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Unavoidable Correction to the Coupling Constant in Einstein's Gravitational Field Equation and the Birth of Realistic Cosmology

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Abstract: *In the framework of general relativity, systematically solve the problem of galaxy formation and cosmological puzzles without the introduction of dark matter and dark energy. The coupling constant in Einstein's gravitational field equation is first modified from -8πG to 4πG , which is an essential modification to the field equation and opens up a new direction of research in cosmology and astrophysics. The modification shows that so-called dark matter and dark energy don't exist, space-time is infinite, its expansion and contraction are cyclic, and the singular point of big bang is eliminated. New matter is proved continuously generating in celestial bodies, the formation of galaxies lies in the continuous growth in the course of universal expansion and not the gather of existing matter. As example, the radius of the earth expands 0.5mm per year, the mass increases by 1.2 trillion tons, the acceleration of surface gravity increases by 10% per 100 million years, the radius of the galactic disk expands at a speed of 900m per second, the distance between the sun and the earth increases at a rate of 9 meters per year, the distance between the moon and the earth increases by 2.8 centimeters a year due to the expansion of space, and the moon retreats only one centimeter due to tidal dissipation. The expansion of the planet orbit and the increase of the mass of the celestial body are the result of the expansion force of time- space, and are not so-called out of nowhere. It is proved that the temperature of celestial bodies is gradually rising, and stars are gradually evolved from planets. For example, the surface temperature rises by 5.2 degrees 100 million years, and the brightness of the sun today is twice as bright as it was 1 billion years ago.*

Keywords: *coupling constant of gravitational field equation; negative pressure; growth of galaxy.*

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1. INTRODUCTION

Though general relativity obtains considerable success, some of the basic difficulties have not been eliminated [1], such as the singularity of big bang, the problem of horizon, whether dark matter and dark energy really exist, as well as the formations of celestial bodies and galaxies. Besides, there are other problems that have not been reasonably solved, which are in fact closely related to the theory of gravitation, such as the mystery of solar neutrino, the asymmetry of particle and antiparticle. These problems long remain implies strongly that the fundamentals of general relativity need to be improved in principle. In order to solve these difficulties, the author does not continue to follow the dark energy of dark matter, but instead goes back to re-examine the basis of general relativity, the author finds that the coupling constant in Einstein's gravitational field equation is not unique, and there is another more reasonable form, which will be presented here. For the purpose, this paper begins with the foundational question that determine the metric of spherically symmetric static gravitational field expressed in actual coordinates.

2. THE STATIC METRIC OF SPHERICAL SYMMETRY EXPRESSED IN USUAL COORDINATES

According to general relativity, in the static spherical symmetric gravitational field, in the standard coordinate system, space-time metric outside gravitational source is[2-5]

$$ds^2 = -\left(1 - \frac{2GM}{l}\right)dt^2 + \left(1 - \frac{2GM}{l}\right)^{-1} dl^2 + l^2(d\theta^2 + \sin^2\theta d\varphi^2) \tag{1}$$

which is so-called Schwareschild metric and is the solution to vacuum field equation $R_{\mu\nu} = 0$ in the coordinate system $(x^0, x^1, x^2, x^3) = (t, l, \theta, \varphi)$. Here M is the mass of gravitational source namely massive celestial body; t, θ, φ are usual time and angles, respectively. Note that l is not interpreted as the usual radius but explain it for standard radial coordinate or radial parameter in common textbooks because it can not describe the invariance of light speed under weak field approximation. l doesn't have clear physical meaning and only in the distance approximately treated as usual radius. In this paper, therefore, we use l instead of r to donate the radial coordinate in order to hint its difference from the usual radius. It is worth noting that In practice, though l isn't explained as usual radius it is used indiscriminately as actual radius. For example, when dealing with the bending of light on the surface of the sun it was treated as solar radius, and though there is no apparent error in conclusion, doing so leads to logical or conceptual confusion. Therefore, In order to describe clearly the motion of a particle in gravitational field and avoid some conceptual confusions and enable general relativity to have common language with Newton's gravitational theory to compare with one another, it is necessary to confirm the relation between l and r. Now we try to figure out the relation, and may as well take $l = l(r)$, where r donates the usual radius and its meaning is the same as that used usually. In the language of the general relativity measurement theory, r is the distance from the origin of coordinates to another point measured by the observer on Earth, and t, θ, φ are the time and angle measured by the observer. Because of the approximate flatness of space-time on Earth, the observer on Earth is actually an infinite observer

As an emphasis, the invariance of the speed of light is not only a theoretical result, but also an observational fact. So far, no observation have shown that the speed of light is variable. No matter what stars the light is given out from, the fact is that they reach the earth at the same speed, neither accelerated nor decelerated by the gravitation of the stars that gave out the light, as shows that at least in weak field the radial speed of light is unchanged. In this paper, we do not deny that the speed of light can be changed in a strong gravitational field, but the speed of light must be unchanged in a weak field along radial direction. General relativity must respect this basic fact that speed of light along radial direction is unchanged in weak field, otherwise it will deviate from the right path, even further and further down the wrong path. In the past, because we did not pay attention to the meaning of coordinates, it was impossible to discuss the dynamic behavior of photons, which is a defect.

So as to enable equation (1) to describe the invariance of the speed of light under weak field approximation, we may introduce the following transformation equation

$$\frac{dl}{dr} = \sqrt{1 - \frac{2GM}{l}} \exp\left(-\frac{GM}{r}\right) \tag{2}$$

which determines a coordinate transformation of $l \to r$. The solution of equation (2) is given by

$$\sqrt{l(l-2GM)}+2GM\ln\left(\sqrt{l}+\sqrt{l-2GM}\right)=C+r-GM\ln r-\frac{1}{2r}G^2M^2+\frac{1}{12r^2}G^3M^3+\cdots \quad (3)$$

Here C is an integral constant. Due to $l=r$ for $M=0$, thus constant $C=0$

Equation (3) shows that $l\to\infty$ for $r\to\infty$, and in the distance the left-hand side of equation (3) becomes

$$\sqrt{l(l-2GM)}+2GM\ln\left(\sqrt{l}+\sqrt{l-2GM}\right)=l\sqrt{1-2GM/l}+GM\ln l+2GM\ln\left(1+\sqrt{1-2GM/l}\right)\approx l+GM\ln l$$

and the right-hand side of equation (3) is $r-GM\ln r-\frac{1}{2r}G^2M^2+\frac{1}{12r^2}G^3M^3+\cdots\approx r-GM\ln r$, that is to say, under weak field approximation

$l=r-GM\ln r-GM\ln l\approx r-2GM\ln r=r(1-\frac{2GM\ln r}{r})$. Note that $\lim_{r\to\infty}\frac{\ln r}{r}=0$, then in an infinite far distance there is $l=r$. And with equation (3), equation (1) is now transformed into

$$ds^2=-\left(1-\frac{2GM}{l}\right)dt^2+\exp(-\frac{2GM}{r})dr^2+l^2\left(d\theta^2+\sin^2\theta d\varphi^2\right) \quad (4)$$

which is, of course, an exact solution of vacuum field equation $R_{\mu\nu}=0$ in the usual coordinate system (t,r,θ,φ). Note that in equation (4) $l=l(r)$ is a specific function with respect of r decided by equation (3) and no longer is a independent variable and t,r,θ,φ are the independent coordinate variables.

Obviously equation (4) can describe the invariance of light speed under weak field approximation, and for the light's moving along the radial direction $ds^2=0$, we have

$$(\frac{dr}{dt})^2=(1-\frac{2GM}{l})\Big/\exp(-\frac{2GM}{r})\approx(1-\frac{2GM}{r})\Big/1-\frac{2GM}{r}=1$$

which shows the speed of light is unchanged in weak field, namely not accelerated by gravitation.

And next we explain why l can not be interpreted for the actual radius. Obviously, if interpret l for the actual radius, namely directly put $l=r$, we have

$$ds^2=-\left(1-\frac{2GM}{r}\right)dt^2+\left(1-\frac{2GM}{r}\right)^{-1}dr^2+r^2(d\theta^2+\sin^2\theta d\varphi^2) \quad (5)$$

which is also an exact solution of vacuum field equation $R_{\mu\nu}=0$ in the usual coordinate system (t,r,θ,φ). However, for the light's moving along the radial direction ($d\theta=d\varphi=0$, $v=\frac{dr}{dt}$) there is $(\frac{dr}{dt})^2=(1-\frac{2GM}{r})^2\approx 1-\frac{4GM}{r}\neq 1$, which shows the speed of light changes in weak field and thus doesn't agree to the facts. Besides, equation (5) also leads to the theoretical inconsistency because it provides $g_{00}=-1+\frac{2GM}{r}$, $g_{11}=\left(1-\frac{2GM}{r}\right)^{-1}$, $g_{22}=r^2$, $g_{33}=r^2\sin^2\theta$, $g_{\mu\nu}=0(\mu\neq\nu)$, $\Gamma^1_{01}=0$,

$\Gamma^1_{11} = \frac{1}{2} g^{1\rho} (\frac{\partial g_{\rho 1}}{\partial x^1} + \frac{\partial g_{\rho 1}}{\partial x^1} - \frac{\partial g_{11}}{\partial x^\rho}) = -\frac{GM}{(1-2GM/r)r^2}$, $\Gamma^0_{01} = \frac{GM}{(1-2GM/r)r^2}$, $\Gamma^1_{00} = \frac{(1-2GM/r)GM}{r^2}$, and

inserting these into the following geodesic equation

$$\frac{d^2 x^\mu}{dt^2} + \Gamma^\mu_{\nu\lambda} \frac{dx^\nu}{dt} . \frac{dx^\lambda}{dt} - \Gamma^0_{\nu\lambda} \frac{dx^\nu}{dt} . \frac{dx^\lambda}{dt} . \frac{dx^\mu}{dt} = 0 \qquad (6)$$

which is a basic equation in post Newton mechanics to solve acceleration and can be deviated from the standard geodesic equation. For the radial motion $d\varphi = d\theta = 0$ and $v = \frac{dr}{dt}$, putting $\mu = 1$ we have

$$\frac{d^2 r}{dt^2} = -\Gamma^1_{00} - \Gamma^1_{11} v^2 + 2v^2 \Gamma^0_{01} = -(1 - \frac{2GM}{r}) \frac{GM}{r^2} + \frac{3GM}{(1-2GM/r)r^2} v^2$$

in the distance (or in weak field) it reduces to $\frac{d^2 r}{dt^2} + (1-3v^2)\frac{GM}{r^2} = 0$, whose solution [6-8] is given by $1 - 3v^2 = k \exp \frac{-6GM}{r}$, k is its integral constant, obviously if the speed of light just coming out of the surface of star is 1, the speed it reaches infinite far through the gravitational field of the star is $v = \sqrt{(1 + 2\exp \frac{6GM}{r_e}) / 3} > 1$ even >>1, not only which is contrary to observation facts but also is contrary to the theoretical result $(\frac{dr}{dt})^2 = (1 - \frac{2GM}{r})^2 \approx 1 - \frac{4GM}{r} \to 1$ for $r \to \infty$. r_e is the radius of the star. These are the cause why l can not be interpreted as the actual radius. Of course, if you continue to ignore the meaning of the coordinate, these basic questions will continue to be covered.

