}{r}$ and $g_{jj} = -1 + \frac{2GM}{r}$ the coupling coefficient must be confirmed as $\gamma = 4\pi G$ instead of the previous $-8\pi G$, and meanwhile for $r = \sqrt{x^2 + y^2 + z^2} \geq r_e$, $r_e$ is the source's radius ( celestial body), there must exist $\int \frac{p}{\xi} dx'dy'dz' = -\int \frac{\rho}{\xi} dx'dy'dz' = -\frac{M}{r}$, the integral is in full space. Note that outside the gravitational source both $p$ and $\rho$ vanish, thus we get

$$\int pdxdydz = -\int \rho dxdydz = -M. \tag{1.3}$$

And for static state time reverse must be symmetric, which means $h_{0j}$, $j = 1,2,3$. Next solve the other three $h_{ij}$ .Obviously if use delay solution like diagonal elements, then $h_{ij} = 0$, however (1.2) can not be satisfied, must research nonzero $h_{ij}$. substituting $h^{\sigma}_{\mu} = \eta^{\sigma\lambda}h_{\lambda\mu}$, $h = \eta^{\nu\lambda}h_{\nu\lambda} = -h_{00} + 3h_{11}$, $h_{11} = h_{22} = h_{33}$, $h^i_j = h_{ij} = h_{ji} = h^j_i$, $h^i_0 = h_{0i} = 0$, $h^0_i = -h_{0i} = 0$ into (1.2) obtains three partial differential equations

$$2(h_{13},_1 + h_{23},_2) = (h_{11} - h_{00}),_3$$

$$2(h_{12},_1 + h_{23},_3) = (h_{11} - h_{00}),_2$$

$$2(h_{12},_2 + h_{13},_3) = (h_{11} - h_{00}),_1$$

differentiating them obtains

$$h_{ij},_i,_j = \frac{1}{4}\left[(h_{11} - h_{00}),_i,_i + (h_{11} - h_{00}),_j,_j - (h_{11} - h_{00}),_k,_k\right]$$

here $i \neq j$, $i \neq k$, $k \neq j$, $i,j,k = 1,2,3$. $x^1 = x$, $x^2 = y$, $x^3 = z$. For $r \to \infty$, $h_{ij} \to 0$, thus $h_{ij}$ are given by

$$h_{ji} = \frac{1}{4}\int_{\infty}^{x^j}\int_{\infty}^{x^i}\left[\left(\frac{\partial^2}{\partial(x^i)^2} + \frac{\partial^2}{\partial(x^j)^2} - \frac{\partial^2}{\partial(x^k)^2}\right)(h_{11} - h_{00})\right]dx^i dx^j.$$

On the other hand, conserved law $T^{\mu}_{\nu;\mu} = 0$, for weak field it becomes $T^{\mu}_{\nu,\mu} = 0$ which is easily proved [1,2]. And applied it to the static state, $0 = T^{\mu}_{\nu,\mu} = [(\rho + p)U_{\nu}U^{\mu}]_{,\mu} + (p\delta^{\mu}_{\nu})_{,\mu} = \frac{\partial p}{\partial x^{\nu}}$, that is to say, $p$ is constant within the source, and using $\nabla^2(h_{00} - h_{jj}) = \nabla^2 h_{00} - \nabla^2 h_{jj} = 16\pi G p$ can verify

$$\nabla^2 h_{ji} = \frac{1}{4}\int_{\infty}^{x^j}\int_{\infty}^{x^i}\left[\left(\frac{\partial^2}{\partial(x^i)^2} + \frac{\partial^2}{\partial(x^j)^2} - \frac{\partial^2}{\partial(x^k)^2}\right)\nabla^2(h_{11} - h_{00})\right]dx^i dx^j = 0.$$

So far all the metric components are determined. It is considerable that from equation (1.3) we conclude that $p = -\bar{\rho}$ ( bar means average), obviously when matter density is uniform $p = -\bar{\rho} = -\rho$, which is very important because is fit to describe the isotropic universal space.

Now the coupling coefficient is reconfirmed as $4\pi G$ to replace the previous $-8\pi G$, corresponding pressure in source takes negative, Einstein's field equation is rewrote as

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 4\pi G T_{\mu\nu} \tag{1.4}$$

Compared with the original $R_{\mu\nu} - 1/2Rg_{\mu\nu} = -8\pi GT_{\mu\nu}$, equation (1.4) is obviously a correction, but the structure doesn't change. Derived with the artificial assumption that the interior pressure of source is zero, coefficient $-8\pi G$ has a congenitally deficient, and the more serious is it give the wrong component $g_{jj} = 1 + \frac{2GM}{r}$ but not the correct $g_{jj} = 1 - \frac{2GM}{r}$. Now we explain why $g_{jj} = 1 - \frac{2GM}{r}$ are correct and $g_{jj} = 1 + \frac{2GM}{r}$ are wrong. Note that the meaning of derivative of coordinate with respect to proper time $\tau$ isn't clear, when we use geodesic $\frac{d^2x^\mu}{d\tau^2} + \Gamma^\mu_{\nu\lambda}\frac{dx^\nu}{d\tau}.\frac{dx^\lambda}{d\tau} = 0$ to solve acceleration or velocity the proper time $\tau$ need be eliminated so as to compare with the relativistic dynamic equation $\frac{d(m\mathbf{v})}{dt} = -\frac{GMm}{r^3}\mathbf{r}$, $m = m_0/\sqrt{1-v^2}$ is relativistic mass of moving particle, and eliminating proper time geodesic is

$$\frac{d^2x^\mu}{dt^2} + \Gamma^\mu_{\nu\lambda}\frac{dx^\nu}{dt}\cdot\frac{dx^\lambda}{dt} - \Gamma^0_{\nu\lambda}\frac{dx^\nu}{dt}\cdot\frac{dx^\lambda}{dt}\cdot\frac{dx^\mu}{dt} = 0 \quad (1.5)$$

in which the derivatives of coordinate with respect to time $t$ are usual speed, their physical meanings are clear and have common language with usual knowledge. Equation (1.5) is a basic formula of post Newtonian mechanics. Substituting the weal field metric solved out above into equation（1.5）can prove equation (1.5) to reduce to he relativistic dynamic equation. Proof**:** May as well take the motion along X-axis for example, emphasize $g_{11} = 1 - \frac{2GM}{x}$, then $\Gamma^1_{00} = \frac{GM}{x^2}$, $\Gamma^1_{11} = \frac{GM}{x^2}$, $\Gamma^0_{01} = \frac{GM}{x^2}$, $\frac{dy}{dt} = \frac{dz}{dt} = 0$, $v_x = \frac{dx}{dt}$, from equation (1.5) put $\mu = 1$, $\frac{d^2x}{dt^2} + \Gamma^1_{00} + \Gamma^1_{11}\frac{dx}{dt}.\frac{dx}{dt} - 2\Gamma^0_{10}\frac{dx}{dt}.\frac{dx}{dt} = 0$, it means $\frac{d^2x}{dt^2} + (1 - v_x^2)\frac{GM}{x^2} = 0$, namely $\frac{d(mv_x)}{dt} = -\frac{GMm}{x^2}$. In fact,

$$\frac{d}{dt}\left[mv_x\right] = m_0\left[v_x\frac{d\left(1-v_x^2\right)^{-1/2}}{dt} + \left(1-v_x^2\right)^{-1/2}\frac{dv_x}{dt}\right]$$
$$= \left(1-v_x^2\right)^{-3/2}\frac{d^2x}{dt^2}m_0 = m\left(1-v_x^2\right)^{-1}\frac{d^2x}{dt^2}.$$

However using the previous $g_{11} = 1 + \frac{2GM}{r}$, then $\Gamma^1_{11} = -\frac{GM}{x^2}$, we get $\frac{d^2x}{dt^2} + (1 - 3v_x^2)\frac{GM}{x^2} = 0$ which goes against the principle of light speed is limit and obviously isn't $\frac{d(mv_x)}{dt} = -\frac{GMm}{x^2}$ and thus is a wrong equation. So far we say $g_{jj} = 1 - \frac{2GM}{r}$ is correct and $g_{jj} = 1 + \frac{2GM}{r}$ is wrong, and it is because $g_{jj} = 1 - \frac{2GM}{r}$ replace $g_{jj} = 1 + \frac{2GM}{r}$ that new equation (1.4) replaces the original field equation.

Must point out that both classical mechanics and relativity don't really refuse negative pressure, in classical mechanics only gradient of pressure appears in equation of motion and the value of pressure may be arbitrary, and in relativity not only the gradient but also the value appear in equation of motion, so the value can not take arbitrarily and need be specified, and it is through the scrupulous calculation that the negative pressure is brought in and not other an assumption.

