

The Decoupling Cosmology Theory

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Abstract

By putting forward the basic hypothesis "Energy Possesses No Gravitation", the energy equation and the motion equation of each stage of the development and evolution of the cosmos are obtained by solving the equivalence principle integrally in the flat space or inertial coordinate system. By comprehensive studying the energy equation and motion equation, the expressions of the cosmic critical scale and the initial cluster of nebulae critical scale (namely the galaxies critical scale), were found and given; During the process of matter and energy decoupling, about 3.3 billion initial cluster of nebulae of the critical scale were generated, and the cosmic scale was at least "Expand Expansion (2E)" at 1,300 times long, and the isotropic homogenization was basically realized above the critical scale; by assuming that the cosmos was born in the "Resonance" of the quantum fluctuation of static photons, deriving the early cosmos grew up at the speed of light and produced elementary matter particles at the speed of light, giving the early cosmos "Light-speed Growth Theory (LGT)" without the Big Bang, inflation and singularity theory; It was found that the rotation during the expansion of the gravitational field of the gas matter was the origin of rotational motion and the de-homogenization of anisotropy in galaxies; It was found that the plasma gas photon decoupling energy was the dark energy of accelerated expansion of the cosmos, the missing mass is the illusion of photon decoupling energy beyond the critical scale, the expressions of the photon decoupling energy and the ultimate expansion velocity of the cosmos are derived, and the exact values which are in good agreement with the Hubble constant were given; proposed and proved through multiple evidences that isotropic homogeneous matter field possesses no gravitation; the Hubble constant and cosmic age expression were derived, and the main parameters of the cosmos, such as the critical scale, were given according to the estimation of the relevant motion equation; By macro energy conservation of the cosmos, it was concluded that the gravitational potential energy was the contraction potential formed after the cosmic thermal expansion energy was converted into inertial rotation energy, the thermal expansion energy, the inertial rotation energy and the gravitational potential energy were transformed in turn and equivalent, and predicts that neutrino thermal expansion energy is the main energy of the formation of gravitational potential energy. Finally, by comparing Friedman-Lemaitre solution equal to the energy equations of the various periods of the cosmos, the expressions of curvature constant K and cosmic factor Λ were given, and the "Phenomenon of Gravitational Lens" is explained by the experiment of "Pseudo-gravitational Lens Effect". The core of this theory is through the basic assumption of "Energy Possesses No Gravitation", to separate matter and energy from their motion in coupled study of gravitational field, so it can be named "The Decoupling Cosmology Theory (DCT)". This theory can be supported by Hubble constant and Cosmic Microwave Background (CMB), and can also be verified by the nuances of the isotropic in different directions of the cosmos, the dark matter and critical scales in the galaxies, and the experiments of "Pseudo-gravitational Lens Effect" etc.

Keywords: Hubble law; Cosmos; Gravitational Field

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1. Introduction

In general relativity (GR), Einstein, by analyzing the motion of objects in free-falling elevators, gave the following expression that inertial force is equal to gravitation:

$$m_i \frac{d^2 r}{d\tau^2} = m_g \frac{GM}{r^2} \quad (1)$$

The following equivalent expression of formula (1) can be derived when assuming that "Gravitational Mass Equals Inertial Mass", i.e. $m_g = m_i$:

$$\frac{d^2 r}{d\tau^2} = \frac{GM}{r^2} \quad (2)$$

Equation (2) is the expression of the Equivalence Principle in the inertial system, that is, the flat space coordinate system, which is the basis of establishing the GR gravitational field equation. According to the conservation equation of mass and energy in the special relativity, Einstein thought that both matter and energy can generate gravitation, and in all stages of the development and evolution of the cosmos, matter and energy are jointly conserved, and do not require the conservation of mass and energy separately. In other words, the mass M in formula (2) is the sum of mass and energy (converted into mass) of matter, which is expressed in the following formula of GR:

$$M = M' = \left(\rho + \frac{3p}{c^2} \right) V = \frac{4\pi}{3} \left(\rho + \frac{3p}{c^2} \right) r^3 = const \quad (3)$$