And on the other hand, as comparison with equation (5), equation (4) provides weak field metric

$g_{00} = -1 + \frac{2GM}{l(r)} \approx -1 + \frac{2GM}{r}$, $g_{11} = \exp(-\frac{2GM}{r}) \approx 1 - \frac{2GM}{r}$, $g_{33} = l^2(r)\sin^2\theta \approx r^2 \sin^2\theta$, $g_{22} = l^2(r) \approx r^2$,

$\Gamma^1_{00} \approx \frac{GM}{r^2}$, $\Gamma^1_{11} \approx \frac{GM}{r^2}$, $\Gamma^0_{01} \approx \frac{GM}{r^2}$, $\Gamma^1_{01} \approx 0$, $\Gamma^0_{00} = 0$, and introducing them into equation (6) for the radial motion, we have $\frac{d^2 r}{dt^2} + (1-v^2)\frac{GM}{r^2} = 0$, not only which shows the invariance of light speed in weak field approximation but also there is no the theoretical inconsistency because it is consistent with the corresponding result

$$(\frac{dr}{dt})^2 = (1 - \frac{2GM}{l}) \Big/ \exp(-\frac{2GM}{r}) \approx (1 - \frac{2GM}{r}) \Big/ 1 - \frac{2GM}{r} = 1$$

So far, we say that equation (4) is the correct line element (metric) expressed in the usual coordinates, which is the line element we're exactly looking for.

Because of the approximate flatness of space-time on the earth, general relativity is the theory of gravity on the flat space-time for the observers on the earth. However, this does not prevent it from being regarded as the bending theory of space-time, its local measurement theory is still valid, and some of its geometric concepts are still valid. It is natural for observers on the earth to use the measured time and distance as coordinates, so that all kinds of theories can be developed in the same coordinate system, draw lessons from each other's experience, and facilitate the in-depth analysis of physical processes. Of course, the electromagnetic law and quantum law summarized from the experiment on earth belong to the theory of flat space-time.

As for to the angle of orbital precession described in actual coordinate system can also be solved. It is well known that in the coordinate system (t, l, θ, φ) the angle of orbital precession around the sun is

$\delta\varphi = 6\pi \frac{GM_{\odot}}{l}$, where $l = \frac{1}{2}(\frac{1}{l_{max}} + \frac{1}{l_{min}})$, $M_{\odot}$ is solar mass Letting $l = r - 2GM_{\odot} \ln r$, it describes the precession in the usual coordinate system (t, r, θ, φ). For Mercury $l_{max} = r_{max} - 2GM_{\odot} \ln r_{max} =$ 69816825980m, where $r_{max} = 69816900km$ is the distance observed from aphelion to solar center, and $l_{min} = r_{min} - 2GM_{\odot} \ln r_{min} = 46001127217m$, where $r_{min} = 46001200km$ is the distance observed from perihelion to solar center. Therefore the angle of orbital precession is given by $\delta\varphi = 6\pi \frac{GM_{\odot}}{l} = \frac{12\pi G l_{max} l_{min} M_{\odot}}{l_{max} + l_{min}} = 43.08''/100year$, whose difference from the previous result (43.07''/100year) is so small that the mistakes of treating l for the actual radius can not be exposed.

And as for to the bending angle of light line on the surface of the sun is now $\Delta\varphi = \frac{4GM_{\odot}}{l}$, note that on the surface $l = R_{\odot} - 2GM_{\odot} \ln R_{\odot} = 594939654m$, we have $\Delta\varphi = \frac{4GM_{\odot}}{l} = 1.76''$, whose difference from the previous result (1.75'') is also so small that the mistake of treating l for the actual radius can not be exposed.

For further discussion, we need transform equation (4) into the rectangular coordinate system $x^{\mu} = (x^0, x^1, x^2, x^3) = (t, x, y, z)$. Note that $r = \sqrt{x^2 + y^2 + z^2}$, $r^2(d\theta^2 + \sin^2\theta d\varphi^2) = dx^2 + dy^2 + dz^2 - dr^2$, $xdx + ydy + zdz = rdr$, $x = r\sin\theta\cos\varphi,\ y = r\sin\theta\sin\varphi,\ z = r\sin\theta$, then equation (4) becomes

$$ds^2 = -\left(1 - \frac{2GM}{l(r)}\right)dt^2 + \frac{(xdx + ydy + zdz)^2}{r^2}\exp(-\frac{2GM}{r}) + \frac{l^2}{r^2}\left(dx^2 + dy^2 + dz^2 - \frac{(xdx + ydy + zdz)^2}{r^2}\right)$$

$$= -[1 - \frac{2GM}{l(r)}]dt^2 + [\frac{x^2}{r^2}\exp(-\frac{2GM}{r}) + \frac{l^2}{r^2} - \frac{l^2x^2}{r^4}]dx^2 + [\frac{y^2}{r^2}\exp(-\frac{2GM}{r}) + \frac{l^2}{r^2} - \frac{l^2y^2}{r^4}]dy^2 +$$

$$[\frac{z^2}{r^2}\exp(-\frac{2GM}{r}) + \frac{l^2}{r^2} - \frac{l^2z^2}{r^4}]dz^2 + 2[\frac{yx}{r^2}\exp(-\frac{2GM}{r}) - \frac{xyl^2}{r^4}]\,dxdy$$

$$+2\,[\frac{zx}{r^2}\exp(-\frac{2GM}{r}) - \frac{xzl^2}{r^4}]\,dxdz + 2\,[\frac{yz}{r^2}\exp(-\frac{2GM}{r}) - \frac{zyl^2}{r^4}]\,dzdy \qquad (7)$$

which is, of course, an exact solution to vacuum field equation $R_{\mu\nu} = 0$ in the rectangular coordinate system. Under weak approximation, $\exp(-\frac{2GM}{r}) = 1 - \frac{2GM}{r}$, $l = r - 2GM\ln r$, $l^2 = r^2 - 4rGM\ln r$

To sum up, in the rectangular coordinate system (t, x, y, z) equation (7) provides the static Spherical symmetric weak field approximate metric components as follows

$$g_{00} = -1 + \frac{2GM}{r},\quad g_{0i} = 0,\quad g_{ii} = 1 - \frac{4GM\ln r}{r} - \frac{2GMx^{i2}}{r^3} + \frac{4GMx^{i2}\ln r}{r^3}$$

$g_{ji} = \frac{-2GM + 4GM \ln r}{r^3} x^i x^j \ (i \neq j\ )$, space indexes $i, j, k = 1, 2, 3$

To stress, the weak field approximate metric components refer actually to the first-order approximation, as is usually discussed in common textbooks, the zero-order approximation is so-called Minkovsky flat metric

$$\eta_{\mu\nu} = \eta^{\mu\nu} = \begin{pmatrix} -1 & & & \\ & 1 & & \\ & & 1 & \\ & & & 1 \end{pmatrix}$$

As the zero-order approximation $l = r$, whose the first-order approximation is $l = r - 2GM \ln r$

The motion behavior of a particle in weak field means the behavior of first-order approximation.

Next, we further verify that the metric components are indeed the correct first-order approximation by direct calculation in the rectangular coordinate system..

For a particle moving along a radial direction, you might as well set it within the first octant , there are the following relationships: $\frac{x}{r} = \frac{v^x}{v} = \frac{a^x}{a}$, $\frac{y}{r} = \frac{v^y}{v} = \frac{a^y}{a}$, $\frac{z}{r} = \frac{v^z}{v} = \frac{a^z}{a}$

where $v^x = \frac{dx}{dt}$, $a^x = \frac{d^2x}{dt^2}$, $v^y = \frac{dy}{dt}$, $a^y = \frac{d^2y}{dt^2}$, $v^z = \frac{dz}{dt}$, $a^z = \frac{d^2z}{dt^2}$, $v = \frac{dr}{dt}$, $a = \frac{d^2r}{dt^2}$,

$v^2 = v^{x2} + v^{y2} + v^{z2}$.

Note that for weak field the raising and lowering of the indexes use η instead of g, connection $\Gamma^{\sigma}_{\mu\nu} = \frac{1}{2}\eta^{\sigma\rho}(\frac{\partial h_{\rho\mu}}{\partial x^{\nu}} + \frac{\partial h_{\rho\nu}}{\partial x^{\mu}} - \frac{\partial h_{\mu\nu}}{\partial x^{\rho}})$, non-zero connections as follows

$$\Gamma^1_{00} = -\frac{1}{2}\frac{\partial g_{00}}{\partial x} = \frac{GM}{r^2},\ \Gamma^0_{01} = -\frac{1}{2}\frac{\partial g_{00}}{\partial x} = \frac{GMx}{r^3},$$

$$\Gamma^0_{02} = -\frac{1}{2}\frac{\partial g_{00}}{\partial y} = \frac{GMy}{r^3},\ \Gamma^0_{03} = -\frac{1}{2}\frac{\partial g_{00}}{\partial z} = \frac{GMz}{r^3}$$

$$\Gamma^1_{11} = \frac{1}{2}\frac{\partial g_{11}}{\partial x} = -\frac{4GMx}{r^3} + \frac{6GMx\ln r}{r^3} + \frac{5GMx^3}{r^5} - \frac{6GMx^3\ln r}{r^5}$$

$$\Gamma^1_{12} = \frac{1}{2}\frac{\partial g_{11}}{\partial y} = -\frac{2GMy}{r^3} + \frac{2GMy\ln r}{r^3} + \frac{5GMx^2y}{r^5} - \frac{6GMx^2y\ln r}{r^5}$$

$$\Gamma^1_{13} = \frac{1}{2}\frac{\partial g_{11}}{\partial z} = -\frac{2GMz}{r^3} + \frac{2GMz\ln r}{r^3} + \frac{5GMx^2z}{r^5} - \frac{6GMx^2z\ln r}{r^5}$$

$$\Gamma^1_{33} = \frac{\partial g_{13}}{\partial z} - \frac{1}{2}\frac{\partial g_{33}}{\partial x} = \frac{-6GM\ln r + 5GM}{r^5}z^2x + \frac{2GM\ln r}{r^3}x$$

$$\Gamma^1_{22} = \frac{\partial g_{12}}{\partial y} - \frac{1}{2}\frac{\partial g_{22}}{\partial x} = \frac{-6GM\ln r + 5GM}{r^5}y^2x + \frac{2GM\ln r}{r^3}x$$

$\Gamma^1_{23} = \frac{1}{2}(\frac{\partial g_{12}}{\partial z} + \frac{\partial g_{31}}{\partial y} - \frac{\partial g_{23}}{\partial x}) = \frac{5GM - 6GM\ln r}{r^5}xyz$, Inserting they into equation (6) we have

$$\frac{d^2x}{dt^2}=-\Gamma^1_{\mu\nu}\frac{dx^\mu}{dt}\frac{dx^\nu}{dt}+\Gamma^0_{\mu\nu}\frac{dx}{dt}\frac{dx^\mu}{dt}\frac{dx^\nu}{dt}$$

$$=-\Gamma^1_{00}-\Gamma^1_{11}(v^x)^2-2\Gamma^1_{12}v^xv^y-2\Gamma^1_{13}v^xv^z-\Gamma^1_{22}v^yv^y-\Gamma^1_{33}v^zv^z-2\Gamma^1_{32}v^zv^y$$

$$+2\Gamma^0_{01}(v^x)^2+2\Gamma^0_{02}v^xv^y+2\Gamma^0_{03}v^xv^z=-\frac{xGM}{r^3}(1-v^2)$$

That is to say, $a=\frac{d^2r}{dt^2}=\frac{r}{x}a^x=\frac{r}{x}\frac{d^2x}{dt^2}=-(1-v^2)\frac{GM}{r^2}$ which shows the invariance of light speed, therefore, the metric components expressed in the rectangular coordinates are indeed the correct first-order approximation.