## 2.2. The Principle of Equal-density Expansion of Celestial Bodies

Applying $T^{\mu\nu}{}_{;\nu} = 0$ to the interior of a celestial body such as the sun or the earth, note that $g_{\mu\nu;\alpha} = 0$, $g^{\mu\nu}{}_{;\alpha} = 0$, $(nU^\alpha)_{;\alpha} = 0$,

$$0 = (U_\beta U^\beta)_{;\alpha} = U_\beta U^\beta{}_{;\alpha} + U_{\beta;\alpha}U^\beta$$
$$= U_\beta U^\beta{}_{;\alpha} + (g_{\mu\beta}U^\mu)_{;\alpha}U^\beta = 2U_\beta U^\beta{}_{;\alpha}$$
$$0 = d\tau U_\alpha T^{\alpha\beta}{}_{;\beta} = dp - d\tau\left[(\rho + p)U^\beta\right]_{;\beta}$$
$$= dp - nd\left(\frac{\rho + p}{n}\right) = -n\left(pd\frac{1}{n} + d\frac{\rho}{n}\right),$$

we obtain

$$pd\frac{1}{n} + d\frac{\rho}{n} = 0 \quad (1.6)$$

where $n$ is number density of particles in the body. Obviously $1/n$ stands for single-particle volume and $\rho/n$ stands for single-particle mass. Of course, here so-called particles not always mean molecule or atom, it may is a small part of the body. May as well treat whole celestial body as a particle, then $n = 1/V$,

$$dm = d(\rho V) = -pdV \quad (1.7)$$

$V$ is volume of the body and $m$ is its mass. Obviously, as $p = -\rho$, we have $d\rho = 0$ or $\rho = const$, which indicates that the density doesn't change in the course of the expansion and new matter creates continuously in the interior of celestial body. (1.7) indicates that the increase of mass doesn't really violate conserved law of energy and it is the result that negative pressure does work. Analogical discussion had already done in 1951 by W. H. McCrea.[3]. Here the appearance of negative pressure is a conclusion of field equation (1.4) but not an extra introduction so there is no problem on logic.

Certainly, equation (1.7) is also fit to describe the change of mass of a galaxy, when describe a galaxy $\rho$

and $p$ refer to the average density and pressure within the galaxy, respectively.

**Theorem**: if celestial bodies, galaxies and space synchronously expand namely they simultaneously enlarge in accordance with Hubble expansion, universal density keeps up invariant.

Proof: in space select a volume $V_1$------- a sphere of radius $r_1$, and $V_2$ and $\rho_2$ are respectively the volume and density of a celestial body inside $V_1$, its radius is $r_2$. Then in volume $V_1$ the average density of matter is $\rho_1 = m/V = \rho_2 V/V_1$, $m$ is mass of the body. Note that $\rho_2$ is invariant in the course of the body's expansion, Hubble expansion means $v_1 = Hr_1$, $r_1 = f_1 R(t)$, $V_1 = k_1 R^3(t)$, and $v_2 = Hr_2$, $r_2 = f_2 R(t)$, $V_2 = k_2 R^3(t)$, and here $v_1, v_2$ are expanding rate relative to each center, and $k_1$, $k_2$, $f_1$, $f_2$ are constants, $R(t)$ is the scale factor of universe, we conclude that

$$\rho_1 = m/V_1 = \rho_2 V_2/V_1 = \rho_2 k_2 R^3(t)/k_1 R^3(t) = \rho_2 k_2/k_1 = const,$$

and when the selected volume $V_1$ is enough large $\rho_1$ is just the so-called universal density. So far the theorem is proved. Of course, here proof is simplified, actual matter's distribution inside $V_1$ may not be a standard sphere, however we can suppose to divide them into some spheres to deal with and the conclusion is still the same.

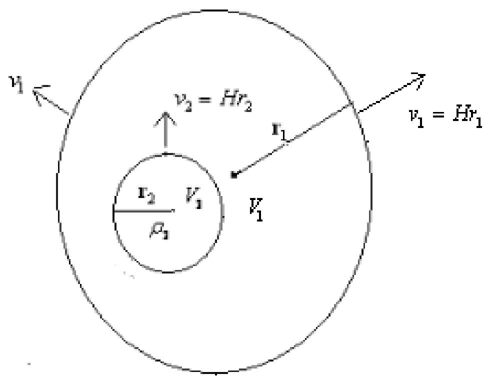


**Figure 1.** Sketch map to describe space and body expand together

## 2.3. Application of Equation (1.4) to Cosmology--The Package Solution of Cosmological Difficulties

The application of (1.4) to cosmology shows strongly the correctness of (1.4) and many difficulties in cosmology are coherently solved. With $l$ as standard radial coordinate, in the co-moving coordinate system $x^\mu = (x^0, x^1, x^2, x^3) = (t, l, \theta, \varphi)$, Robertson-Walker metric [1,2], describes isotropic space, is given by

$$ds^2 = -dt^2 + R^2(t)\left[\frac{1}{1-kl^2}dl^2 + l^2 d\theta^2 + l^2 \sin^2\theta d\varphi^2\right]$$

$R(t)$ is just the scale factor mentioned above. Proper distance to origin point $d_p = R(t)\int_0^l dl/\sqrt{1-kl^2}$, proper rate $v_p = Hd_p$, $H \equiv dR/Rdt$. Combining Robertson-Walker with (1.4) gets two independent equations

$$\left(\frac{dR}{dt}\right)^2 + k = \frac{4\pi G}{3}\rho R^2 \qquad (1.8)$$

$$\frac{d\rho}{dt}R + 3\frac{dR}{dt}(p+\rho) = 0. \qquad (1.9)$$

Consequently the constant $k$ must be negative, so far universe is proved infinite and no longer depends on so-called critical density. Change (1.9) into $d(\rho a^3) + pda^3 = 0$. For isotropic, using $p = -\rho(t)$ obtains

$$p = -\rho = const, \qquad (1.10)$$

which indicates that universal density and pressure invariant in spite of expansion, and according to the above proved theorem we conclude that celestial bodies, galaxies and space synchronously expand to obey Hubble law, and the density of celestial bodies or galaxies themselves invariant too, therefore the mass of any celestial body or galaxy changes and meets $m/V = m/kR^3(t) = const$, that is to say, for arbitrary two moments $t_1$, $t_2$

$$m(t_1)R^3(t_2) = m(t_2)R^3(t_1) \qquad (1.11)$$

(1.11) shows that galaxies form from continuous growth. Recent observations found X-shaped structure in the central of Milky Way [4], which implies big galaxies weren't come from galactic merge, and therefore (1.11) correctly reflects the course of galaxy formation. And solving equation (1.8) gives

$$R(t) = A\sin\left(t\sqrt{4\pi G\rho/3}\right) \qquad (1.12)$$

$A$ is a positive constant. So far universal expansion and contraction prove circular like a harmonic oscillator.

Next we derive "our universal age", namely the time from last $R(t) = 0$ (at this moment, $t$ may as well take 0) to today. With $H \equiv dR/Rdt = 2\sqrt{\pi G\rho/3}\,ctg\left(2t\sqrt{\pi G\rho/3}\right)$, "our universal age "reads

$$t_0 = tg^{-1}\sqrt{q_0}/(H_0\sqrt{q_0}) = 1.37\times 10^{10}\,yr. \qquad (1.13)$$

Here take $q_0 = 0.14$ and $H_0 = 70km\cdot s^{-1}\cdot Mpc^{-1}$. And actual observations show $q_0 \equiv \frac{4\pi G\rho}{3H_0^2} = 0.1 \pm 0.05$. Note that the subscript 0 stands for today. Now the horizon of universe is

$$d_h(t) \equiv R(t)\int_0^t dt/R(t) = \sin\left(t\sqrt{4\pi G\rho/3}\right)\int_0^t dt/\sin\left(t\sqrt{4\pi G\rho/3}\right) = \infty, t > 0. \qquad (1.14)$$

So-called horizon puzzle no longer exists, observed in any time universe is infinite for any observation is in a time interval. We think universal size is zero at the moment *R* (t) =0, but universe looks infinite at any time. Further using (1.4) can obtain the new relation between distance and re-shift of a distant galaxy or celestial body [7]

$$H_0 d_L = \frac{z+1}{\sqrt{q_0+1}} \ln \frac{(z+1)\sqrt{q_0+1}+\sqrt{(q_0+1)(z+1)^2-q_0}}{1+\sqrt{q_0+1}} \quad (1.15)$$

$d_L$ is luminosity distance. With $q_0 = 0.14$, $H_0 \equiv H(t_0) = 70km \cdot s^{-1} \cdot Mpc^{-1}$, (1.15) well conforms to current observations [5-7] and powerfully prove (1.4) successful. $H_0 d_L = z + \frac{1-q_0}{2} z^2 + \frac{3q_0^2 - 2q_0 - 1}{6} z^3 + \cdots$ is the power series of $z$ and omitting high order small obtains the conventional Hubble law.

## 2.4. Solution to the Puzzle of Dark Matter

The negative pressure as important gravitational source is invisible, and it is the negative pressure that plays as the role of dark matter and mass seems missing, explain as follows.