The density ρ in the formula (3) is the common density of the matter and the energy system, and the pressure p is the common pressure of the matter and energy system. In case of possible confusion, we use M' to represent the sum of rest mass matter and energy, and M to represent the mass of rest mass matter to prevent confusion occurred. (Only when necessary)

However, "Energy Possesses Gravitation" cannot be drawn from the mass and energy conservation equations in special relativity, and no one has given relevant proof so far. If we put forward the hypothesis that "Energy Possesses No Gravitation", and consider matter and energy in the cosmos is not only jointly conserved, but also that mass and energy should be separately conserved after the formation period of matter, that is, the mass M in formula (2) is expressed by formula (4), which does not violate any theory or fact.

$$M = \rho V = \frac{4\pi\rho}{3} r^3 = const \quad (4)$$

In formula (4), M is the static mass substances, ρ is the density of the static matter, and neither contains energy.

It can be proved that the GR gravitational field equation is the result of transforming equation (2) from flat coordinate system to curvilinear coordinate system, which is equivalent to solving equation (2) in curved space. Mathematically, coordinate transformation does not change the mathematical properties of physical equations, which is the mathematical basis of the generalized covariant principle, but the physical significance of mathematical equations before and after coordinate transformation is not completely the same.

Based on the assumption of "Energy Possesses No Gravitation", and the viewpoint of mass and energy are respectively conserved

after the formation of cosmic matter, bring equation (4) to equation (2) and solved directly in the flat space coordinate system, and the physical significance of the solution results is explored in depth.

2. Solve the Equivalence Principle Expression

Formula (2) is a scalar expression of the vector equation, and that the vector direction of the velocity w has the same and opposite conditions as the vector direction of the scale r , and that the right of the formula (2) is always positive, so the left of formula (2) is transformed as follows:

$$\frac{d^2 r}{d\tau^2} = \pm w \frac{dw}{dr}, \quad w = \frac{dr}{d\tau} \quad (5)$$

In the formula, the " \pm " sign represents the effect of different vectors on the equation. We have known that the cosmos can expand, shrink, or rotational motion on a small-scale gravitational fields, but the current universe is now accelerating on a large scale gravitational fields. In this paper, according to the small-scale and large scale two kinds of matter fields (gravitational field), according to the different motion conditions, the formula (5) is substituted into the formula (2) to solve the integral, and the results of the integral are studied.

In this paper, it is assumed that the gravitational fields are spherically symmetric, the scale r and velocity w take the geometric center as the origin of spherical coordinates, and:

- The mass M is the total mass of matter in the spherical symmetry volume at the origin of the spherical coordinates less than or equal to r , and all mass M refers to the mass of bright matter, including the black hole, and does not include the neutrino of hot dark matter;
- The moving substance m at r takes a unit mass of $m=1\text{kg}$, and is not enough to have any effect on the matter field, the moving matter at the r is outside the M of the matter field and is not contained in the M , the scale r is greater than or equal to the radius of the matter field M ;
- The velocity w at r is the radial motion velocity, w and r are two vectors on the same radial line, and the directions of the two vectors are the same when the scale expands, the directions of the two vectors are opposite when the scale shrinks.

2.1 Small-Scale Gravitational Field

As the small-scale gravitational field expands, the velocity of matter at r from the center of gravitation is slower and slower ($dw < 0$) with the increase of r ($dr > 0$), dw/dr is negative; as the cosmos shrinks, the velocity of matter at r from the center of gravitation is faster and faster ($dw > 0$) with the decrease of r ($dr < 0$), dw/dr is negative. The formula (2) is always positive, the "-" sign must be taken when substituting formula (5) into formula (2), the formula (2) should be written as:

$$-w \frac{dw}{dr} = \frac{GM}{r^2} \quad (6)$$

Formula (6) integral, get:

$$\frac{1}{2}w^2 = \frac{GM}{r} + C_1 \quad (7)$$

Formula (7) is the energy equation of the small-scale gravitational field, the left of the formula represents the kinetic energy of the radial motion of the matter, i.e. the expansion flat kinetic energy, the first item of the right of the formula is the gravitational potential energy of the matter i.e. the radial shrinkage potential, and C_1 is the integral constant representing the energy. After replacing equation (3) with formula (4) according to the hypothesis of "Energy Possesses No Gravitation", energy can naturally appear through integral constant, and will not cause the "Loss" of cosmic energy.