Finally, it should be explained that, in principle, once the coordinate system is determined, the metric should be unique and can not be set at will, but because the metric tensor satisfies Bianchi Identity , the field equation is an indefinite equation, and there are four metric components that can be selected arbitrarily. Therefore only the correct or correct metric can be found through the field equation and the only correct metric cannot be determined, which is similar to that of the electromagnetic potential that different gauges give different electromagnetic potentials. The correctness of the solution can only be judged from the degree of conformity with the practice. Coordinate transformation is often used in general relativity. In principle, the new metric obtained by coordinate transformation describes the same physical content as the original metric, but only if the meaning of the two sets of coordinates is different, such as the transformation from rectangular coordinates to spherical coordinates. In practice, the meaning of a set of coordinates must be clear, otherwise it will not be related to reality. If two sets of coordinates are given the same meaning, then the new metric is the different solution of the field equation in the same coordinate system and at this point, it is important to distinguish which solution is correct or more correct, because the dynamic behavior they describe may be different.

3. Modification to the Coupling Constant of Gravitational Field Equation

Since this coupling constant is determined with the weak field metric, the coupling constant needs to be changed accordingly when the metric changes. You will see that when space components $g_{ii}=1-\frac{4GM\ln r}{r}-\frac{2GMx^{i2}}{r^3}+\frac{4GMx^{i2}\ln r}{r^3}$ outside the static spherically symmetric gravitational source，the coupling constant is reconfirmed as $\gamma=4\pi G$ instead of the old $\gamma=-8\pi G$. To this end we need first be familiar with some basic calculation and rules. Field equation $R_{\mu\nu}-\frac{1}{2}Rg_{\mu\nu}=\gamma T_{\mu\nu}$, where γ is the coupling constant, $T_{\mu\nu}=(\rho+p)U_\mu U_\nu+pg_{\mu\nu}$ is the energy-stress tensor of gravitational source, and Ricci tensor $R_{\mu\nu}\equiv R^\sigma_{\mu\nu\sigma}=\Gamma^\sigma_{\mu\sigma,\nu}-\Gamma^\sigma_{\mu\nu,\sigma}+\Gamma^\sigma_{\mu\beta}\Gamma^\beta_{\sigma\nu}-\Gamma^\sigma_{\mu\nu}\Gamma^\beta_{\sigma\beta}$. In accordance with convention, the repeat of superscript and subscript means summation, and indexes $\mu,\nu,\sigma,\lambda=0,1,2,3$ and light speed $c=1$.

And contracting indexes of both sides $g^{\mu\nu}(R_{\mu\nu}-\frac{1}{2}Rg_{\mu\nu})=g^{\mu\nu}\gamma T_{\mu\nu}$ gets $R=-\gamma T$, and then

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

which is another form of field equation, where $g^{\mu\nu}$ is the inverse matrix of $g_{\mu\nu}$, and $g_{\mu\nu}g^{\mu\nu}=4$. Note that $R\equiv g^{\mu\nu}R_{\mu\nu}=R^{\mu}_{\mu}$, $T\equiv g^{\mu\nu}T_{\mu\nu}=T^{\mu}_{\mu}$. And from $ds^2=-d\tau^2=g_{\mu\nu}dx^{\mu}dx^{\nu}$, $U^{\mu}\equiv\frac{dx^{\mu}}{d\tau}$, $U_{\mu}\equiv g_{\mu\nu}U^{\nu}$,we have $U_{\mu}U^{\mu}=-1$, and

$$T=g^{\mu\nu}T_{\mu\nu}=g^{\mu\nu}(\rho+p)U_{\mu}U_{\nu}+pg^{\mu\nu}g_{\mu\nu}=(\rho+p)U_{\mu}U^{\mu}+4p=3p-\rho$$

Now pressure p inside source is not assumed as zero in advance and it need be solved together with metric as well as the coupling constant. It is obviously subjective to take pressure for zero without calculation, of course, outside source of gravitation both density and pressure are zero.

In the right-angled coordinate system $x^{\mu}=(x^0,x^1,x^2,x^3)=(t,x,y,z)$), for weak field, its metric can be written as $g_{\mu\nu}=h_{\mu\nu}+\eta_{\mu\nu}$, where $|h_{\mu\nu}|<<1$. Note that under weak field approximation use η to raise and fall indexes instead of g , then $h^{\mu}_{\beta}=\eta^{\mu\rho}h_{\rho\beta}$, $h=h^{\mu}_{\mu}=\eta^{\mu\rho}h_{\mu\rho}$, $h^{i}_{j}=h_{ij}=h_{ji}=h^{j}_{i}$ And after omitting less than $o(h^2)$, Ricci tensor becomes

$$R_{\mu\nu}=\Gamma^{\sigma}_{\mu\sigma},_{\nu}-\Gamma^{\sigma}_{\mu\nu},_{\sigma}=\frac{1}{2}\eta^{\sigma\rho}(\frac{\partial h_{\rho\mu}}{\partial x^{\sigma}}+\frac{\partial h_{\rho\sigma}}{\partial x^{\mu}}-\frac{\partial h_{\mu\sigma}}{\partial x^{\rho}})_{,\nu}-\frac{1}{2}\eta^{\sigma\rho}(\frac{\partial h_{\rho\mu}}{\partial x^{\nu}}+\frac{\partial h_{\rho\nu}}{\partial x^{\mu}}-\frac{\partial h_{\mu\nu}}{\partial x^{\rho}})_{,\sigma}$$

$$=\frac{1}{2}(\frac{\partial^2 h^{\sigma}_{\mu}}{\partial x^{\sigma}\partial x^{\nu}}+\frac{\partial^2 h}{\partial x^{\mu}\partial x^{\nu}}-\frac{\partial^2 h^{\rho}_{\mu}}{\partial x^{\rho}\partial x^{\nu}})-\frac{1}{2}\frac{\partial^2 h^{\sigma}_{\mu}}{\partial x^{\nu}\partial x^{\sigma}}-\frac{1}{2}\frac{\partial^2 h^{\sigma}_{\nu}}{\partial x^{\mu}\partial x^{\sigma}}+\frac{1}{2}\eta^{\sigma\rho}\frac{\partial h_{\mu\nu}}{\partial x^{\rho}\partial x^{\sigma}}$$

$$=\frac{1}{2}(\frac{\partial^2 h}{\partial x^{\mu}\partial x^{\nu}}-\frac{\partial^2 h^{\rho}_{\mu}}{\partial x^{\rho}\partial x^{\nu}}-\frac{\partial^2 h^{\sigma}_{\nu}}{\partial x^{\mu}\partial x^{\sigma}})+\frac{1}{2}\eta^{\sigma\rho}\frac{\partial h_{\mu\nu}}{\partial x^{\rho}\partial x^{\sigma}}$$

that is to say

$$R_{\mu\nu}=\frac{1}{2}\eta^{\sigma\lambda}h_{\mu\nu,\lambda,\sigma}+\frac{1}{2}(h,_{\mu},_{\nu}-h^{\rho}_{\mu},_{\rho},_{\nu}-h^{\sigma}_{\nu},_{\sigma},_{\mu}=\gamma(T_{\mu\nu}-\frac{1}{2}T\eta_{\mu\nu}) \tag{8}$$

Note that as indexes the commas denote common derivative with respect of corresponding coordinate, for example $A_{,\mu}=\frac{\partial A}{\partial x^{\mu}}$ and $A_{,\mu,\nu}=\frac{\partial^2 A}{\partial x^{\nu}\partial x^{\mu}}$

And for the static spherically symmetric gravitational source, both ρ and p are only the function of r namely $\rho=\rho(r)$ and $p=p(r)$, in addition, $U_0=\eta_{0\mu}U^{\mu}=-1$, $U_j=\eta_{j\lambda}U^{\lambda}=0$. And in the weak field, the covariant divergence of energy-stress tensor is zero degenerates to that ordinary divergence is zero, that is, $T^{\mu}_{\nu\ ;\mu}=0$ degenerates to $T^{\mu}_{\nu\ ,\mu}=0$, and proved as follows.

After neglecting less than $o(h^2)$, we have $R^{\mu}_{\nu\ ;\mu}=R^{\mu}_{\nu\ ,\mu}+\Gamma^{\mu}_{\lambda\mu}R^{\lambda}_{\nu}-\Gamma^{\mu}_{\lambda\nu}R^{\lambda}_{\mu}=R^{\mu}_{\nu\ ,\mu}+o(h^2)=R^{\mu}_{\nu\ ,\mu}$

where, as indexes the semicolons denote covariant derivative with respect of corresponding coordinate. And using Bianchi identity $0=(R^{\mu}_{\nu}-\frac{1}{2}R\delta^{\mu}_{\nu})_{;\mu}=R^{\mu}_{\nu\ ;\mu}-\frac{1}{2}R_{\ ;\nu}=R^{\mu}_{\nu\ ,\mu}-\frac{1}{2}R_{,\nu}$, and $R=-\gamma T$,

then $R^{\mu}_{\nu\ ,\mu}=\gamma(T^{\mu}_{\nu}-\frac{1}{2}T\delta^{\mu}_{\nu})_{,\mu}=\gamma(T^{\mu}_{\nu\ ,\mu}-\frac{1}{2}T_{,\nu})=\gamma T^{\mu}_{\nu\ ,\mu}+\frac{1}{2}R_{\ ,\nu}$, hence it is proved that $T^{\mu}_{\nu\ ,\mu}=0$.

And for the static case, $T^{\mu}_{\nu\ ,\mu}=[(\rho+p)U_{\nu}U^{\mu}]_{,\mu}+(p\delta^{\mu}_{\nu})_{,\mu}=0$ means $\frac{\partial p}{\partial x^{\nu}}=0$, $\nu=0,1,2,3$

that is to say, pressure is a constant in celestial body namely in source of gravitation.

For the static case there are $h_{01}=h_{02}=h_{03}=0$, $\frac{\partial g_{\mu\nu}}{\partial t}=0$. And from equation (8) we have

$$\nabla^2 h_{00}=\gamma(\rho+3p) \tag{9}$$

$$-\frac{\partial^2 h_{00}}{\partial x^2}+\frac{\partial^2 h_{22}}{\partial x^2}+\frac{\partial^2 h_{33}}{\partial x^2}+\frac{\partial^2 h_{11}}{\partial y^2}+\frac{\partial h_{11}}{\partial z^2}-2\frac{\partial^2 h_{13}}{\partial x\partial z}-2\frac{\partial^2 h_{12}}{\partial x\partial y}-\gamma(\rho-p)=0 \tag{10}$$

$$-\frac{\partial^2 h_{00}}{\partial y^2}+\frac{\partial^2 h_{11}}{\partial y^2}+\frac{\partial^2 h_{33}}{\partial y^2}+\frac{\partial^2 h_{22}}{\partial x^2}+\frac{\partial^2 h_{22}}{\partial z^2}-2\frac{\partial^2 h_{12}}{\partial x\partial y}-2\frac{\partial^2 h_{23}}{\partial z\partial y}-\gamma(\rho-p)=0 \tag{11}$$

$$-\frac{\partial^2 h_{00}}{\partial z^2}+\frac{\partial^2 h_{11}}{\partial z^2}+\frac{\partial^2 h_{22}}{\partial z^2}+\frac{\partial^2 h_{33}}{\partial x^2}+\frac{\partial^2 h_{33}}{\partial y^2}-2\frac{\partial^2 h_{13}}{\partial x\partial z}-2\frac{\partial^2 h_{23}}{\partial z\partial y}-\gamma(\rho-p)=0 \tag{12}$$

$$-\frac{\partial^2 h_{00}}{\partial x\partial y}+\frac{\partial^2 h_{33}}{\partial x\partial y}-\frac{\partial^2 h_{13}}{\partial z\partial y}-\frac{\partial^2 h_{23}}{\partial z\partial x}+\frac{\partial^2 h_{12}}{\partial z^2}=0 \tag{13}$$

$$-\frac{\partial^2 h_{00}}{\partial x\partial z}+\frac{\partial^2 h_{22}}{\partial x\partial z}-\frac{\partial^2 h_{12}}{\partial z\partial y}-\frac{\partial^2 h_{23}}{\partial y\partial x}+\frac{\partial^2 h_{13}}{\partial y^2}=0 \tag{14}$$

$$-\frac{\partial^2 h_{00}}{\partial y\partial z}+\frac{\partial^2 h_{11}}{\partial y\partial z}-\frac{\partial^2 h_{13}}{\partial x\partial y}-\frac{\partial^2 h_{12}}{\partial z\partial x}+\frac{\partial^2 h_{23}}{\partial x^2}=0 \tag{15}$$