Speaking generally, within a galaxy the metric field is weak field, may as well regard a galaxy as a celestial body, according to the above discussion, within the celestial body from (1.3), $p = const = -3M / 4\pi r_e^3$, then

$$\begin{aligned} h_{00} &= -G\int \frac{\rho+3p}{\xi} dx'dy'dz' \\ &= -4\pi G\left( r^{-1}\int_0^r \rho r^2 dr + \int_0^{r_e} \rho r dr - \int_0^r \rho r dr \right) \\ &\quad - 6G\pi p r_e^2 + 2G\pi p r^2. \end{aligned}$$

Here $r_e$ is its radius, and according to geodesic equation the gravity acceleration within the galaxy is given by

$$\begin{aligned} g &= -\Gamma_{00}^1 = \frac{1}{2}\frac{dh_{00}}{dr} = 2\pi Gpr + \frac{2\pi G}{r^2}\int_0^r \rho r^2 dr \\ &= 2\pi Gpr + \frac{Gm(r)}{2r^2} \end{aligned} \quad (1.16)$$

where $m(r) \equiv 4\pi\int_0^r \rho r^2 dr$, and $g$ may be positive or negative since pressure is negative, and the negative $g$ indicates the direction of acceleration is towards the center. And the corresponding orbital speed $v$ reads

$$v^2 = -gr = -2\pi Gpr - Gm(r)/2r \quad (1.17)$$

(1.17) tells that even *m*(r) (1.17) vanishes near the center $v$ can also be big, so-called missing mass.the inverse square law begins to restore as $r \ge r_e$ [8]. So far we say that the negative pressure has the dual nature of dark matter and dark energy, and the meaning of equation (1.4) is more rich. The negative pressure is a conclusion of field equation (1.4) but not an extra introduction so more strict on logic than the extra introduction of dark matter and dark energy.

## 2.5. Exact Solution of (1.4) in the Case of Spherical Symmetry in the Background Coordinate System

Firstly, we decide external exact solution of (1.4). Outside gravitational source $\rho$ =0, *p*=0, (1.4) becomes vacuum field equation $R_{\mu\nu} = 0$, in the standard coordinate system its static spherical symmetric solution was given by

$$\begin{aligned} ds^2 \equiv -d\tau^2 &= -\left(1-\frac{2GM}{l}\right)dt^2 + \left(1-\frac{2GM}{l}\right)^{-1} dl^2 \\ &\quad + l^2(d\theta^2 + \sin^2\theta d\varphi^2) \end{aligned} \quad (1.18)$$

*M* is mass of source, $l$ is explained as standard radial coordinate or radial parameter, its physical meaning isn't too clear and only in the far field can be viewed as radius vector. In order to describe clearly position of gravitational field and enable general relativity to have common language with other theories and compare result one another, it is necessary to transform equation (1.18) into the form expressed in background coordinates. Hence we take transformation $l = l(r)$. $r$ is usual radius and also call background coordinate [9], $t, \theta, \varphi$ are standard coordinates and can also be viewed as background coordinates, namely usual time and angle. Now we try to determine the specific form of $l = l(r)$. For the sake, we introduce a transformation equation

$$\frac{dl}{dr} = \sqrt{1-\frac{2GM}{l}} \exp(-\frac{GM}{r}). \quad (1.19)$$

The correctness of equation (1.19) will be seen later. Separating variables gives the solution

$$\begin{aligned} &\sqrt{l(l-2GM)} + 2GM \ln\left(\sqrt{l} + \sqrt{l-2GM}\right) \\ &= C_1 + r - GM \ln r - \frac{1}{2r}G^2M^2 + \frac{1}{12r^2}G^3M^3 + \cdots \end{aligned} \quad (1.20)$$

(1.20) defines a coordinate transformation $l \to r$. Here constant $C_1$ is determined from the continuity of function $l = l(r)$ on the boundary of source, and the back equation (1.26) gives the boundary value $l(r_e)$, $r_e$ denotes source's radius ( celestial body radius). And obviously $l \approx r$ for $r \to \infty$. In fact, equation (1.19) gives $l \to \infty$ for $r \to \infty$, and considering of $\lim_{x\to\infty} \frac{\ln x}{x} = 0$, when $l \to \infty$ the left-hand side of (1.20) is

$$l\left[\sqrt{1-\frac{2GM}{l}} - \frac{GM}{l}\ln l - \frac{2GM}{l}\ln\left(1+\sqrt{1-\frac{2GM}{l}}\right)\right] \approx l,$$

and $r\left(\frac{C_1}{r} + 1 - \frac{GM}{r}\ln r - \frac{G^2M^2}{2r^2} + \frac{G^3M^3}{12r^3} + \cdots\right) \approx r$ for the right-hand side when $r \to \infty$. (1.18) is transformed into the following

$$ds^2 = -\left(1 - \frac{2GM}{l}\right)dt^2 + \exp(-\frac{2GM}{r})dr^2 + l^2\left(d\theta^2 + \sin^2\theta d\varphi^2\right). \quad (1.21)$$

Note that now $l = l(r)$ is already a concrete implicit function with respect to $r$, confirmed by ( 1.20 ), that is to say, with $t, r, \theta, \varphi$ as independent variables (1.21) is the solution of vacuum field $R_{\mu\nu} = 0$. In the distance, (1.21) provides

$$g_{00} = -1 + \frac{2GM}{l(r)} \approx -1 + \frac{2GM}{r},$$

$g_{11} = \exp(-\frac{2GM}{r}) \approx 1 - \frac{2GM}{r}$ , $g_{22} = l^2(r) \approx r^2$ , $g_{33} = l^2(r)\sin^2\theta \approx r^2\sin^2\theta$ , $\Gamma^1_{00} \approx \frac{GM}{r^2}$ , $\Gamma^1_{11} \approx \frac{GM}{r^2}$ , $\Gamma^0_{01} \approx \frac{GM}{r^2}$ , $\Gamma^1_{01} \approx 0$, $\Gamma^0_{00} = 0$, and introducing them into (1.5) for radial motion, $d\theta = d\varphi = 0$, $v = dr/dt$, we get

$$\frac{d^2r}{dt^2} + (1 - v^2)\frac{GM}{r^2} = 0, \quad (1.22)$$

which is just the relativistic dynamic equation, therefore we say that the introduction of equation (1.19) is reasonable and not only line element (1.21) is a solution of field equation but also meets physical requirement.

Now explain why $l$ can not be given the meaning of background coordinate. In fact, if directly put $l = r$ equation (1.18) becomes

$$ds^2 = -\left(1 - \frac{2GM}{r}\right)dt^2 + \left(1 - \frac{2GM}{r}\right)^{-1}dr^2 + r^2(d\theta^2 + \sin^2\theta d\varphi^2). \quad (1.23)$$

Obviously it provide $g_{00} = -1 + \frac{2GM}{r}$, $g_{11} = \left(1 - \frac{2GM}{r}\right)^{-1}$, $g_{22} = r^2$, $g_{33} = r^2\sin^2\theta$, $g_{\mu\nu} = 0(\mu \neq \nu)$,

$$\Gamma^1_{11} = \frac{1}{2}g^{1\rho}(\frac{\partial g_{\rho 1}}{\partial x^1} + \frac{\partial g_{\rho 1}}{\partial x^1} - \frac{\partial g_{11}}{\partial x^\rho}) = -\frac{GM}{(1 - 2GM/r)r^2},$$

$\Gamma^0_{01} = \frac{GM}{(1 - 2GM/r)r^2}$ , $\Gamma^1_{00} = \frac{(1 - 2GM/r)GM}{r^2}$ , $\Gamma^1_{01} = 0$, using (1.5) for radial motion $d\varphi = d\theta = 0$,

$$\frac{d^2r}{dt^2} = -\Gamma^1_{00} - \Gamma^1_{11}v^2 + 2v^2\Gamma^1_{01} = -\left(1 - \frac{2GM}{r}\right)\frac{GM}{r^2} + \frac{3GM}{(1 - 2GM/r)r^2}v^2,$$

in the distance it reduces to $\frac{d^2r}{dt^2} + (1 - 3v^2)\frac{GM}{r^2} = 0$ which is not the relativistic dynamical equation.

Note that the angle of orbital procession described by (1.18) is the same as that described by (1.21) or (1.23), procession angle doesn't change under the transformation of radial coordinates. And using background coordinates general relativity can compare dynamic behavior with other gravitational theories.

Secondly, we decide internal exact solution of equation (1.4) in the background coordinate system. With $l$ as standard radial coordinate the exact interior solution of (1.4) is given by.

$$ds^2 = -\exp\left[C_2 + \int_l^{l_e} f(l)\left(1 + \frac{\omega(l)}{l}\right)^{-1} dl\right]dt^2 + \left(1 + \frac{G\omega(l)}{l}\right)^{-1} dl^2 + l^2(d\theta^2 + \sin^2\theta d\varphi^2) \quad (1.24)$$

here $\omega(l) \equiv 4\pi\int_0^l \rho(l)l^2 dl$ , $f(l) \equiv \frac{G}{l^2}\left[4\pi l^3 p(l) + \omega(l)\right]$ , $l_e = l(r_e)$. Constant $C_2 = \ln[1 - \frac{2GM}{l_e}]$ which makes sure $g_{00}$ is continual on the boundary of the celestial body. About the derivation of (1.24) see [7].