The following are divided into different circumstances, the energy equation (7) is further integrated to solve, to obtain the equation of motion.

2.1.1 Small-Scale Gravitational Field Motion Equation:

1. When $C_1=0$: Depending on the formula (7), get:

$$\frac{1}{2}w^2 = \frac{GM}{r} \quad (8)$$

The formula (8) indicates that in a gravitational field there is no other energy other than gravitational potential energy, the gravitational potential energy can be converted into the translational kinetic energy of matter flying away or flying toward the gravitational field. After the formation of the gas pressure in the galaxies can be considered as zero, there is no other energy other than gravitational potential energy, so formula (8) is the energy equation for radial motion of matter within the galaxies and the stellar system and the planetary system.

For the integral of formula (8), get:

$$\frac{2}{3}r^{3/2} = C_2 \pm \tau\sqrt{2GM} \quad (9)$$

(a) Matter flies away from the gravitational field: Available under formula (8):

$$w = \sqrt{\frac{2GM}{r}} \quad (10)$$

The formula (10) indicates the escape velocity from the gravitational field, which becomes smaller and smaller as the scale increases. This is not consistent with astronomical observations of the accelerated expansion of the cosmos, so the formula (10) cannot describe the accelerated expansion of the cosmos.

If the gravitational field expands from the initial scale r' when $\tau=0$, and substituted into formula (9), the integral constant C_2 is obtained:

$$C_2 = \frac{2}{3}r'^{3/2} \quad (11)$$

In formula (9), take "+" before τ and replace equation (11) with, to obtain the equation of motion when matter leaves the gravitational field:

$$r^{3/2} - r'^{3/2} = \frac{3}{2} \tau \sqrt{2GM} \tag{12}$$

At the time of $r \gg r'$ or $r'=0$, the formula (12) can be written as:

$$r = \left(3\tau \sqrt{\frac{GM}{2}} \right)^{2/3} \tag{13}$$

If the scale at the time of the τ_1 is known to be r_1 , then the scale r of any time τ of the tick is:

$$r = r_1 \left(\frac{\tau}{\tau_1} \right)^{2/3} \tag{14}$$

Formula (14) is the special solution of Einstein-Desitter solution of the GR gravitational field equation. Since formula (14) is derived from the integral of formula (10), the formula (14), i.e. the Einstein-Desitter solution, cannot describe the accelerated expansion of the cosmos.

By the formula (10), as the scale increases, the radial motion velocity becomes slower and slower. If the gravitational field matter moves radially to the scale r_0' , it stops moving when $\tau=\tau_0'$, the velocity $w=0$, substituted into formula (9), the integral constant C_2 :

$$C_2 = \frac{2}{3} r_0'^{3/2} - \tau_0' \sqrt{2GM} \tag{15}$$

In formula (9), take "+" before τ , we substitute formula (15) into (9), get:

$$r_0'^{3/2} - r^{3/2} = \frac{3}{2} (\tau_0' - \tau) \sqrt{2GM} \tag{16}$$

Equation (16) can describe the motion process that after the celestial body explodes (such as supernova explosion), the matter flies away to the scale r_0' away from the center of gravity and then does not continue to move away. A process of launching a satellite into a fixed-orbit r_0' can also be described in formula (16).

(b) Matter flies to gravitation: by Formula (8):

$$w = -\sqrt{\frac{2GM}{r}} \tag{17}$$

Formula (17) indicates the velocity at which matter flies toward the gravitational field, increasing as the scale decreases. The formula (17) is integrated, and make the scale as r' when $\tau=0$, get:

$$r'^{3/2} - r^{3/2} = \frac{3}{2} \tau \sqrt{2GM} \tag{18}$$

The motion described in formula (8) does not occur spontaneously in the stationarity gravitational field after the formation of the cosmos and galaxies, such as the moon does not hit the earth or flee the Earth-Moon System, the eight planets do not hit the sun or flee the solar system. If gas expansion pressure cannot be ignored in the cosmic and galaxies forming processes, i.e., non-steady state gravitational fields cannot be described in a formula (8). However, in an non-steady state gravitational field where gas pressure can be negligible, these kinds of can be described in formula (8): first, after the celestial body "Explosion", the motion process of matter dispersed to a certain distance from the center of gravitation will no longer continue to away from the gravitational field, such as the "Pressure Burst" caused by the nuclear fusion pressure, the formation of star clusters and star in the

process of motion; the second is the motion of non-gas substances flying into the gravitational field, such as the motion of asteroids, meteorites, etc; Third, the movement of the launch and recycling of man-made satellites.