Only four of these seven equations are independent, as can be see from the following solving course. Obviously, solution of equation (9) is $h_{00}=-\frac{\gamma}{4\pi}\int\frac{(\rho+3p)d\mathbf{r}'}{|\mathbf{r}-\mathbf{r}'|}$, and due to both ρ and p are only the function of r, similar to the calculation of Newton's gravitational potential we have

$$h_{00}=-\frac{\gamma}{4\pi}\int\frac{\rho+3p}{|\mathbf{r}-\mathbf{r}'|}d\mathbf{r}'=-\frac{\gamma}{4\pi}\left(\frac{m(r_e)}{r_e}+\int_r^{r_e}\frac{m(r)}{r^2}dr\right)$$

where r_e is the source's radius and $m(r)=\int_0^r(\rho+3p)4\pi r^2dr$. Note that outside source $\rho=0$ and $p=0$. And (10) + (11) - (12) gets

$$-\nabla^2 h_{00}+2\frac{\partial^2 h_{00}}{\partial z^2}+2\frac{\partial^2 h_{22}}{\partial x^2}+2\frac{\partial^2 h_{11}}{\partial y^2}-\gamma(\rho-p)=4\frac{\partial^2 h_{12}}{\partial x\partial y} \tag{16}$$

Similarly $-\nabla^2 h_{00}+2\frac{\partial^2 h_{00}}{\partial y^2}+2\frac{\partial^2 h_{33}}{\partial x^2}+2\frac{\partial^2 h_{11}}{\partial z^2}-\gamma(\rho-p)=4\frac{\partial^2 h_{13}}{\partial x\partial z}$ (17)

$$-\nabla^2 h_{00}+2\frac{\partial^2 h_{00}}{\partial x^2}+2\frac{\partial^2 h_{22}}{\partial z^2}+2\frac{\partial^2 h_{33}}{\partial y^2}-\gamma(\rho-p)=4\frac{\partial^2 h_{32}}{\partial z\partial y} \tag{18}$$

differentiating (15) with respect of z + differentiating (13) with respect of x gets

$$-2\frac{\partial^3 h_{00}}{\partial y \partial x^2}+2\frac{\partial^3 h_{33}}{\partial y \partial x^2}-4\frac{\partial^3 h_{13}}{\partial y \partial z \partial x}-2\frac{\partial^3 h_{00}}{\partial y \partial z^2}+2\frac{\partial^3 h_{11}}{\partial y \partial z^2}=0 \tag{19}$$

Integrating equation (19) with respect of y gets

$$-2\frac{\partial^2 h_{00}}{\partial x^2}+2\frac{\partial^2 h_{33}}{\partial x^2}-4\frac{\partial^2 h_{13}}{\partial z \partial x}-2\frac{\partial^2 h_{00}}{\partial z^2}+2\frac{\partial^2 h_{11}}{\partial z^2}+C=0 \tag{20}$$

Similarly $-2\frac{\partial^2 h_{00}}{\partial x^2}+2\frac{\partial^2 h_{22}}{\partial x^2}-4\frac{\partial^2 h_{12}}{\partial y \partial x}-2\frac{\partial^2 h_{00}}{\partial y^2}+2\frac{\partial^2 h_{11}}{\partial y^2}+C=0$ (21)

$$-2\frac{\partial^2 h_{00}}{\partial y^2}+2\frac{\partial^2 h_{33}}{\partial y^2}-4\frac{\partial^2 h_{23}}{\partial z \partial y}-2\frac{\partial^2 h_{00}}{\partial z^2}+2\frac{\partial^2 h_{22}}{\partial z^2}+C=0 \tag{22}$$

where C is a constant. And (20) - (17) gets $\nabla^2 h_{00}-\gamma(\rho-p)-C=0$, thus $C=4\gamma p$, it shows that the equation (20) is completely equivalent to the equation (17). Similarly, the other equivalence. Therefore, equation (13), equation (14) and equation (15) need not to be considered in the process of solution, and it is enough that only consider equation (9)---equation (12). And may as well assume $h_{ii}=\omega(r)+\frac{\psi(r)-\omega(r)}{r^2}x^{i2}$, $h_{ji}=\frac{\psi(r)-\omega(r)}{r^2}x^i x^j$ ($i \neq j$). Without loss of generality, we consider $h_{11}=\omega(r)+\frac{\psi(r)-\omega(r)}{r^2}x^2$, $h_{22}=\omega(r)+\frac{\psi(r)-\omega(r)}{r^2}y^2$ and $h_{12}=\frac{\psi(r)-\omega(r)}{r^2}xy$. Of course, if consider the other components the conclusions will be the same.

Then $\frac{\partial h_{11}}{\partial y}=\frac{y}{r}\frac{d\omega}{dr}+\frac{x^2 y}{r}\frac{d}{dr}(\frac{\psi-\omega}{r^2})$, and

$$\frac{\partial^2 h_{11}}{\partial y^2}=-\frac{y^2}{r^3}\frac{d\omega}{dr}+\frac{d\omega}{rdr}+\frac{d^2\omega}{dr^2}\frac{y^2}{r^2}+\frac{x^2}{r}\frac{d}{dr}(\frac{\psi-\omega}{r^2})-\frac{y^2x^2}{r^3}\frac{d}{dr}(\frac{\psi-\omega}{r^2})+\frac{y^2x^2}{r^2}\frac{d^2}{dr^2}(\frac{\psi-\omega}{r^2}).$$

Similarly, $\frac{\partial^2 h_{22}}{\partial x^2}=-\frac{x^2}{r^3}\frac{d\omega}{dr}+\frac{d\omega}{rdr}+\frac{d^2\omega}{dr^2}\frac{x^2}{r^2}+\frac{y^2}{r}\frac{d}{dr}(\frac{\psi-\omega}{r^2})-\frac{y^2x^2}{r^3}\frac{d}{dr}(\frac{\psi-\omega}{r^2})+\frac{y^2x^2}{r^2}\frac{d^2}{dr^2}(\frac{\psi-\omega}{r^2})$,

$$\frac{\partial^2 h_{12}}{\partial x \partial y}=\frac{\partial^2}{\partial x \partial y}[\frac{\psi(r)-\omega(r)}{r^2}xy]=\frac{\psi(r)-\omega(r)}{r^2}+\frac{d}{dr}[\frac{\psi(r)-\omega(r)}{r^2}]\frac{x^2+y^2}{r}+\frac{d^2}{dr^2}[\frac{\psi(r)-\omega(r)}{r^2}]\frac{x^2y^2}{r^2}-\frac{d}{dr}[\frac{\psi(r)-\omega(r)}{r^2}]\frac{x^2y^2}{r^3}$$

And inserting them into equation (16) gets

$$-\frac{y^2+x^2}{r^3}\frac{d\omega}{dr}+\frac{d\omega}{rdr}+\frac{d^2\omega}{dr^2}\frac{y^2+x^2}{r^2}-2(\frac{\psi-\omega}{r^2})-\frac{y^2+x^2}{r}\frac{d}{dr}(\frac{\psi-\omega}{r^2})-\gamma(\rho+p)+\frac{\partial^2 h_{00}}{\partial z^2}=0 ,$$

where $\frac{\partial^2 h_{00}}{\partial z^2}=\frac{\gamma\int_0^r(\rho+3p)r^2dr}{r^3}-\frac{3\gamma z^2\int_0^r(\rho+3p)r^2dr}{r^5}+\frac{\gamma z^2}{r^2}(\rho+3p)$. And further we have

$$\frac{2d\omega}{rdr}+\frac{d^2\omega}{dr^2}-\gamma(\rho+p)-\frac{d\psi}{rdr}+\frac{\gamma}{r^3}\int_0^r(\rho+3p)r^2dr+\frac{z^2}{r^2}[\frac{d\psi}{rdr}-\frac{d^2\omega}{dr^2}+\frac{2\omega}{r^2}-\frac{2\psi}{r^2}+\gamma(\rho+3p)-\frac{3\gamma}{r^3}\int_0^r(\rho+3p)r^2dr]=0$$

And due to z is arbitrary, thus we obtain the following two equations

$$\frac{2d\omega}{rdr}+\frac{d^2\omega}{dr^2}-\gamma(\rho+p)-\frac{d\psi}{rdr}+\frac{\gamma}{r^3}\int_0^r(\rho+3p)r^2dr=0 \tag{23}$$

$$\frac{d\psi}{rdr}-\frac{d^2\omega}{dr^2}+\frac{2\omega}{r^2}-\frac{2\psi}{r^2}+\gamma(\rho+3p)-\frac{3\gamma}{r^3}\int_0^r(\rho+3p)r^2dr=0 \tag{24}$$

And (23)+(24) gets

$\psi=r\frac{d\omega}{dr^2}+\omega+p\gamma r^2-\frac{\gamma}{r}\int_0^r(\rho+3p)r^2dr$, and considering of $p=const$, differentiating it with respect of r we have $\frac{d\psi}{dr}=\frac{d\omega}{dr}+r\frac{d^2\omega}{dr^2}+\frac{d\omega}{dr}+\frac{\gamma}{r^2}\int_0^r(\rho+3p)r^2dr-\gamma(\rho+p)r$, which is exactly equation (23) and indicates that equation (23) isn't independent from equation (24), we need only consider one of equation (23) and equation (24). The solution of equation (23) or equation (24) is given by

$$\omega(r)=-\frac{\gamma\ln r}{2\pi}\int\frac{\rho-p}{|\mathbf{r}-\mathbf{r}'|}d\mathbf{r}'=-\frac{\gamma\ln r}{2\pi}[\frac{\mu(r_e)}{r_e}+\int_r^{r_e}\frac{\mu(r)}{r^2}dr],\ \text{where}\ \mu(r)=\int_0^r(\rho-p)4\pi r^2dr,$$

$$\psi(r)=\int_\infty^r[-\frac{\gamma\mu(r_e)}{2\pi rr_e}+\frac{\gamma\mu(r)}{\pi r^2}-\frac{\gamma}{2\pi r}\int_r^{r_e}\frac{\mu(r)}{r^2}dr+\gamma(\rho-3p)r+\frac{\gamma}{4\pi r^2}\int_0^r(\rho+3p)4\pi r^2dr]dr$$

outside the gravitational source $\mu(r)=\mu(r_e)=const$, $m(r)=m(r_e)=const$, we have

$$\omega(r)=-\frac{\gamma\ln r}{2\pi}[\frac{\mu(r_e)}{r_e}+\int_r^{r_e}\frac{\mu(r)}{r^2}dr]=-\frac{\gamma\ln r}{2\pi r}\int_0^{r_e}(\rho-p)4\pi r^2dr=-\frac{\gamma\ln r}{2\pi r}\mu(r_e)$$

$$\psi(r)=-\frac{\gamma}{2\pi r}\int_0^{r_e}(\rho-p)4\pi r^2dr-\frac{\gamma}{4\pi r}\int_0^{r_e}(\rho+3p)4\pi r^2dr=-\frac{\gamma\mu(r_e)}{2\pi r}-\frac{\gamma m(r_e)}{4\pi r}$$

Therefore, in order to make $\omega(r)=-\frac{4GM\ln r}{r}$ and $\psi(r)=-\frac{2GM}{r}$ outside the source it must be required that coupling constant $\gamma=4\pi G$ and meanwhile pressure p must satisfy

$$\int_0^{r_e}p\cdot4\pi r^2dr=-\int_0^{r_e}\rho\cdot4\pi r^2dr=-M \tag{25}$$

It is shown that $h_{00}=-\frac{\gamma}{4\pi}\left(\frac{m(r_e)}{r_e}+\int_r^{r_e}\frac{m(r)}{r^2}dr\right)=-G\left(\frac{m(r_e)}{r_e}+m(r_e)\int_r^{r_e}\frac{1}{r^2}dr\right)=\frac{2GM}{r}$

So far, all metric components of the static spherically symmetric weak field are solved, and by solving the new metric we find that the pressure p as gravitational source is a negative constant and from equation (25) we have

$$p=-\bar{\rho} \tag{26}$$

The above bar stands for the average of ρ. This means that pressure is uniformly distributed in the celestial body or in the gravitational source, and does not change in sync with the density.