Next we determine the solution in background coordinates. For this, (1.19) is extended as inside the source

$$\frac{dl}{dr} = \sqrt{1 + \frac{G\omega(l)}{l}}\exp\left(-G\iiint\frac{\rho}{\xi}dx'dy'dz'\right). \quad (1.25)$$

Obvious line element (1.24) is transformed into

$$ds^2 = -\exp\left[C_2 + \int_l^{l_e} f(l)\left(1 + \frac{\omega(l)}{l}\right)^{-1} dl\right]dt^2 + \exp\left(-2G\iiint\frac{\rho}{\xi}dx'dy'dz'\right)dr^2 + l^2(d\theta^2 + \sin^2\theta d\varphi^2). \quad (1.26)$$

Here $l = l(r)$ is already a specific function of $r$, which is determined by equation (1.25). Line element (1.26) is just the exact solution sought in background coordinate system $x^\mu = (x^0, x^1, x^2, x^3) = (t, r, \theta, \varphi)$

The solution of (1.25) satisfies the initial condition $l(0) = 0$. In fact, because there is no acceleration tendency towards any direction at the center, $dg_{00}/dr$ must vanish, and from (1.26) we have

$$0 = \frac{dg_{00}}{dr} = \frac{dl}{dr}\frac{dg_{00}}{dl} = \frac{dl}{dr}f(l)\left(1 + \frac{\omega(l)}{l}\right)^{-1}\exp\left[C_2 + \int_l^{l_e} f(l)\left(1 + \frac{\omega(l)}{l}\right)^{-1} dl\right],$$

which indicates $f(l) = 0$ at the center, and so $l = l(0) = 0$ at the center. If $\rho = const = 3M/4\pi r_e^3$, then

$$\int\frac{\rho}{\xi}dx'dy'dz' = \frac{3M}{2r_e} - \frac{M}{2r_e^3}r^2,$$

$\omega(l) = 4\pi\int_0^l \rho(l)l^2 dl = \frac{M}{r_e^3} l^3$, the solution of (1.25) is easily given by

$$\sqrt{\frac{r_e^3}{GM}} \ln\left(\sqrt{\frac{GM}{r_e^3}} l + \sqrt{1 + \frac{GM}{r_e^3} l^2}\right) = \left[r + \frac{GM}{6r_e^3} r^3 + \frac{1}{40}\left(\frac{GM}{r_e^3}\right)^2 r^5 + \cdots\right] \exp(-\frac{3GM}{2r_e}). \quad (1.27)$$

For example, on the surface of the sun $r = r_e = 6.96 \times 10^8$ m, the sun's mass $M = 1.99 \times 10^{30}$ kg, and because the sun isn't too big its density may think constant, and using (1.27) we work out the surface's $l = l(r_e) = 6.96 \times 10^8$ m $-1720$ m. And according to the continuity of $l = l(r)$ on the surface not only we can determine the constant $C_1$ but also can recalculate the deflected angle of light on the surface of the sun. Using (1.18) the deflected angle is given by $\alpha = 4MG/l = 4MG/l(r_e) = 1.78"$, which is more consistent with observational result $(1.89")$ and former theoretical value $\alpha = 4MG/r = 4MG/r = 1.75"$.

Now decide pressure near the surface. On the boundary the gravity acceleration should be continual, using (1.5) and (1.19), (1.21), (1.25), (1.26) obtain $(\Gamma^1_{00})_{r=r_e^+} = (\Gamma^1_{00})_{r=r_e^-}$, namely, $(g^{11}\frac{dg_{00}}{dr})_{r=r_e^+} = (g^{11}\frac{dg_{00}}{dr})_{r=r_e^-}$,

$$\left[\frac{dl}{dr}\frac{d}{dl}\left(1 - \frac{2GM}{l}\right)\right]_{r=r_e^+} = \left\{\frac{dl}{dr}\frac{d}{dl}\exp\left[C_2 + \int_l^{l_e} f(l)\left(1 + \frac{\omega(l)}{l}\right)^{-1} dl\right]\right\}_{r=r_e^-},$$

having simplified, it becomes

$$[4\pi l_e^3 p + \omega(l_e)]\sqrt{l_e - 2GM} = -2M\sqrt{l_e + G\omega(l_e)}. \quad (1.28)$$

Generally say, gravitational field is weak, $l_e = l(r_e) \approx r_e$, $2GM/l_e << 1$, and from (1.28) the boundary pressure $p \approx -\bar{\rho} = 3M/4\pi r_e^3$. The interior pressure can be solved from

$$\frac{dp}{dl} = G(p + \rho)\left(2\pi l^3 p + \frac{\omega}{2}\right)\left(l^2 + lG\omega(l)\right)^{-1}. \quad (1.29)$$

# 3. Local Effect of Cosmic Expansion---- Details of Galaxy Formation and Evolution

It is obviously not sensible only to understand space-time expansion for mutual separation among galaxies, inside a galaxy there should also be corresponding response [10-25], which is the inevitable requirement of space-time's continuity. In fact, with scientific experiments developed, the effect of space-time expansion has already been found in small scope. For example, the earth is found going away from the sun, and the earth itself is also growing, after considering tidal effect the moon has still other motion to leave the earth and so on. In the following we show that it is the local effect of space-time expansion that determines formation and evolution of galaxies. In order to facilitate understanding, we begin with generalizing Newton gravitational theory to expanding space-time and then come into exact description of general relativity.

## 3.1. Newton Theory of Motion in a Central Gravitational Field

So-called central motion refers to that a less object of mass $m$ revolves round a bigger one of mass $M$, and the bigger object may be thought stationary. Newton classical track equation is

$$r = \frac{L^2}{GMm^2(1 + e\cos\varphi)}. \quad (2.1)$$

Here $e = \frac{c}{a} = \sqrt{1 + \frac{2EL^2}{G^2M^2m^3}}$ stands for eccentricity of the cone curve, and $L = m\omega r^2$ stands for angular momentum of revolving object, $E$ stands for its mechanical energy, both $L$ and $E$ are conserved.

For $e < 1$, $E = -GmM/2a$, the curve is ellipse, and $a$ is the semi-major axis. And for $E = 0$, $e = 1$, the curve is parabola. For $E = GMm/2a$, $e > 1$, the curve is hyperbola, $a$ stands for the half distance between two vertexes. The differential equations of dynamics are

$$\frac{dr}{dt} = \pm\sqrt{\frac{2}{m}\left[E - V(r) - \frac{L^2}{2mr^2}\right]} \quad (2.2)$$

$$\frac{d\varphi}{dt} = \frac{L}{mr^2}. \quad (2.3)$$

Here $V(r) = -GMm/r$ is the potential energy of revolving object. In Newton theory both $m$ and $M$ are constants. About equation (2.1), (2.2) and (2.3) readers may refer to any textbook of theoretical mechanics

## 3.2. Generalize Newton Theory to the Expanding Space-time

May as well take ellipse motion for example, classical Kepler law is

$$4\pi^2 a^3 = GMT^2 \quad (2.4)$$

$T$ is the revolution period of object of mass $m$, namely the time the object revolves round the center across $2\pi$ angle to cost, and $M$ is the mass of the central body, $a$ is ellipse's semi-major axis.

Now consider the expansion of space-time, namely think $M$ for variable with respect to time $t$ and meets equation (1.11), and differentiating both sides of equation (2.4) we attain

$$\frac{da}{dt} = aH + \frac{2a}{3T}\frac{dT}{dt}. \quad (2.5)$$

Here $H = dR / Rdt$ is just Hubble parameter and shows the global behavior of universal expansion. The last term of equation (2.5) stands for so-called tidal effect, which has nothing to do with universal expansion, and the term $aH$ stands for the effect of universal expansion. In fact, as $a \to \infty$, $dT$ becomes zero because equation (2.5) must return to the usual Hubble law under such extreme condition, therefore it is reasonable to explain the last term of equation (2.5) for tidal effect.

Equation (2.5) indicates that only considering space-time expansion the points on the ellipse go away from the center and meet Hubble law, the ellipse becomes larger and larger with the speed of revolving object continuously increasing but the period $T$ is invariant. Note that the generalization of Newton theory to expanding space-time belongs still to the theory of low speed.

Extend the result to whole universe, the global picture of universal evolution turns up, that is, not only the space around galaxies enlarges but also celestial bodies and galaxies themselves simultaneously enlarge in accordance Hubble expansion, but the periods of revolution or rotation keep invariant. This means that universal expansion is similar to we are looking towards the sky at night to use a magnifying glass---- all including the space magnify simultaneously in the same proportion. Thus we say that space-time expansion possess convex lens effect, which determines how galaxies form and evolution.