Making $w=c$, and substituted into (8):

$$r_s = \frac{2GM_s}{c^2} \quad (19)$$

The formula (19) indicates that for a gravitational field with a mass $M \geq M_s$ and no other energy present (i.e. $C_1=0$), after the scale is contracted to the $r \leq r_s$ by the contraction motion of formula (17), the light cannot escape the gravitational field, so the gravitational field is not visible, cosmology calls the gravitational field with $M \geq M_s$ mass and $r \leq r_s$ scale as "Black Hole", and formula (19) scale r_s is called the Schwarzschild radius of black hole. GR suggests that photons can't escape black holes because the curvature of spacetime (or the gravitational field of black holes is too much for photons).

However, the black hole is formed by the contraction of gas matter, the gas expansion pressure of the gravitational field is not only not zero but also very large, so the formation process of the black hole cannot be described by the formula (8) and formula (17), equation (98) will be given in the following expansion or contraction of the gravitational field of gas matter to describe the process of the black hole formation of the motion in this paper. In addition, according to the "Energy Possesses No Gravitation" hypothesis, black holes do not have a gravitational effect on light, and this cannot be explained by gravitation or curvature of spacetime. The author speculates that it is possible that a black hole is a state of motion in which photons (energy) can be coupled into matter or converted into matter, and the photons that shoot into the black hole are completely absorbed, that is, the black hole is a complete black body, so it is invisible. Of course, based on the assumption that "Energy Possesses No Gravitation", the issue of the invisibility of black holes needs to be studied specifically, which is not discussed in depth in this paper.

2. When $C_1 < 0$: The integral constant $C_1 < 0$ means that there is an energy that is opposite the direction of gravitational potential energy and can resist gravitational contraction. The role of the gas expansion pressure energy is that, so the integral constant C_1 represents the gas expansion pressure energy, which can be written as:

$$C_1 = -\frac{p}{\rho} Jkg^{-1} \quad (20)$$

p and ρ are the pressure and density of the gas substance and energy system. The density of a photon gas can be expressed as:

$$\rho = \frac{E/c^2}{V} = \frac{E}{c^2V} \quad (21)$$

Substitute formula (20) into formula (7), the energy equation of the gravitational field can be obtained when the gas pressure cannot be ignored:

$$\frac{1}{2}w^2 = \frac{GM}{r} - \frac{p}{\rho} \quad (22)$$

3. When $C_1 > 0$: At the same time as the integral constant $C_1 > 0$, if

$$\frac{GM}{r} \neq 0 \quad (23)$$

$C_1 > 0$ indicates the existence of a "Shrink Energy" or "Negative Energy" in the same direction as the gravitational potential energy, which enhances the motion of gravitational contraction. This is omitted because no such "Negative Energy" is found in the cosmos

other than gravitational potential energy.

At the same time as the integral constant $C_1 > 0$, if

$$\frac{GM}{r} = 0 \tag{24}$$

$C_1 > 0$ indicates that there is an energy that can cause the expansion of the cosmos in the absence of gravitational potential energy.

The gas pressure can do just that, so the integral constant C_1 can be written as:

$$C_1 = \frac{p}{\rho} \tag{25}$$

Substitute formula (24) and (25) into (7), get:

$$\frac{1}{2} w^2 = \frac{p}{\rho} \tag{26}$$

Formula (26) shows that in a system of gaseous matter and/or energy with zero gravitational potential energy, the pressure energy of the system p/ρ is the only energy for the expansion of the cosmos.