When the source's density is even it becomes $p=-\rho$, which is very important to cosmology because space described by cosmology is isotropic and uniform space.

Readers may think that this negative pressure is unreasonable, which is actually a kind of prejudice. In fact, the pressure is similar to the potential, the size can be set arbitrarily, not necessarily confined to the positive value, the important thing is the pressure difference. The reason why p is called pressure is for conservation law $T^{\mu\nu}{}_{;\nu}=0$, that is, In the equation of motion it represents the pressure of ideal fluid. Only from a dynamic point of view, it is enough to think of p as the pressure of the fluid, but to take a negative value, and the deeper meaning of p is discussed at the end of this paper.

And in a word with the new coupling constant $\gamma=4\pi G$, field equation is now written as

$$R_{\mu\nu}-\frac{1}{2}Rg_{\mu\nu}=4\pi GT_{\mu\nu} \tag{27}$$

The pressure that matches it takes a negative value

4. Application of Equation (27) in Cosmology

The correctness of a new theory lies in the test of practice, and the equation (27) is well consistent with observation. Besides, there are some new and meaningful results, and eliminates some cosmological difficulties

The metric describing cosmic space is Robertson-Walker metric

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

where l is co-moving radial coordinate, $R(t)$ is scale factor..And connecting it to equation (27) gets

$$\left(\frac{dR}{dt}\right)^2+k=-\frac{4\pi G}{3}\rho R^2 \tag{28}$$

$$\frac{d\rho}{dt}R+3\frac{dR}{dt}(p+\rho)=0 \tag{29}$$

The equation (28) is similar to the original Friedman equation，and only replacing G there with $-\frac{G}{2}$ gets equation (28) here, so there's no need to repeat the derivation here. Equation (28) means constant k must be negative and therefore space is proven to be infinite. Inserting $p=-\rho$ into equation (29) gets $p=-\rho=const$, which means that the density of the universe does not change in the process of expansion and therefore new matter must produce continuously. Equation (28) becomes easy to solve, and its solution is given by

$$R(t)=A\sin\left(t\sqrt{\frac{4\pi G\rho}{3}}\right). \tag{30}$$

where A is a positive constant. Equation (30) shows the cycle of expansion and contraction. The moment $R(t)=0$ is both the end of the last contraction and the beginning of the next expansion, we might as well still call it big bang since at the moment the rate of spatial expansion is infinite (but the density and temperature are no longer infinite). Such a big bang has taken place countless times, and today's universe is in the phase of expansion of final a cycle. May as well put the start time of the final expansion $t=0$, and t_0 is the time from $t=0$ to today , namely our universal age. Therefore, the horizon of observational universe is

$$d_h(t)\equiv R(t)\int_0^t\frac{1}{R(t)}dt=\sin\left(t\sqrt{\frac{4\pi G\rho}{3}}\right)\int_0^t\frac{dt}{\sin\left(t\sqrt{4\pi G\rho/3}\right)}=\infty$$

Just right, this integral is divergent, as long as $t\neq 0$ The so-called horizon difficulties no longer exist, and the universe looks infinite at any time. There is no need to introduce another inflation mechanism . It is worth noting that the volume of the universe is indeed zero at the moment $R(t)=0$, but this state is unobservable because any observation is made at a certain time interval, and the above formula shows that only at time $R(t)=0$ the horizon of the universe is zero, and at any other time the horizon is infinite.

Next we derive the relation between distance and red-shift. If the light given out by distant galaxy at the time t_e reaches the earth at the time t_0 of today, its red-shift $z=\frac{\lambda_0-\lambda_e}{\lambda_e}=\frac{R(t_0)}{R(t_e)}-1$. λ is wave length. May as well put today's $R(t_0)=1$. And differentiating $1+z=\frac{1}{R(t)}$ gets

$$dz=-\frac{dR}{R^2(t)}=-\frac{dR}{Rdt}\frac{dt}{R}.$$

And from equation (28) we have $q\equiv\frac{4\pi G\rho}{3H^2}=-\frac{R\ddot{R}}{\dot{R}^2}$, $H\equiv\frac{dR}{Rdt}$.

Writing today's $\frac{4\pi G\rho}{3H_0^2}\equiv q_0$, $H(t_0)=H_0$, then $H=H_0\sqrt{(1+q_0)(1+z)^2-q_0}$, $k=-H_0^2(1+q_0)$

And for light line $ds^2=0$, $\frac{dt}{R(t)}=-\frac{dz}{H}=-\frac{dl}{\sqrt{(1-kl^2)}}$, $\int_0^z\frac{dz}{H}=\int_0^{l_a}\frac{dl}{\sqrt{1-kl^2}}$. l_a is the galaxy's unchanged co-moving coordinate. Considering of proper distance $d_p=R(t)\int_0^{l_a}\frac{dl}{\sqrt{1-kl^2}}$, luminosity-distance

$d_L=(1+z)\int_0^{l_a}\frac{dl}{\sqrt{1-kl^2}}$, we get

$$H_0d_L=\frac{z+1}{\sqrt{q_0+1}}\ln\frac{(z+1)\sqrt{q_0+1}+\sqrt{(q_0+1)(z+1)^2-q_0}}{1+\sqrt{q_0+1}} \quad (31)$$

Obviously as $z\to 0$, it is $H_0d_L=z+\frac{1-q_0}{2}z^2+\frac{3q_0^{\,2}-2q_0-1}{6}z^3+\cdots$,

after omitting high order terms, it becomes classical Hubble law. The conclusion of equation（31）is in good agreement with the observed distance and red-shift data[9-19], which strongly indicates that the field equation (27) is correct and so-called dark energy doesn't exist and the expansion of the universe.is still decelerating not accelerating.The conclusion of accelerated expansion is based on the wrong theoretical model [20-24], and even if the observation data are correct, once the theoretical model which is used to analyze the data is wrong, it is natural that the conclusion is wrong. The curved line in Figure 1 is the image of equation (31) with $q_0=0.14$ and $H_0=70km\cdot s^{-1}\cdot Mpc^{-1}$. H_0 is Hubble parameter of today. And using $H=\frac{dR}{Rdt}=2\sqrt{\frac{\pi G\rho}{3}}ctg\left(2t\sqrt{\frac{\pi G\rho}{3}}\right)$, our universal age is given by

$$t_0=\frac{tg^{-1}\sqrt{q_0}}{H_0\sqrt{q_0}}=1.37\times 10^{10}\,yr,.$$

which is the same result as current theory.

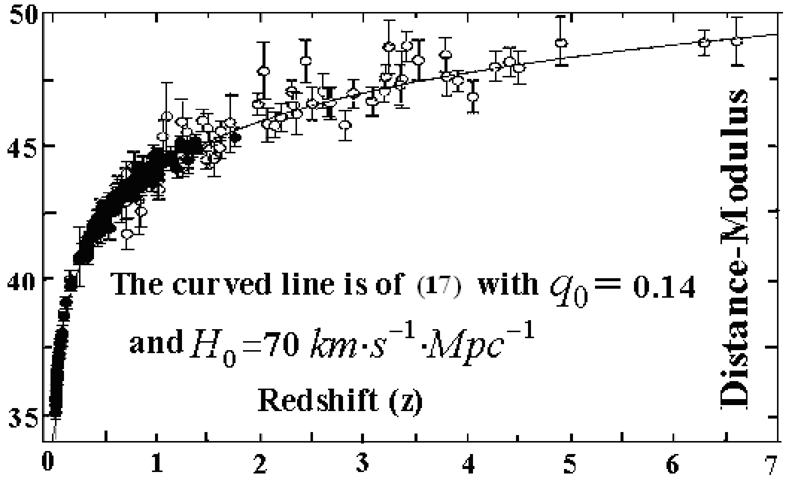

Fig1. *The Recent Hubble diagram of 69 GRBs and 192 SNe Ia***.**

Recent observations show that $q_0 = \frac{4\pi G\rho}{3H_0^2} = 0.1 \pm 0.05$. Note that Distance-Modulus is equal to $5\lg d_L + 25$, unit of d_L is Mpc. Below it is also to prove that at the time $R(t) = 0$, everything disappears and the new galaxy will be reformed.

5. The Issue of Dark Matter

Because negative pressure is a more important gravitational source than mass and compared with mass it is in a dominant position, it is not necessary to introduce artificially dark matter to explain mass missing. Next we try to prove this.

In the center of the galaxy, there is a pronounced bulge. Therefore, we can think of a galaxy as a disk, at the center of which extra superimposing a spherical symmetric celestial body whose radius is r_e, as is a reasonable assumption for convenience of calculation.

The gravitational field in the galaxy is still treated as a weak field, at any point on the disk the metric is just a function of r . Without loss of generality, we calculate h_{00} at point N, ON $= r$ (reference to figure 2), it is

$$h_{00} = -G\int \frac{\rho + 3p}{|\mathbf{r} - \mathbf{r}'|} d\mathbf{r}' = -G\iiint_{\pi r_e^3} \frac{\rho + 3p}{|\mathbf{r} - \mathbf{r}'|} d\mathbf{r}' - G\iint_{\pi R^2} \frac{\sigma_1 + 3\sigma_2}{\xi} ds$$

where σ_1 is the area density of mass and σ_2 is the area density of pressure on the disk, r_b is radius of the disk (the distance from the edge of the disk to the center), $ds = \xi d\xi d\alpha$ is area element. Note that p is even in the sphere and σ_2 is even on the disk, and $\rho = \rho(r)$ in the sphere and $\sigma_1 = \sigma_1(r)$ on the disk, besides they must satisfy $\int_0^{r_e} p \cdot 4\pi r^2 dr = -\int_0^{r_e} \rho \cdot 4\pi r^2 dr$ and $\iint_{\pi r_b^2} \sigma_2 ds = -\iint_{\pi r_b^2} \sigma_1 ds$, thus