Why the period of rotation of celestial body is also invariant like revolution can so be understood as follows: any celestial body can divide into some small parts and every part can be looked as a object revolving round the common axis, this is to say, the rotation is the integration of revolutions of different part of the celestial body. The convex lens effect of space-time expansion requires angular speed $\omega = \omega(\varphi, t)$ to meet

$$\omega(\varphi, t_1) = \omega(\varphi + 2n\pi, t_2) \quad (2.6)$$

Considering space-time expansion the track equation of revolving object is actually

$$r = r(\varphi, t) = \frac{L^2}{GMm^2(1 + e\cos\varphi)}. \quad (2.7)$$

Notice that now $L$ $L, m, M$ are all the functions with respect to time $t$, $m, M$ meet (1.11), $L = m\omega r^2$. Easily prove eccentricity is still invariant. In fact, write the semi-major axis $a = k_1 R(t)$, the semi-minor axis $b = k_2 R(t)$, $k_1, k_2$ are two constants, $e = c / a$ $= \sqrt{k_1^2 - k_2^2} / k_1 = const.$ However the difference between long axis and short axis increases all the time owe to $a - b = (k_1 - k_2)R(t)$. And from (2.7) we have

$$\frac{r(\varphi, t_1)}{r(\varphi + 2n\pi, t_2)} = \frac{R(t_1)}{R(t_2)} \quad (2.8)$$

correspondingly the orbit speed $v = v(\theta, t)$ of revolving object meets

$$\frac{\mathrm{v}(\varphi, t_1)}{\mathrm{v}(\varphi + 2n\pi, t_2)} = \frac{R(t_1)}{R(t_2)} \quad (2.9)$$

where $n = 0 \pm 1, \pm 2 \cdots$. And further we have $\frac{\partial \mathrm{v}(\varphi, t)}{\partial t} = \mathrm{v}(\varphi, t)H(t)$, which indicates the revolving object has the mean tangential acceleration, this is just the effect of space-time expansion but not exist real tangential force. This result demonstrates the recent observed fact that the revolving speed of the earth is becoming faster and faster because astronomical unit is found increasing but the length of the year is not found to change [14,21], and the fact obviously not understood by conventional knowledge. Equation (2.6) -- (2.9) are enough qualified to describe various motions in central gravitational field and not only fit to deal with elliptic motion.

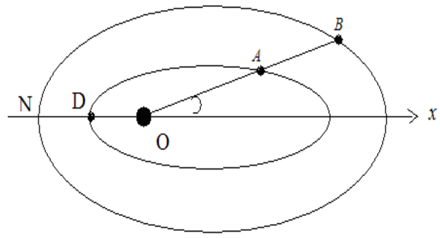


**Figure 2.** Sketch map of a moving particle on different ellipses at different time

**Example 1:** refer to Figure 2. Assume time $t_1$ object is at point D, speed is $v_D$, and if not considering space-time expansion its track is the interior small ellipse, now decide the position and speed of time $t_2$ under considering space-time expansion.

Solving: at time $t_2$ point D arrives at point N to meet Hubble law, the real position of revolving object at time $t_2$ is sure on the ellipse that passes point N, may as well think at point B, and join point O (center body position) to point B, then point A is the position that object should arrive at according to classical theory at time $t_2$, the speed $v_A$ is easily solved using classical theory. Here OD and $v_D$ are already known, since $ON = OD\frac{R(t_2)}{R(t_1)}$, $OB = OA\frac{R(t_2)}{R(t_1)}$, from (2.2) we have $t_2 - t_1 = \int_{OD}^{OA} dr / \sqrt{\frac{2}{m}\left[E + \frac{GMm}{r} - \frac{l^2}{2mr^2}\right]}$, so OA can be decided, notice that here $M, m, l$ take the values of time $t_1$, treated as constants in the course of integral. And according to $\frac{1}{2}mv_D^2 - \frac{GMm}{r_D} = \frac{1}{2}mv_A^2 - \frac{GMm}{r_A}$, we can decide $v_A$, here $r_D = OD.$ Finally using $v_B = v_A R(t_2) / R(t_1)$, we can decide the real speed $v_B$ at time $t_2$.

**Example 2**. Investigate the secular change of distance of perigee or apogee of the moon due to space-time expansion, and referring to the data from tidal rhythmites study the mean speed of lunar recession over the past 450myr, as well the the change of length of sidereal day.

Solving: today, the distance of perigee of the moon is $d_1 = 36.3\times10^4 km$, and according to Hubble expansion in a year the distance increases by $\Delta d_1 = H_0 d_1 \Delta t = 26.13mm$ , here $\Delta t$ takes 1 year, and the distance of apogee is $d_2 = 40.6\times10^4 km$, the corresponding increases in 1 year is $\Delta d_2 = H_0 d_2 \Delta t = 29.23mm$. The increase of the difference between distances of apogee and perigee due to space-time expansion is $\Delta d_2 - \Delta d_1 = 3.1mm$ a year, but observational value is around 6mm [14,15], which means tide only make the increase by 2.9mm a year. And due to space-time expansion the semi-major axis increases by $(\Delta d_2 + \Delta d_2)/2 = 27.68mm$, but the observational value is around 3.8cm (Lunar laser Ranging data), which means tide make the semi-major axis increase only 1.03cm a year today. If attribute all the increase of 3.8cm to tidal effect, through calculation James Williams found the change of eccentricity unreasonable [14,15,16].

The above result show that the influence of the tide is quite limited to lunar orbit and the effect of space-time expansion is the main dynamic for orbit to evolve. And only when the scale of celestial body is not too small compared with the distance between two celestial bodies the effect of tides is distinct.

Now calculate the average speed of lunar recession over the past 450myr. Tidal rhythmites tell us that the Ordovician period (began 485myr ago and ended 443myr ago) a year had 382.7 sidereal days and 13.81 sidereal months [20]. Since the period of revolution of the earth does not change neglecting the tides of sun-earth system, thus the length of the year keeps invariant, then the length of a sidereal month was given by $\frac{365.24\times24hr}{13.81} = 634.7hr$, today the length is $\frac{365.24\times24hr}{13.37} = 655.6hr$ . Using [20] $\frac{4\pi^2 a^3}{T^2} = GM_e$ and $R(t) = A\sin\left(t\sqrt{4\pi G\rho/3}\right)$, universal observed density $\rho = 3.1\times10^{-24} kg/m^3$, for two moments $t_0$, $t_1$

$$\frac{a^3(t_0)}{T^2(t_0)} \div \frac{a^3(t_1)}{T^2(t_1)} = \frac{M_e(t_0)}{M_e(t_1)} = \frac{R^3(t_0)}{R^3(t_1)} \quad (2.10)$$

may as well take $t_0 = 1.37\times10^{10} yr$,

$$t_1 = (1.37-0.045)\times10^{10} yr,$$

$T(t_1) = 634.7hr$, $T(t_0) = 655.6hr$, $a(t_0) = 38.4\times10^4 km$, from (2.10) we obtain $a(t_1) = 36.27\times10^4 km$. Thus the average rate of the increase of lunar semi-major axis over the past 450myr is now

$$\frac{\Delta a}{\Delta t} = \frac{(38.4-36.27)\times10^9 cm}{4.5\times10^8 yr} = 4.7cm/yr \quad (2.11)$$

Which indicates the past recession rate was higher than today's 3.8cm/yr and is compatible with the tidal formula $a^{11/2}\frac{da}{dt} = const$ [16,23]. Using it the recession rate during the Ordovician is calculated for

$$\begin{aligned} \frac{da(t_1)}{dt} &= (\frac{a_0}{a_1})^{11/2}\frac{da(t_0)}{dt} \\ &= (\frac{38.4}{36.27})^{11/2}\times3.8cm/yr = 5.2cm/yr \end{aligned} \quad (2.12)$$

which demonstrates that the farther distance is, the weaker effect of tides is.

However without considering the change of the earth's mass, using Kepler law the corresponding mean recession rate is calculated for $\frac{(38.4-37.5)\times10^9 cm}{4.5\times10^8 yr} = 2cm/yr$ which is lower than today's 3.8cm/yr and obviously isn't self-consistent. This is just so-called the anomaly of recession rate of the moon. And once considering (1.11) the anomaly no longer arises. Next, estimate the change rate of length of sidereal day today.