4. Equations of the expansion or contraction of small-scale gravitational fields: Rewrite the formula (22) to:

$$w = \frac{dr}{d\tau} = \pm \sqrt{\frac{2GM}{r} - \frac{2p}{\rho}} \tag{27}$$

When the pressure energy p/ρ is integral constant in the formula (27), but the pressure p and density ρ are not necessarily constant. When $p > GM/r^2$, the matter field expands, the right side of the formula takes "+"; when $p < GM/r^2$, the matter field shrinks, the right side of the formula takes "-".

The analysis of (27) shows that there must be

$$\frac{GM}{r} \geq \frac{p}{\rho} \tag{28}$$

That is, when the gravitational potential energy is not less than the pressure energy, the formula (27) can be established. There must be a constant r_0 , and have the following relationship

$$-C_1 = \frac{p}{\rho} = \frac{GM}{r_0} \tag{29}$$

And only

$$\frac{GM}{r} \geq \frac{GM}{r_0} \tag{30}$$

that is, when the scale $r \leq r_0$, the formula (27) can be established. This means that a small-scale gravitational field has a critical scale r_0 , and only $r \leq r_0$, i.e.

$$r \leq r_0 = \frac{GM}{-C_1} = \frac{GM}{p/\rho} \tag{31}$$

the velocity equation (27) and the energy equation (22) can be established. It can be seen, formula (31) is the maximum limit scale of the small-scale gravitational field.

Integrating formula (27), get:

$$\arcsin\left(\frac{2pr}{\rho GM} - 1\right) = \frac{1}{GM} \sqrt{\left(\frac{2p}{\rho}\right)^3} \left(C_3 \pm \tau + \frac{\rho}{2p} \sqrt{2GMr - \frac{2p}{\rho} r^2}\right) \tag{32}$$

The C_3 in the formula is an integral constant, and before τ , the "+" means expansion, and the "-" means contraction.

Substitute formula (29) into (32), get:

$$\arcsin\left(\frac{2r}{r_0} - 1\right) = \frac{2}{r_0} \left(\sqrt{\frac{2p}{\rho}} (C_3 \pm \tau) + r \sqrt{\frac{r_0}{r} - 1}\right) \tag{33}$$

That is:

$$\frac{2r}{r_0} - 1 = \sin \left[\frac{2}{r_0} \left(\sqrt{\frac{2p}{\rho}} (C_3 \pm \tau) + r \sqrt{\frac{r_0}{r} - 1} \right) \right] \tag{34}$$

In the expansion, $r=0$ when $\tau=0$, In the contraction, $r=r_0$ when $\tau=0$, substituted into (34), the integral constant is obtained:

$$C_3 = \mp \frac{\pi r_0}{4\sqrt{2p/\rho}} \tag{35}$$

It should be noted that formula (35) take the "-" when expanding and "+" when shrinking.

Substitute formula (35) into (34), get:

$$\frac{r}{r_0} = \frac{1}{2} + \frac{1}{2} \sin \left(\pm \left(\frac{2\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{2} \right) + 2\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \right) \tag{36}$$

Based on the periodicity of the sine function, rewrite the formula (36) to:

$$\frac{r}{r_0} = \frac{1}{2} + \frac{1}{2} \sin \left(2n\pi \pm \left(\frac{2\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{2} \right) + 2\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \right) \tag{37}$$

The formula (37) is the equation of small-scale gravitational field motion, which is the rotational motion described by the sine function and expresses the origin of the celestial rotation i.e. the rotational motion. The question of how the centrifugal force and centripetal force of the rotational motion of formula (37) are generated will be studied later.

If $r=r_i \neq 0$ when $\tau=0$ in expansion, equivalent to if plasma gas expansion is after the end of the matter generation period, and then expands based on the already formed scale r_i , then the integral constant C_3 and formula (36) will become very complex, even loss obvious regularity in a certain sense, which is obviously very unreasonable. Taking $r=0$ at $\tau=0$ indicates that the expansion from $r=0$, that is, the center of the cosmos the plasma gas expansion and matter generation period is to some extent overlapping, the

matter generation period has not yet ended, it has begun from the center of the cosmos, since the plasma gas expansion period.