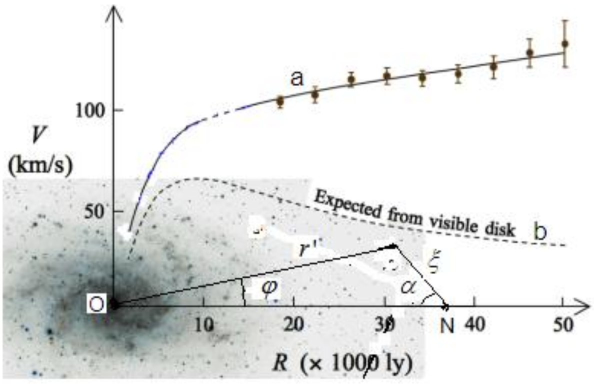

Figure2. *sketch diagram of velocity distribution of stars in a galaxy. The curve a represents the actual observation, and the curve b represents the situation predicted by the old field equation or Newton gravity.*

$$h_{00}=-G\iiint_{\pi r_e^3}\frac{\rho+3p}{|\mathbf{r}-\mathbf{r}'|}d\mathbf{r}'-G\iint_{\pi r_b^2}\frac{\sigma_1}{\xi}ds-3\sigma_2G\iint_{\pi r_b^2}\frac{1}{\xi}ds$$

$$=-G\frac{m(r_e)}{r_e}-G\int_r^{r_e}\frac{m(r)}{r^2}dr-3\sigma_2G\int_0^{2\pi}d\alpha\int_0^{r\cos\alpha+\sqrt{r_b^2-r\sin^2\alpha}}d\xi-G\int_0^{2\pi}d\alpha\int_0^{r\cos\alpha+\sqrt{r_b^2-r\sin^2\alpha}}\sigma_1(\xi,\alpha)d\xi$$

$$=-G\frac{m(r_e)}{r_e}-G\int_r^{r_e}\frac{m(r)}{r^2}dr-G\int_0^{2\pi}d\alpha\int_0^{r\cos\alpha+\sqrt{r_b^2-r\sin^2\alpha}}\sigma_1d\xi-3\sigma_2G\int_0^{2\pi}(r\cos\alpha+\sqrt{r_b^2-r\sin^2\alpha})d\alpha$$

$$=-G\frac{m(r_e)}{r_e}-G\int_r^{r_e}\frac{m(r)}{r^2}dr-G\int_0^{2\pi}d\alpha\int_0^{r\cos\alpha+\sqrt{r_b^2-r^2\sin^2\alpha}}\sigma_1d\xi-\frac{3\sigma_2G}{r_b}\int_0^{2\pi}\sqrt{1-r^2\sin^2\alpha/r_b^2}d\alpha$$

$$=-G\frac{m(r_e)}{r_e}-G\int_r^{r_e}\frac{m(r)}{r^2}dr-G\int_0^{2\pi}d\alpha\int_0^{r\cos\alpha+\sqrt{r_b^2-r^2\sin^2\alpha}}\sigma_1d\xi-\frac{6\pi\sigma_2G}{r_b}(1-\frac{r^2}{4r_b^2}-\frac{3r^4}{64r_b^4}-\cdots)$$

In the above calculation, we use the recursion formula $\int_0^{2\pi}\sin^n d\alpha=\frac{n-1}{n}\int_0^{2\pi}\sin^{n-2}d\alpha$ and power series $\sqrt{1-k^2\sin^2\alpha}=1-\frac{k^2}{2}\sin^2\alpha-\frac{k^4}{2\cdot4}\sin^4\alpha-\frac{3k^6}{2\cdot4\cdot6}\sin^6\alpha-\frac{5k^8}{2\cdot4\cdot6\cdot8}\sin^8\alpha-\cdots$

Note that whether it is in the rectangular coordinate system (t,x,y,z) or in the spherical coordinate system (t,r,θ,φ), h_{00} is the same, so we might as well calculate the speed in the spherical coordinate system. Of course, the result calculated in the rectangular coordinate system is the same.

Assume the star at point N moving around the circle on the disk, in the spherical coordinate system (t,r,θ,φ), speed $v=r\frac{d\varphi}{dt}$, $\theta=\frac{\pi}{2}$, $\frac{dr}{dt}=0$, its geodesic is

$$0=\frac{d^2r}{dt^2}=-\Gamma^1_{\mu\nu}\frac{dx^\mu}{dt}\frac{dx^\nu}{dt}+\Gamma^0_{\mu\nu}\frac{dr}{dt}\frac{dx^\mu}{dt}\frac{dx^\nu}{dt}=-\Gamma^1_{\mu\nu}\frac{dx^\mu}{dt}\frac{dx^\nu}{dt}$$

$$=-\Gamma^1_{00}-\Gamma^1_{33}(\frac{d\varphi}{dt})^2\approx\frac{1}{2}\frac{\partial h_{00}}{\partial r}+r(\frac{d\varphi}{dt})^2=\frac{1}{2}\frac{\partial h_{00}}{\partial r}+\frac{v^2}{r}$$

$$=\frac{v^2}{r}+G\frac{m(r)}{2r^2}-\frac{G}{2}\frac{\partial}{\partial r}(\int_0^{2\pi}d\alpha\int_0^{r\cos\alpha+\sqrt{r_b^2-r^2\sin^2\alpha}}\sigma_1d\xi)+\frac{3\pi\sigma_2G}{r_b}(\frac{r}{2r_b^2}-\frac{3r^3}{16r_b^4}-\cdots)$$

therefore

$$v^2 = -G\frac{1}{2r}(\int_0^r 4\pi\rho r^2 dr + 3\int_0^r 4\pi p r^2 dr) + \frac{Gr}{2}\frac{\partial}{\partial r}(\int_0^{2\pi} d\alpha \int_0^{r\cos\alpha+\sqrt{r_b^2-r^2\sin^2\alpha}} \sigma_1 d\xi) - \frac{3\pi\sigma_2 G}{r_b}(\frac{r^2}{2r_b^2} - \frac{3r^4}{16r_b^4} - \cdots)$$

And as $r \le r_e$, we have

$$v^2 = -G\frac{1}{2r}\int_0^r 4\pi\rho r^2 dr - 2Gpr^2 + \frac{Gr}{2}\frac{\partial}{\partial r}(\int_0^{2\pi} d\alpha \int_0^{r\cos\alpha+\sqrt{r_b^2-r^2\sin^2\alpha}} \sigma_1 d\xi) - \frac{3\pi\sigma_2 G}{r_b}(\frac{r^2}{2r_b^2} - \frac{3r^4}{16r_b^4} - \cdots)$$

$\approx -\frac{G}{2r}\int_0^r 4\rho\pi r^2 dr - 2Gpr^2$. Obvious, if ρ is also even distribution In the sphere, then $p = -\rho$, $v^2 \approx -\frac{G}{2r}\int_0^r 4\rho\pi r^2 dr - 2Gpr^2 = -\frac{4}{3}Gpr^2$ which shows that $v \propto r$ and is consistent with observation, refer to the curve a in figure 2. And as $r_e < r < r_b$, we have

$$v^2 = \frac{G}{r}\int_0^{r_e} 4\pi\rho r^2 dr + \frac{Gr}{2}\frac{\partial}{\partial r}(\int_0^{2\pi} d\alpha \int_0^{r\cos\alpha+\sqrt{r_b^2-r^2\sin^2\alpha}} \sigma_1 d\xi) - \frac{3\pi\sigma_2 G}{r_b}(\frac{r^2}{2r_b^2} - \frac{3r^4}{16r_b^4} - \cdots)$$

which shows that v need not decrease as r increases. Note that σ_2 is negative.

If σ_1 is also even distribution on the disk, we have

$$\sigma_1 = -\sigma_2, \quad v^2 = \frac{G}{r}\int_0^{r_e} 4\pi\rho r^2 dr - \frac{2\pi\sigma_2 G}{r_b}(\frac{r^2}{2r_b^2} - \frac{3r^4}{16r_b^4} - \cdots) \approx \frac{GM}{r} + \frac{\pi\sigma_1 G r^2}{r_b^3}$$

which certainly allows the situation described by curve a, refer to figure 2. It's worth noting that its angular velocity

$$\phi = \frac{v}{r} = \sqrt{\frac{\pi\sigma_1 G}{r_b^3}} + \frac{M r_b^3}{2r^3\pi\sigma_1}\sqrt{\frac{\pi\sigma_1 G}{r_b^3}}$$

which shows that the closer to the edge, the smaller the angular velocity, although the speed is increasing. The above formula explains why all the disc-shaped galaxies observed are in the opposite direction to the opening of the arms. Refers to Figure 4.

Of course, generally speaking, σ_1 and ρ are not even, however, because it is σ_2 and p that play a leading role, the actual velocity distribution function calculated here will not deviate from the curve a too far. In short, the introduction of dark matter is superfluous [25], the negative acts as a dual role of dark matter and dark energy.The important thing is that this negative pressure is a property of ordinary matter not the independent physical existence, besides it can be solved from field equation and there is no need to introduce artificially from the outside. In fact, if there is dark matter in universe, their distribution should not always be accompanied by ordinary matter, there should be dark matter celestial bodies or dark matter galaxy. But, actually we don't find a dark matter galaxy or dark matter celestial body, as is enough to show that the so-called dark matter does not exist.

6. Continuous Creation of Matter, the Growth of Celestial Bodies

The density of the universe remains unchanged as it expands, which requires that matter in the universe must continuously generate. On the other hand， since the negative pressure is only distributed in the celestial bodies, the continuous generation of matter can only happen in the celestial bodies not all space. With the expansion of the universe the celestial bodies also expand and meanwhile their mass increase.

Applying $T^{\mu\nu}_{;\nu}=0$ and $U_\mu U^\mu=-1$ to a celestial body and noting that $g_{\mu\nu;\alpha}=0$, $g^{\mu\nu}{}_{;\alpha}=0$,

$$0=(U_\beta U^\beta)_{;\alpha}=U_\beta U^\beta{}_{;\alpha}+U_{\beta;\alpha}U^\beta=U_\beta U^\beta{}_{;\alpha}+(g_{\mu\beta}U^\mu)_{;\alpha}U^\beta=2U_\beta U^\beta{}_{;\alpha} \quad \text{and} \quad (nU^\alpha)_{;\alpha}=0$$

which denotes the conservation of particle number, *n* is number density of particle in the celestial body, we have

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

obviously $\frac{1}{n}$ denotes single-particle volume and $\frac{\rho}{n}$ denotes single-particle mass. If view whole celestial body as a particle, then $n=\frac{1}{V}$, $m=\frac{\rho}{n}$ we have

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

which shows that the expansion force of the universe overcomes the negative pressure to do work and increase the energy or mass of the celestial bod. Here V is the volume of the celestial body and m is its mass.

Therefore , when the celestial body expands with universal expansion its radius meets $r_e\propto R(t)$, and its volume $V\propto R^3(t)$， its mass $dm=-pdV=\rho dV=\frac{m}{V}dV$， namely $m\propto R^3(t)$ or

$$\frac{m(t_1)}{m(t_2)}=\frac{R^3(t_1)}{R^3(t_2)} \tag{32}$$

As example, for the earth, today its radius expands by 0.5 millimetres a year and its mass increases by 1.2 trillion tons a year. Equation (32) shows that the density of celestial body is unchanged during its expansion process because new matter is continuously formed inside the celestial body.

Obviously, equation (32) is also applicable to describe change in the mass of a galaxy. It is worth noting that equation (32) shows that at the moment $R(t)=0$ all things in universe disappear

It is shown below that when celestial bodies expand with the expansion of the universe, the mass change of a single celestial body satisfies (32) and does ensure that the average density in the universe remains unchanged on a large scale.

Select a ball with a radius of r at any point in the space（as shown in figure 3）， the volume is V ， with the expansion of space-time, the change of V is satisfied $V=kR^3(t)$， k is a constant. Assume that there are n celestial bodies in the ball, and the mass is satisfied. $m_1=k_1R^3(t)$， $m_2=k_2R^3(t)$ ......