During the Ordovician the length of a sidereal day was $\frac{365.24\times24hr}{382.7} = 22.9hr$, and today is $23.9hr$. Thus the mean change rate of the length of a sidereal day over the past 450myr is

$$\frac{\Delta T_e}{\Delta t} = \frac{(23.9-22.9)\times3600s}{4.5\times10^8 yr} = 0.8ms/cy. \quad (2.13)$$

Since space-time expansion does not change a variety of periods of rotation or revolution, the change of length of day originate only from tide, and for tidal interaction angular momentum is conserved and the following empirical equation (2.14) derived by R. G. Williamson [15] is still valid to treat tidal question.

$$\frac{d\Omega}{dt} = (49\pm3)\frac{dn}{dt} \quad (2.14)$$

Where $\Omega$ is angular speed of rotation of the earth, and $n$ is the angular speed of revolution of the moon. Using (2.5) the change rate of length of sidereal month is today (following the subscript m and e refer to the moon and the earth, respectively),

$$\frac{dT_m}{dt} = \frac{3T_m}{2a}(\frac{da}{dt} - Ha) = \frac{3\times655.6\times3600\times1.03s}{2\times38.4\times10^9 yr} = 9.4ms/yr.$$

And using $\frac{dT_e}{T_e^2 dt} = (49\pm3)\frac{dT_m}{T_m^2 dt}$ the change rate of length of sidereal day is today calculated as

$$\frac{dT_e}{dt} = (0.61\pm0.05)ms/cy \quad (2.15)$$

This result is smaller than the average value of 0.8ms/cy, and therefore is reasonable and again verify that the past tidal action is stronger than today.

However, other some works such as according to eclipse records over 2700 years without considering space-time expansion conclude that the current change rate of day length is $(1.7\pm 0.05)ms/cy$, which is obviously higher than the average value of 0.8ms/cy and therefore is unreasonable. This is just so-called the anomaly of the change of length of day [10,11,12,13,14]. In a word the the past change rate should be faster than today.

### 3.3. Link with Exact Description of General Relativity

Next, we prove that equation (2.6) ~ equation (2.9) are the approximations of exact description of general relativity under low speed and weak field.

Birkhoff 's theorem indicates that in the gravitational field of spherical symmetry, no matter how the gravitational source behaves, as long as the spherical symmetry keeps up the line element is the same form

$$ds^2 = -(1-\frac{2Gk}{l})dt^2 + (1-\frac{2Gk}{l})^{-1}dl^2 + l^2(d\theta^2 + \sin^2\theta d\varphi^2). \quad (2.16)$$

This is to say, with $t,l,\theta,\varphi$ as independent variables (2.16) is a solution of vacuum field equation $R_{\mu\nu}=0$. When the mass of central body changes and meets equation (1.11) the gravitational field is still described by (2.16), in other words equation (2.16) not only describes static-source gravitational field but also variable-source gravitational field, only requirement is the spherical symmetry keeps up. In the metric field described by (2.16), for a revolving object, in $t,l,\theta,\varphi$ coordinate system, metric $g_{00}=-1+\frac{2Gk}{l}$, $g_{11}=\left(1-\frac{2Gk}{l}\right)^{-1}$, $g_{22}=l^2$, $g_{33}=l^2\sin^2\theta$, $g_{\mu\nu}=0(\mu\neq\nu)$, and as plane motion $\theta=\frac{\pi}{2}$,, geodesic equation

$$0=\frac{d^2\varphi}{d\tau^2}+\Gamma^3_{\alpha\beta}\frac{dx^\alpha}{d\tau}\frac{dx^\beta}{d\tau}=\frac{d^2\varphi}{d\tau^2}+\frac{2}{l}\frac{dl}{d\tau}\frac{d\varphi}{d\tau},$$

its solution is $\frac{d\varphi}{d\tau}l^2=const=\varepsilon$, and another $0=\frac{d^2t}{d\tau^2}+\Gamma^0_{\alpha\beta}\frac{dx^\alpha}{d\tau}\frac{dx^\beta}{d\tau}=\frac{d^2t}{d\tau^2}+\frac{1}{g_{00}}\frac{\partial g_{00}}{\partial l}\frac{dl}{d\tau}\frac{d\varphi}{d\tau}$, its solution is $\frac{dt}{d\tau}(1-\frac{2GK}{l})=const=\alpha$, and combining with (2.16) obtains the trajectory equation of revolving object

$$\frac{\varepsilon^2}{l^4}\left(\frac{dl}{d\varphi}\right)^2+\frac{\varepsilon^2}{l^2}=(\alpha^2-1)+\frac{2Gk}{l}+\frac{2Gk\varepsilon^2}{l^3} \quad (2.17)$$

$\alpha$ and $\varepsilon$ are two integral constants. Readers may refer to any textbook of general relativity about (2.17). In the distance or in weak field after neglecting $2Gk\varepsilon^2/l^3$, (2.17) has the approximate solution

$$l=\frac{\varepsilon^2}{Gk(1-e\cos\varphi)}. \quad (2.18)$$

Compared with (2.6) and (2.7), for specific central body of mass $M$ (t) we conclude that constant $k=M(t)/R^3(t)$ And now we need investigate the behavior of motion of the object in background coordinate system, so we introduce transformation $t'=t$, $l=l'(r)/R(t)$, and considering of (1.20) $l'=l'(r)$ is required to meet

$$\sqrt{l'(l'-2Gk)}+2Gk\ln\left(\sqrt{l'}+\sqrt{l'-2Gk}\right) = C_1+rGk\ln r-\frac{1}{2r}G^2k^2+\frac{1}{12r^2}G^3k^3+...$$

this transformation makes sure that if space-time expansion is neglected, namely $R$ (t) =1, all will return to the static metric field. And in the distance or in weak field $l'(r)\approx r$, (2.18) is transformed into (2.7), namely $r=\frac{R^4(t)\varepsilon^2}{GM(t)(1-e\cos\varphi)}=\frac{L^2}{GM(t)m^2(t)(1-e\cos\varphi)}$. For different function $M$ (t) constant $k$. differs. And further get

$$\varepsilon=\frac{d\varphi}{d\tau}l^2=\frac{d\varphi}{d\tau}\frac{r^2}{R^2(t)}=\frac{dt}{d\tau}\frac{d\varphi}{dt}\frac{r^2}{R^2(t)} =\frac{\omega\alpha r^2}{R^2(t)(1-2Gk/l)} \quad (2.19)$$

which means (2.6) to hold in weak field. So far we have already proved that (2.6) ~ (2.9) are the approximations of general relativity under low speed and weak field, namely planet orbits expand in accordance with Hubble law is a result of general relativity. Substituting $l=r/R(t)$, $k=M(t)/R^3(t)$ into (2.17) obtains the more rigorous trajectory equation in background coordinate system.

$$\frac{R^2\varepsilon^2}{r^4}\left(\frac{dr}{d\varphi}\right)^2-\frac{R\varepsilon^2}{r^3}\frac{dr}{d\varphi}\frac{dR}{d\varphi}+\frac{\varepsilon^2}{r^2}\left(\frac{dR}{d\varphi}\right)^2+\frac{R^2\varepsilon^2}{r^2} =(\alpha^2-1)+\frac{2GM}{R^2r}+\frac{2GM\varepsilon^2}{r^3} \quad (2.20)$$

which is a gradually magnifying and rotating spiral line, the points on the line go away from the center body and meet Hubble law. And **w**hen (2.20) is used to a spiral galaxy, the spiral arms rotate and meanwhile stretch outward, the galaxy becomes bigger and bigger, that is to say, galactic formation lies in gradual growth but not the gather of existent matter. Randomly select three planes of different time in space, and take three equal squares on the three planes respectively, the black spots represent the galaxies cut by the planes, Figure 3 is the diagrammatic sketch, shows that galaxies grow up while space enlarges, earlier time is, smaller and denser galaxies are. Notice that the earlier stage means the time around the beginning of recent a circulation of expansion and contraction, the beginning of expansion is just the end of the previous contraction. The uniformity of matter's distribution in big scope today is just the magnification of the uniformity of early matter's distribution in small scope. For universe to finish a course of expansion and contraction calls a circulation, in the beginning of expansion or the end of contraction all galaxy's mass is zero. And today universe is in the stage of expansion, so far the expansion has already been lasting for $1.37\times10^{10}\,yr$, which is in accordance with the age of big bang.

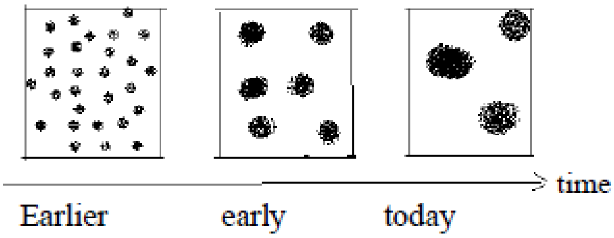


**Figure 3.** Sketch of size and distribution of galaxies in different time

In a word**,** galaxies or celestial bodies come from gradual growth but not the assemblage of existent material, new matter continuously generates inside celestial bodies or galaxies. Conventional conserved laws are the approximation of small space-time and in big space-time no longer valid in the same manner.

## 3.4. Quantum Mechanism of Matter Continuously Creates in Celestial Bodies, the Sun Neutrino Puzzle

$P=-\rho$ tells us that the negative pressure in celestial bodies is equivalent to a negative energy field, it is the constant excitation of the negative energy that creates material particles, this guarantees total energy in universe, namely the sum of negative and positive energy is zero all along.

And since matter in universe is neutral, the incipient material particles are imagined to be neutrons, and soon some neutrons decay into protons. The initial nuclear reactions should be

$$n\to p+\bar{\nu}+e^{-},n+p\to D+\gamma,\ {}^{1}\mathrm{H}+{}^{1}\mathrm{H}\to{}^{2}D+\nu+e^{+},$$

$${}^{2}D+{}^{1}\mathrm{H}\to{}^{3}\mathrm{He}+\gamma,{}^{3}\mathrm{He}+{}^{3}\mathrm{He}\to{}^{4}\mathrm{He}+2{}^{1}\mathrm{H},$$

$${}^{3}\mathrm{He}+{}^{3}\mathrm{He}\to{}^{7}\mathrm{Be}+\gamma,e^{-}+{}^{7}\mathrm{Be}\to{}^{7}Li+\nu+\gamma,$$

$${}^{1}\mathrm{H}+{}^{7}Be\to{}^{8}\mathrm{B}+\gamma,{}^{8}\mathrm{B}\to{}^{8}\mathrm{Be}+e^{+}+\nu,\nu+\bar{\nu}\to2\gamma$$

The final reaction $\nu+\bar{\nu}\to2\gamma$ explains why the measured neutrino are less than the theoretical value. It is most neutrinos and anti-neutrinos annihilate into photons that the measured value is less than theoretical value.

It is wrong to understand neutrino puzzle for the conversion that electric neutrinos convert into $\mu$ neutrinos, because we didn't find the equal-number $\mu$ neutrinos.

The negative energy field within celestial bodies offers much energy, only minor energy radiates and major energy stays in celestial bodies in the form of matter, for example the sun is offered energy a year today according to equation (1.11)

$$\Delta E=\Delta m_0c^2=3H_0m_0c^2\Delta t=3.9\times10^{37}\,J$$

and observations show that the sun radiates energy $10^{30}\,J$ a year today, accounted for only 2/100000000 of the total offered energy. Elemental abundance in a celestial body could be evaluated in use of statistical mechanics, see [7]

## 3.5. Evolution of Temperature, Brightness and Surface's Gas Pressure of Celestial Bodies

According to the principle that space, celestial bodies and galaxies together expand at the same size, radius $r_e$ of a celestial body will increase with expansion of space and meet $r_e\propto R(t)$, that is to say, $dr_e=Hr_edt$, and for arbitrary two moments $t_1,\ t_2$ there exists $r_e(t_1)R(t_2)=r_e(t_2)R(t_1)$, using the formula in one year today the radius of the earth increases by $\Delta r_{e0}=H_0r_{e0}\Delta t=0.7\times10^{-10}/yr\times6400km\times1yr=0.46mm$, which is in accordance with recent observations[17,18,22]. 2.7 billion years ago its radius was about 5185km.

It is easily derived that gravity acceleration of surface of a star at random two moments meets

$$\frac{g(t_1)}{g(t_2)}=\frac{m(t_1)}{r^{2}(t_1)}\div\frac{m(t_1)}{r^{2}(t_2)}=\frac{R(t_1)}{R(t_2)}\qquad(2.21)$$

Further the atmosphere pressure of the surface changes to meet

$$\frac{p_t(t_1)}{p_t(t_2)}=\rho g(t_1)h(t_1)/\rho g(t_2)h(t_2)=\frac{R^2(t_1)}{R^2(t_2)}.\ (2.22)$$

Here use $p_t$ to expresses common pressure so as to distinguish the pressure as gravitational source，and $h(t)$ expresses height of surface's gas of celestial body, and according to the principle of equal-proportion expansion in different time atmosphere height evolves to meet $h(t_1)R(t_2)=h(t_2)R(t_1)$.

As application of (2.22), the radio of surface's gas pressure of the earth is, 2.7 billion years ago to today $\frac{p_t(t_1)}{p_t(t_0)}=\frac{R^2(t_1)}{R^2(t_0)}\approx(\frac{t_1}{t_0})^2=(\frac{137-27}{137})^2=64\%$, in the center we have

$$p_t=\int_0^{r_e}\frac{G\rho m(r)}{r^2}dr=\frac{2\pi G\rho^2r_e^2}{3}\propto R^2(t).\qquad(2.23)$$

If matter around the center meets ideal gas law $p_t=\rho RT/\mu$, the temperature changes to meet

$$T(t_1)R^2(t_2)=T(t_2)R^2(t_1).\qquad(2.24)$$

Equal-density expansion of celestial bodies means the temperature of celestial bodies must constantly rise so as to resist the continuous rising gravitation.

But the temperature of surface is our interest, because it has direct contact with observation. For the sake we consider mass-luminosity relation, the following are several conventional empirical formula

$$\frac{L}{L_\odot} = 2.3(\frac{M}{M_\odot})^{2.3}, M < 0.43M_\odot,$$

$$and\ \frac{L}{L_\odot} = (\frac{M}{M_\odot})^4, 0.43M_\odot < M < 2M_\odot,$$

$$and\ \frac{L}{L_\odot} = 1.5(\frac{M}{M_\odot})^{3.5}, 2M_\odot < M < 20M_\odot,$$

$$and\ \frac{L}{L_\odot} = 3200\left(\frac{M}{M_\odot}\right), 20M_\odot < M.$$

These relations show the horizontal link among celestial bodies, and now we use them to research the vertical comparison of a celestial body itself. $r_e \propto R(t)$, $d_p \propto R(t)$, $d_p$ is the proper distance from the celestial body to us, absolute luminosity $L = 4\pi r_e^2 \cdot \sigma T_e^{\ 4} = 4\pi r_e^2 \cdot l_e$ $= 4\pi d_p^2 \cdot \sigma T_p^{\ 4} = 4\pi d_p^2 \cdot l_p$, and $l_e$ is absolute brightness, $l_p$ is vision brightness, $\sigma, \rho$ are invariant, $M = 4/3\pi\rho r_e^3$, and we can obtain the following relations about brightness and surface's temperature of the same body

$$\frac{l_e(t_1)}{l_e(t_2)} = \frac{l_p(t_1)}{l_p(t_2)} = \frac{T_e^{\ 4}(t_1)}{T_e^{\ 4}(t_2)} = \frac{T_p^{\ 4}(t_1)}{T_p^{\ 4}(t_2)} = \frac{R^{4.9}(t_1)}{R^{4.9}(t_2)},$$
$$M < 0.43M_\odot,$$

$$\frac{l_e(t_1)}{l_e(t_2)} = \frac{l_p(t_1)}{l_p(t_2)} = \frac{T_e^{\ 4}(t_1)}{T_e^{\ 4}(t_2)} = \frac{T_p^{\ 4}(t_1)}{T_p^{\ 4}(t_2)} = \frac{R^{10}(t_1)}{R^{10}(t_2)},$$
$$0.43M_\odot < M < 2M_\odot,$$

$$\frac{l_e(t_1)}{l_e(t_2)} = \frac{l_p(t_1)}{l_p(t_2)} = \frac{T_e^{\ 4}(t_1)}{T_e^{\ 4}(t_2)} = \frac{T_p^{\ 4}(t_1)}{T_p^{\ 4}(t_2)} = \frac{R^{8.5}(t_1)}{R^{8.5}(t_2)},$$
$$2M_\odot < M < 20M_\odot,$$

$$\frac{l_e(t_1)}{l_e(t_2)} = \frac{l_p(t_1)}{l_p(t_2)} = \frac{T_e^{\ 4}(t_1)}{T_e^{\ 4}(t_2)} = \frac{T_p^{\ 4}(t_1)}{T_p^{\ 4}(t_2)} = \frac{R(t_1)}{R(t_2)}, 20M_\odot < M.$$

Note that $L_\odot, M_\odot$ are respectively absolute luminosity and mass of the sun today, may be viewed as constants. As application, the ratio of the sun's brightness is, 2.7 billion years ago to today

$$\frac{l_p(t_1)}{l_p(t_0)} = \frac{R^{10}(t_1)}{R^{10}(t_0)} \approx (\frac{t_1}{t_0})^{10} = (\frac{137-27}{137})^{10} = 11\%$$

which indicates that the sun is brighter and brighter. Again, if the temperature of surface of the earth is 298K (25°C) today, then it was, 2.4 billion years ago,

$$T_e(t_1) = T_e(t_0)\frac{R^{1.2}(t_1)}{R^{1.2}(t_0)} \approx 298 \times \left(\frac{t_1}{t_0}\right)^{1.2} = 298 \times \left(\frac{137-24}{137}\right)^{1.2} = 234K \quad (2.25)$$

namely – 38°C, is a world of ice. The same way, we can work out temperature of the surface of the earth was 0°C 0.9 billion years ago, which means life began 0.9 billion years ago.