$m_n=k_nR^3(t)$， where k_1 ,k_2 .... k_n are proportional constant, so the average density in the sphere is

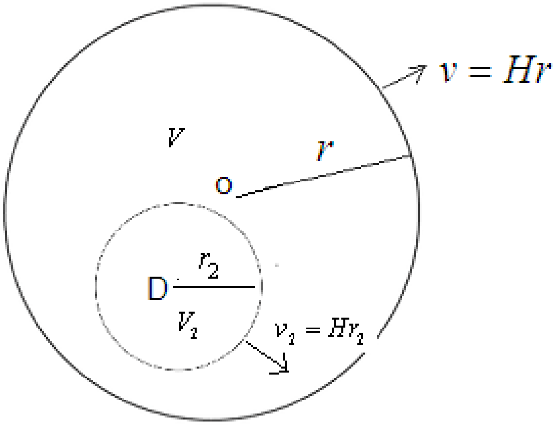

Figure3. *schematic diagram of celestial bodies expanding with the expansion of the universe*

$$\rho = \frac{m}{V} = \frac{k_1 R^3(t) + k_1 R^3(t) + \cdots k_n R^3(t)}{kR^3(t)} = \frac{k_1 + k_1 + \cdots k_n}{k} = const$$

put $r \to \infty$, The above formula indicates that the density of the universe is constant in a wide range, that is, the density of the universe is unchanged.

As an example, the radius of the earth expands at a rate of 0.5 millimeters per year today, and the mass of the earth can be increased by 1.2 trillion tons a year by using the equation (32). Obviously, equation (32) is also suitable to describe the change of galaxy mass. At that time $R(t) = 0$, the mass of celestial body or galaxy is zero, everything disappears, the next cycle begins, and new galaxy begins to form.

It is worth noting that there is a difference between the continuous creation demonstrated in this paper and the continuous creation described by Hoyle. The continuous creation of Hoyle takes place in the full space, and new galaxies continue to form, the size of the galaxy remains the same, and the density of the universe remains the same in the process of expansion.The continuous creation proved in this paper is only carried out in celestial bodies, the galaxies are growing, there is no new galaxy to form, the density of the universe remains unchanged in the process of expansion. Observations show that the early (namely distant)galaxy were more dense, so the Hoyle theory is negated, and instead the galaxy formation and evolution process demonstrated in this paper is completely consistent with the observations. Besides, Hoyle's C-field, which leads to the continuous production of matter, is artificially introduced so there is a logical flaw. And the negative pressure in this paper, which leads to the continuous production of matter, is inherent in the field equation so there is no logical flaw.

7. General Relativity Description of Orbital Hubble Expansion, the Continuous Growth Mechanism of Galaxy Formation

The usual conservation of angular momentum or energy is a concept established without considering the expansion of space, so it can only be approximated in a small period of time. Once the expansion of space is considered, the previous conservation laws should be modified accordingly. According to cosmological principles, space is equal right everywhere, so the expansion of space should be uniform everywhere, which requires that the orbit of the planet orbiting the center is also far from the center according to Hubble's law. Now we prove that general relativity can indeed describe the Hubble expansion of the planet orbit, that is, the Hubble expansion of the planet orbit is a prediction of general relativity, and in the same time it is stated that the periods of rotation or revolution are not changed by Hubble expansion

Birkhoff law tells that in the gravitational field of spherical symmetry, no matter how the gravitational source changes, certainly not ruling out the change in mass, as long as the spherical symmetry can keep up the form of space-time line element is the same

$$ds^2 = -(1-\frac{2Gk}{l})dt^2 + \frac{1}{1-\frac{2Gk}{l}}dl^2 + l^2(d\theta^2 + \sin^2\theta d\varphi^2) \qquad (33)$$

This is to say, with t, l, θ, φ as independent coordinate variables equation (33) is a solution of vacuum field equation $R_{\mu\nu}$ =0, namely when the mass of central body changes to meet equation (32) its gravitational field can still be described by (33). Here k is a constant relating to the central body and later will give the specific value, and l is called standard radial coordinate or radial parameter.

Let the orbital plane of the galaxy be $\theta = \frac{\pi}{2}$, then $ds^2 = -(1-\frac{2Gk}{l})dt^2 + \frac{1}{1-\frac{2Gk}{l}}dl^2 + l^2 d\varphi^2$ namely

$$(1-\frac{2Gk}{l}) = -(1-\frac{2Gk}{l})^2\frac{dt^2}{ds^2} + \frac{dl^2}{ds^2} + l^2(1-\frac{2Gk}{l})\frac{d\varphi^2}{ds^2} \qquad (34)$$

On the other hand, the equation (33) provides

$g_{00} = -1 + \frac{2Gk}{l}$, $g_{11} = \left(1-\frac{2Gk}{l}\right)^{-1}$, $g_{22} = l^2$, $g_{33} = l^2\sin^2\theta$, $g_{\mu\nu} = 0(\mu \neq \nu)$, and nonzero connection

$\Gamma^1_{11} = \frac{1}{2}g^{1\rho}(\frac{\partial g_{\rho 1}}{\partial x^1} + \frac{\partial g_{\rho 1}}{\partial x^1} - \frac{\partial g_{11}}{\partial x^\rho}) = -\frac{Gk}{(1-2Gk/l)r^2}$, $\Gamma^0_{01} = \frac{Gk}{(1-2Gk/l)l^2}$, $\Gamma^1_{00} = \frac{(1-2Gk/l)Gk}{l^2}$,

$\Gamma^2_{12} = \frac{1}{l}$, $\Gamma^1_{22} = \Gamma^1_{33} = -(1-\frac{2Gk}{l})l$, $\Gamma^3_{13} = \frac{1}{l}$, then we have the geodesic equation

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

$$\frac{d\varphi}{ds}l^2 = const = h \qquad (35)$$

and another geodesic equation is $0 = \frac{d^2t}{ds^2} + \Gamma^0_{\alpha\beta}\frac{dx^\alpha}{ds}\frac{dx^\beta}{ds} = \frac{d^2t}{ds^2} + \frac{1}{g_{00}}\frac{\partial g_{00}}{\partial l}\frac{dl}{ds}\frac{d\varphi}{ds}$, whose solution is

$$\frac{dt}{ds}(1-\frac{2GK}{l}) = const = \alpha \qquad (36)$$

And inserting (35) and (36) into (34) gets trajectory equation of planet

$$\frac{h^2}{l^4}\left(\frac{dl}{d\varphi}\right)^2 + \frac{h^2}{l^2} = (a^2+1) - \frac{2Gk}{l} + \frac{2Gkh^2}{l^3} \qquad (37)$$

Here α and h are imaginary integral constants. In the distance neglecting $\frac{2Gkh^2}{l^3}$, equation (37) has the approximate solution

$$l = -\frac{h^2}{Gk(1-e\cos\varphi)} \qquad (38)$$

where e is also a positive integral constant and $h^2 < 0$.

And the above results are in the standard coordinate system but, what we care about is the behavior in the actual coordinate system (t,r,θ,φ), and in order to get the desired result we may introduce coordinate transformation $l=\frac{r}{R(t)}$ and $t'=t$, and meanwhile put constant $k=\frac{M(t)}{R^3(t)}$, where $M(t)$ is the mass of the central massive body, then equation (38) becomes

$$r=-\frac{R^4(t)h^2}{GM(t)(1-e\cos\varphi)}=-\frac{R(t)h^2}{Gk(1-e\cos\varphi)} \tag{39}$$

which is just the equation we are searching for to describe the expansion of the orbits of planets following Hubble law in the actual coordinate system. So far, we say that general relativity is able to describe orbit's Hubble expansion, or say that general relativity had already predicted the Hubble expansion of the orbit, but we didn't notice it.

And again, it is worth noting that when the orbit of the planet is expanding following Hubble law its period of revolution is unchanged because

$$\frac{d\varphi}{dt}\approx\frac{d\varphi}{d\tau}=\frac{d\varphi}{ids}=-ih/l^2=-i\frac{GK(1-e\cos\varphi)}{h}$$

is only the function of φ and does not thing with the expansion of orbit, which means the speed of revolution of the planet is higher and higher. And again, because the rotation of the celestial body is made up of the revolution of all its parts, the periods of rotation of celestial bodies are unchanged, too.

To further illustrate this we consider Kepler law $\frac{4\pi^2a^3}{T^2}=GM$,T is the period， a is ellipse's semi-major axis, M is mass of central body. Now M is a variable to meets equation (32), and differentiating $\frac{4\pi^2a^3}{T^2}=GM$ we attain

$$\frac{da}{dt}=aH+\frac{2a}{3T}\frac{dT}{dt} \tag{37}$$

Obviously aH is the effect of spacetime expansion. The last term in equation (37) is explained for the effect of tide or other perturbation. In fact, as $a\to\infty$， dT must become zero because equation（37) must return to the usual Hubble law under such condition，which is a fact of observation (stars in the distance are receding following Hubble law). Therefore it is reasonable to explain the last term in equation (37) for tidal or perturbation effect. That is to say, spacetime expansion doesn't change the periods of kinds of rotations or revolutions although the orbits are expanding (receding from centers), and the actual change observed come from tide or other perturbations

As example, The radius of the Milky way is expanding at 900 meters per second，and the earth is leaving from the sun at a rate of 9 meters every year. The moon is 2.8 centimeters further from the earth every year and the tides dissipate makes it further only by 1 centimeter every year, so the increase of length of the day (namely the increase of period of rotation of the earth) is 0.6ms/100 years.

Substituting $l=\frac{r}{R(t)}$, $k=\frac{M(t)}{R^3(t)}$ into (37) obtains the more rigorous equation,

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

obviously it is a gradually magnifying and rotating spiral curve, the points on the line go away from the center body of mass M(t) and meet Hubble law.

We look back to look at the evolution of the Milky Way. As discussed in section 4, the direction of rotation of the disk is opposite to the direction of the opening, as shown in figure 4. The rotation direction of the disk and the distance between the solar system and the center are shown in the figure. It is important to note that the more you go to the edge of the disk, the higher the rotation speed of the material on the disk, but the smaller the angular speed . Therefore, in order to maintain the shape of the rotating arms for a long time, they must be gradually opened while rotating, otherwise they will become more and more tight, and finally the structure of the rotating arms will be completely destroyed. The equation (39) tells us that the galactic spiral arms are indeed gradually opening, and will not rotate more and more tightly. The opening velocity , that is, the radial expansion speed, satisfies Hubble expansion $v = Hr$, which is the distance from that point to the silver centerand will not be as tight as it will be, and the speed of expansion, that is, the radial expansion speed, will satisfy the Hubble expansion $v = Hr$ ，r is the distance from this point to the center. On the edge, today's $v_0 = 5.2$ ten thousand light years，

So the radius expansion rate of the disk is $v_0 = H_0 r_0 = 900m/s$， Similarly, the solar system leaves the heart about 450 meters per second today.

In the past, the formation of the galaxy are isolated from the expansion of the universe, and only the space between the galaxies is admitted to expansion, and the expansion of the galaxy itself is not recognized, and thus the long-standing of the shape of the arms can not be explained.

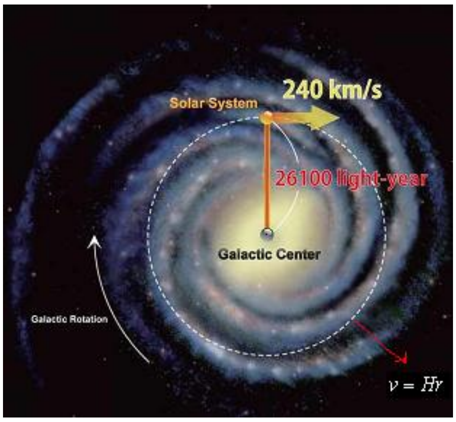

Figure4. *Evolution diagram of the Milky Way*

In a word, the picture of the evolution of the universe given by the new field equation is that not only the space between galaxies enlarges but also galaxies theirselves enlarge in following Hubble law, and new matter continuously creates in celestial bodies, but the periods of revolution or rotation of galaxies or celestial bodies keep invariant. Such the situation of universal evolution is similar to we look towards the sky at night to use a magnifying glass----- all are magnified at the same proportion.