Recent an in-depth study [23] shows that the earth was a hockey 2.4 billion years ago, temperature of the equator was -40°C, this conclusion is highly in accordance with present theory. And recent another in-depth study [24] shows that the atmosphere pressure 2.7 billion years ago was half of today's that, the brightness of the sun 2.7 billions years ago was 15% of today's that, highly conformable with our result.

It is continuous creation of matter that makes celestial bodies brighter and brighter, their temperature is higher higher, and universe was dark ten billion years ago and so-called big bang fireball didn't exist at all.

Observations show that the sun indeed is becoming brighter and brighter, the fact is wrongly explained in terms of gravitational collapse in the framework of big bang. In fact, since think that the sun's mass is smaller and smaller because of unceasing burning, its gravitation should be smaller and smaller and thus collapse should be weaker and weaker, the sun becomes impossibly brighter and brighter. And more serious question is that there is not controllable mechanism why the burning is neither too fast nor too slow.

In a word in the framework of big bang the temperature of matter can only be getting lower and lower and the sun impossibly becomes brighter and brighter and the earth will not also become hotter and hotter. The world based on big bang is actually a gradually dying and declining world and on contrary, the world based on the continuous creation is a energetic and exuberant world.

In fact, the picture of galaxy formation and evolution given by big bang goes against the second law of thermal dynamics. In the light of big bang theory, from the high disorderly status a variety of particles gradually coalesced and began to have common velocity and finally formed various celestial bodies and galaxies, obviously this was a evolving course from highly disorderly thermal movement to highly orderly mechanical movement, thus this course was a course that entropy decreased and obviously forbidden by thermal dynamic second law and in nature could not happen really. About problems of big bang, see [25,26].

## 4. Appendix: Problems with the Original Field Equation in Practice and in Theory

Whether a theory is correct or not is ultimately determined by practice. Though the external solution of the original field equation $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = -8\pi GT_{\mu\nu}$ is well in accordance with observed results, applied to cosmology its internal solution fell across trouble in principle, that is to say, when the relation between distance and re-shift derived out from the field equation fitted observed data the density of universe must be concluded zero or negative, this is obviously impossible. Besides, the original field also leaded to some inherent difficulties and absurdity, such as flatness difficult, horizon difficult, magnetic monopole difficult and so on. These problem actually announced that there are serious mistakes with the original field equation. In fact, in theory the coupling coefficient $-8\pi G$ can also be found not to be too reasonable. We knows that in weak field neglecting $o(h^2)$ then $0=T^{\nu}_{\mu;\nu}=T^{\nu}_{\mu,\nu}+O(h^2)=T^{\nu}_{\mu,\nu}$, applying it to static state we have $\frac{\partial p}{\partial x^i}\approx 0$, and on the other hand $0=T^{\mu\nu}{}_{;\nu}=\frac{\partial p}{\partial x^i}+\frac{1}{g_{00}}(\rho+p)\frac{\partial g_{00}}{\partial x^i}=0$ which requires $\frac{1}{g_{00}}(\rho+p)\frac{\partial g_{00}}{\partial x^i}\sim 0$, obviously $p\sim-\rho$ is more easy to realize the requirement than $p=0$, that is to say, coupling coefficient $-8\pi G$ derived with the assumption $p=0$ has too large error. But when people sensed the conclusions derived from the original field equation were not in consistent with observation, the correctness of coupling coefficient $-8\pi G$ was given no doubt, in order to adjust to accordance with Ia supernova observation data people added cosmological constant to the equation, namely

$$R_{\mu\nu}-\frac{1}{2}Rg_{\mu\nu}+Ag_{\mu\nu}=-8\pi GT_{\mu\nu} \qquad (3.1)$$

which is actually a most direct modification of the original field equation, there is no mathematical problem. But such modification is just to say that even if there is no material space-time is still curved, which is obviously contrary to the original intention of general relativity. Secondly, (3.1) is not able to make the geodesic of the moving particles in the spherical symmetry field return to Newton law of gravitation in the distance because with the increase of distance cosmological constant gradually begins to play a major role and can’t continue to be neglected. Therefore neither this modification is self-consistent in theory and nor is possible to be verified in the solar system. It is because (3.1) can’t return to Newton law, strictly saying, (3.1) can’t be called gravitational field equation, it is nothing. Further must point out that any modification to field equation must return to Newton’s theory in spherical symmetric gravitational field in the distance or it isn’t successful modification and must be forbidden.

# References


[1] Weinberg, S. (1972). Gravitation and Cosmology. Wiley, New York.

[2] Wald R M. General Relativity. Chicago: The University of Chicago Press, 1984

[3] W. H. McCrea. Relativity theory and the creation of matter. *Proc. R. Soc*. Lond. A 1951 206, 562-575.

[4] Melissa Ness and Dustin Lang. The X-Shaped bulge of the Milky Way revealed Bywise. *The Astronomical Journal*, 2016, 152(1): 14.

[5] Dai Zi Gao. Constraining dark energy with GRBs. *The astrophysical journal letters*. Vol: 612. 2004.

[6] Fa Yin, Dai Zi Gao and Shi Qi. (2008). Constraints on generalized Chaplygin gas model incliding gamma-ray bursts. *Research in Astronomy and Astrophysics*. Vol: 9. No 5 (2009)

[7] Ming Yang, Jian Liang Yang, (2012). The Amelioration of Einstein’s Equation and New Steady Cosmology. *Science Journal of Physics* (ISSN: 2276-6367), Volume 2012 (2012), Issue 2, 25 Pages.

[8] Ming Yang, (2010). Modification of Gravitational field equation and rational solution to cosmological Puzzles. *International Journal of the Physical Science*, Vol. 5 (2), pp. 145-153, February, 2010.

[9] Zhou P. Y. 1983. “On Coordinates and Coordinate Transformation in Einstein’s Theory of Gravitation” in Proc. of the Third Marcel Grossmann Meetings on Gen. Relativ. *Science Press & North Holland*, 1-20

[10] Lorenzo Lorio, (2015). Gravitational anomalies in the solar system. *International journal of Modern Physics D*, 24, 1530015

[11] James G. Williams, Slava G. The past and present Earth-Moon system: the speed of light stays steady as tides evolve. *Planetary Science*, 2014, 32.

[12] Louise Riofrio, Calcuation of lunar orbit anomaly. *Planetary Science*, 12/2012, 1: 1.

[13] Lorenzo Iorio. (2014) The Lingering Anomalous Secular Increase of the Eccentricity of the Orbit of the Moon: Further Attempts of Explanations of Cosmological Origin.*Galaxies* 2014, 2, 259-262.

[14] M. W. Kalinowski,(2015) Pioneer 10 and 11Spacecraft Anomalous Acceleration in the light of the Nonsymmetric Kaluza-klein Theory. *Fortschritte der physik* 2015, 63: 10. 1002/prop. V63. 11-12, 711-918

[15] R. G. Williamson, S. M. Klosko. Observed tidal braking in the earth/moon/sun system. *Journal of geophysical research*. VOL. 93. No. B6. PAGES 6216-6236, June 10, 1988

[16] James C G. Walker, Kevin J. Zahnle, (1986) lunar nodal tide and distance to the moon during the Precambrian. *Nature* VOL.302 17 APRIL 1986.

[17] W. B. Shen, R. Sun, W. Chen, et al. (2011) The expanding earth at present: evidence from temporal gravity field and space-geodetic data. Ann Geophysics, 54(4) (2011), pp.436-453.

[18] Harutyunian, H.A., 1995, Some similarities of expansion phenomena in the vicinity of the Earth and in the Universe as a whole, *Astrophysics*, 38, 667.

[19] Cooperstock, F. I., Faraoni, V., Vollick, D. N. (1998) The influence of the cosmological expansion on local systems. *Astrophys. J*. 1998, 503.

[20] Zhou Yao qi, Chen Hai Yun. Tidal rhythmites in Cambrian-Ordovician, North China and evolution of orbital parameters. *Journal of Chinese University of Geosciences*. VOL. 27 No.6 Nov. 2002.

[21] Iorio, L. An Empirical Explanation of the Anomalous Increases in the Astronomical Unit and the Lunar Eccentricity. *Astron. J*. 2011, 142.

[22] Egyed, L., (1956). Determination of changes in the dimensions of the Earth from palaeogeographical data, *Nature*, 178, 534.

[23] Daniel Herwartz, Andreas Pack, et al. (2015). Revealing the climate of snowball Earth from Δ17O systematics of hydrothermal rocks**.** *PNAS* 2015 112 (17) 5337-5344.

[24] Sanjoy M. Som, Roger Buick, et al. (2016) Earth's air pressure 2.7 billion years ago constrained to less than half of modem levels. *Nature Geoscience* 9, 448-451(2016).

[25] Jian liang Yang, Criticism to universal big bang. *Journal of Astrophysics & Aerospace*. 2016,4:1

[26] Forrest W. Noble, Timothy M. Cooper. Observations that seem to contradict the big bang model while at the same time support alternative cosmology. *American international journal of contemporary research*. Vol. 4, No. 9 September 2014.