The previous galactic formation theory holds that the large galaxies came from the mergers of small galaxies, which are seriously contradictory to the observation that the universe is expanding. Therefore, the previous theory of galaxy formation is wrong. The so-called galactic merger is nothing more than a fantasy. In fact, if the galaxies could merge, they would merge at the Big Bang, and there would be no need to wait until later, because their matter was closest to each other at the Big Bang. Besides, if the large galaxies are formed by the mergers of the small galaxies, then any large galaxy must go through several mergers, the merger phenomenon will be the mainstream, the spreading out of each other will be in a subordinate position, there are no reason to continue to talk about the expansion of the universe.

It is worth emphasizing that the formation or evolution process of the galaxy given in this paper is clear and can be verified or disproved by experiments, so the new theory is called realistic cosmology, which argues that today is the initial condition to infer the past and the future, understanding the past and the future must proceed from the facts of today instead of using an imaginary past to simulate today or future. In addition, the new theory interprets the world with the concept of gradual change and refuses to use the catastrophe to interpret the world.

8. The Evolution of Temperature or Brightness of a Celestial Body

Mass-Luminosity Ratio tell that the greater the mass of a star, the greater the brightness, so when the mass of a star increases following equation (32), its brightness or temperature increases

Through long observation, for stars in different mass ranges, people found the following mass-luminosity relation or say empirical formula

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

$$\frac{L}{L_\odot}=\left(\frac{M}{M_\odot}\right)^{4} \qquad 0.43M_\odot<M<2M_\odot$$

$$\frac{L}{L_\odot}=1.5\left(\frac{M}{M_\odot}\right)^{3.5} \qquad 2M_\odot<M<20M_\odot$$

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

L is the absolute luminosity of the star, $L_\odot$ and $M_\odot$ are respectively luminosity and mass of the sun .

Now we treat M as a variable and satisfied equation (32), its radius $r_e \propto R(t)$, and $d_p \propto R(t)$ is the distance from the star to us , and $L=4\pi r_e^2\cdot\sigma T_e^{\,4}=4\pi r_e^2\cdot l_e=4\pi d_p^2\cdot\sigma T_p^{\,4}=4\pi d_p^2\cdot l_p$

where l_e is absolute brightness of star, l_p is vision brightness, σ is Stefan-Boltzmann constant. Inserting them into the empirical formulas and noting that $L_\odot$, $M_\odot$ are viewed unchanged, for the same star, at any two different moments t_1 and t_2 there are the following results

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

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

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

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

Of course, these conclusions apply not only to stars, but also to ordinary celestial bodies.

As an example, we study the sun. In view of the range of the mass of the sun today, the change of solar vision brightness should meet the second relation, namely $\frac{l_p(t_1)}{l_p(t_2)} = \frac{R^{10}(t_1)}{R^{10}(t_2)}$, and assume $t_2 = t_0 = 1.37 \times 10^{10} a$, then a billion years ago $t_1 = (1.37 - 0.1) \times 10^{10} a = 1.27 \times 10^{10} a$, and refer to equation (30) we have

$$\frac{l_p(t_1)}{l_p(t_2)} \approx (\frac{1.27}{1.37})^{10} = 46/100$$

which means that the sun's vision brightness was less than half today's 1 billion ago. Note that here it's applied in the approximate calculation that $x \approx \sin x$ for $x \to 0$

As for the surface temperature of the earth, it should be the temperature at which the solar photons reach the surface of the earth, therefore, the temperature change of the earth's surface satisfies $\frac{T_p(t_1)}{T_p(t_2)} = \frac{R^{2.5}(t_1)}{R^{2.5}(t_2)}$, so today, compared with a billion years ago

$$\frac{T_p(t_1)}{T_p(t_2)} \approx (\frac{1.27}{1.37})^{2.5} = 82/100$$

If the earth's temperature is today $25^\circ C$, namely 298T, So a billion years ago, its temperature was 246T, namely $-27^\circ C$, which means that the temperature of the earth's surface increases by $5.2^\circ C$ and life's existence is not more than 2 billion years [8].

Similarly, the evolution of gravity acceleration on the surface of the earth can be deduced, it is $\frac{g(t_1)}{g(t_2)} = \frac{R(t_1)}{R(t_2)}$, a billion years ago the acceleration of gravity on the surface was

$$g(t_1) = g(t_2)\frac{R(t_1)}{R(t_2)} = 10m/ss \times \frac{1.27}{1.37} = 9.2m/ss$$

which means the weight of animals increases by nearly 10% per a billion years. Similarly, we can calculate the change of surface atmospheric pressure, due to space constraints, no longer give specific calculations, here.

The temperature of the celestial body rises and becomes brighter and brighter, indicating that the stars evolved from the planets, and today the stars are becoming more and more strong, they will become weaker and weaker only at the stage of the contraction of the universe. The so-called gravitational collapse is just a fantasy, actually celestial bodies are becoming bigger and bigger.

9. Quantum Mechanical Explanations of Continuous Formation of New Matter

The continuous formation of matter in celestial bodies is the result of spatial expansion force overcoming the negative pressure in celestial bodies, which is characterized by the division of nucleons in the microscopic level, that is, the space expansion force overcomes the nuclear force and opens one nucleon into two nucleons, that is, one neutron is divided into two neutrons, one proton is divided into one proton and one neutron and the charge conservation is conserved. This is all going on in the nucleus. With the increase of the number of nucleons in the nucleus, the nucleus decays, releases energy, forms new elements, and then comes with what is commonly known as various nuclear reactions. Because of the unexpected β decay, the mystery of the sun's neutrino ceases to exist. The continuous generation of elements ensures the relative stability of the abundance of elements in celestial bodies and does not decrease due to decay. It is a dynamic balance and ensures the sustained and stable release of energy from stars. In the past, there is no reasonable controllable mechanism for stars to burn slowly.

This powerful negative pressure in celestial bodies can be understood as the summary binding energy of matter, which includes the binding energy generated by the strong interaction within and between nucleons, that is, the binding energy generated by the interaction between quarks, as well as the binding energy generated by electromagnetic and gravitational interactions. That is to say, if the celestial body is infinitely divided, the parts are placed in an infinite distance, the work done to the celestial body is the integral of the negative pressure, the magnitude is equal to the mass of the celestial body, the sum of the positive and negative energy of the celestial body is zero. so the total energy of the whole universe is zero

It is consistent to understand the pressure as the binding energy of the substance to Einstein's interpretation, in the book " the meaning of relativity", Princeton University Press Published 1922 (page 117), for $T^{\mu\nu} = \rho \frac{dx^{\mu}}{ds}\frac{dx^{\nu}}{ds}$, Einstein said: we "shall add a pressure term that may be physically established as follows. Matter consists of electrically charged particles. On the basis of Maxwell's theory these cannot be conceived of as electromagnetic fields free from singularities. In order to be consistent with the facts, it is necessary to introduce energy terms, not contained in Maxwell's theory, so that the single electric particles may hold together in spite of the mutual repulsion between their elements, charged with electricity of one sign. For the sake of consistency with this fact, Poincare has assumed a pressure to exist inside these particles which balances the electrostatic repulsion. It cannot, however, be asserted that this pressure vanishes outside the particles. We shall be consistent with this circumstance if, in our phenomenological presentation, we add a pressure term. This must not, however, be confused with a hydrodynamical pressure, as it serves only for the energetic presentation of the dynamical relations inside matter". It can be seen from this that Einstein did not understand the pressure as the source of gravity as the ordinary pressure of the fluid, although in the equation of motion it is equivalent to the pressure of the ideal fluid, but tends to regard it as a phenomenological expression of energy in matter. Obviously, once it is understood as some kind of energy, it is not difficult to understand the negative value inside the matter.

In the actual calculation, if the pressure in the celestial body is taken as a positive value, it will lead to an absurd result (which has not been paid enough attention to so far), that is, when the ratio of the mass to the radius of the celestial body $\frac{2GM}{R} > \frac{8}{9}$, the pressure inside the celestial body appears infinity or singularity, which means that such a celestial body cannot exist. The reason why this conclusion is absurd is that general relativity has no additional requirements for the distribution of matter, that is to say, the pressure should be limited in any case.

From another example, it can also be seen that the pressure as a gravitational source can not be understood as the usual dynamic pressure. For a solid sphere, the internal dynamic pressure is usually considered to be zero, which is not a problem from the point of view of continuum mechanics, but not as a gravitational source, because the metric must satisfy the TOV equation

$\frac{dg_{00}}{g_{00}dr} = -\frac{2}{\rho + p}\frac{dp}{dr}$ If, $p = 0$, inevitably lead $\frac{dg_{00}}{dr} = 0$, which means that the acceleration of gravity inside the solid sphere must be zero, which is clearly unrealistic.

In this paper, it is considered that vacuum can not have energy, otherwise it is not called vacuum. Because according to relativity, there must be mass if there is energy, and mass represents inertia, which is the symbol of the existence of matter, that is to say, if vacuum has energy, then vacuum has mass or inertia, which contradicts the concept of vacuum. When people encounter puzzling problems, they should not be prone to vacuum energy or anything, but should focus on grasping the deep-seated laws of material movement. Preventing the resurrection of etheric theory is a task of physics, otherwise it can only circle in the old theory. Dark energy or vacuum energy is the contemporary etheric, its real function is to limit people's thoughts to existing theories. Dark energy or vacuum energy has pushed physics into an ethereal world, and it seems that any crappy theory can be invincible.

Next, estimate the period of a nucleon division. Today's $t_0 = 1.37\times10^{10}a$, when the mass of a nucleon is doubled, by using the equation (32) $t_1 = \sqrt[3]{\frac{m(t_1)}{m(t_0)}}t_0 = \sqrt[3]{2}\times1.37\times10^{10}a$, then

$$\Delta t = t_1 - t_0 = \sqrt[3]{2}\times1.37\times10^{10}a - 1.37\times10^{10}a = 2.7\times10^{9}a$$

In other words, at today's mass growth rate, it will take about 2.7 billion years for one nucleon to split into two, and there is no hope of seeing a single nucleon split.

10. CONCLUSION

The coupling constant of Einstein's gravitational field equation should be modified from -8πG to 4πG. Galaxies and celestial bodies form from gradual growth, not the aggregation of existing matter. New matter continuously creates in celestial bodies [26-32]， not created only in the moment of the Big Bang. The expansion and contraction of the universe cycle back and forth, and space-time is infinite and what people see, including microwave background radiation, is merely a tiny piece of space. Microwave background radiation is never the ashes of the so-called Big Bang and it is only the integrated effect of light emitted by distant material on instruments, its uniformity lies in the remote of distance of the light source, just as we look at distant targets, the farther the distance, the lower the resolution, and the black body spectrum lies in that the density of cosmic matter is so thin that universe is equivalent to an empty cavity. The big bangs had occurred countless times, but there were no singular point with infinite density and infinite temperature, only is the quick expansion and quick creation of matter, and at the moments of the big bangs the temperature of the matter was just the lowest and then gradually increased until today. Space expansion force is the most basic energy source of all activities. The universe creates both matter and space in the same time, and the continuous expansion of space is exactly the continuous creation of space. It is absurd that spacetime originated from a singularity, because the existence of singularity is contrary to dialectical philosophy and can not be correct. Dialectical philosophy thinks the real nature will not go to extremes, for the extremes of things are bound to be reversed， namely once a certain limit is reached, a change in the opposite direction is inevitable. Therefore, the real nature doesn't have any singularity, and the singularity only exists in mathematics and in imagination of heads. Today, science especially cosmology is still inseparable from the guidance of dialectical philosophy, otherwise it is very likely to go further and further on the evil road.

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