5. Gravitational field critical scale r_0 and critical time τ_0 : Sine function (37) has a maximum value, that is, the critical scale r_0 .

Since the maximum value can only be reached by expansion, when $r=r_0$ and the sign before τ is "+" in formula (37), we can get:

$$1 = \sin\left(2n\pi + \frac{2\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{2}\right) \tag{38}$$

The sine function in the right side of the formula (38) must be at an angle equal to 90 degrees, i.e.:

$$2n\pi + \frac{2\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{2} = \frac{\pi}{2} \tag{39}$$

From formula (39):

$$r_0 = \frac{2\tau}{(1-2n)\pi} \sqrt{\frac{2p}{\rho}} \tag{40}$$

The critical scale r_0 is greater than zero, so the n in formula (40) must be zero. Substitute formula (29) and $n=0$ into (40), get:

$$r_0 = \frac{2\tau}{\pi} \sqrt{\frac{2p}{\rho}} = \frac{2\tau}{\pi} \sqrt{\frac{2GM}{r_0}} \tag{41}$$

Formula (41) is an expression of the critical scale r_0 . As can be seen, there has a critical time corresponding to the critical scale r_0 :

$$\tau_0 = \frac{\pi r_0}{2\sqrt{2p/\rho}} \tag{42}$$

Transform formula (42), to:

$$\frac{\pi}{2} = \frac{\tau_0}{r_0} \sqrt{\frac{2p}{\rho}} \tag{43}$$

It can be seen from the formula (43) that the critical scale r_0 is the radial scale increased by the $\pi/2$ degree rotation in τ_0 of the gas matter gravitational field of small-scale during expansion.

The critical scale in formula (41) can be expressed as follows:

$$r_0 = \frac{2\tau_0}{\pi} \sqrt{\frac{2p_0}{\rho_0}} \tag{44}$$

By formula (44), when the critical scale r_0 is reached, a rotational motion with ω_0 angular velocity is formed:

$$\frac{\pi/2}{\tau_0} = \omega_0 = \frac{v_0}{r_0} = \frac{\sqrt{2p_0/\rho_0}}{r_0} \tag{45}$$

The tangent velocity v_0 of the rotational motion can be obtained by formula (45):

$$v_0 = \omega_0 r_0 = \sqrt{\frac{2p_0}{\rho_0}} \tag{46}$$

It can be seen from formula (46) that the inertial rotation energy of the rotational motion is as follows:

$$\frac{1}{2}v_0^2 = \frac{p_0}{\rho_0} \tag{47}$$

The formula (45) ~ (47) indicates that after the gas thermal expansion turns $\pi/2$ degree in τ_0 and reaches the critical scale r_0 , the thermal expansion pressure can be all converted to inertial rotation energy, get the circumferential rotational motion with the tangential velocity v_0 .

According to formula (41) and formula (44), the gaseous matter gravitational field of small-scale should also have a critical mass:

$$M_0 = \frac{p_0 r_0}{\rho_0 G} \tag{48}$$

The physical meaning of the formula (48) is that only the matter with a critical mass M_0 in the matter field possesses gravitation, and the rest of the matter with more than M_0 possesses no gravitation. There are two possibilities if the isotropic homogeneous matter field possesses no gravitation (as will be proved later in this paper): one is that only the matter with the mass of M_0 achieve anisotropy non-uniform distribution in the matter field and the rest of the matter cannot achieved non-uniform distribution; The second is that matter with mass greater than M_0 are outside the scale r_0 , so there is no gravitational contribution to the gravitational field.

6. Analysis of the motion equation of small-scale gravitational field: To analyze the matter, energy, and temperature distribution of the gravitational field of gas matter, the following attempt is to simplify the formula of the sine function of the formula (37) into an algebraic equation. According to the trigonometric function doubling angle formula, the main function of formula (37) without $2n\pi$ terms is transformed, and the following results are obtained:

$$\frac{r}{r_0} - \frac{1}{2} = \sin \left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right) \times \cos \left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right) \tag{49}$$

By converting the cosine function in formula (49) into the sine function, and the two sides of the equation are squared:

$$\left(\frac{r}{r_0} - \frac{1}{2} \right)^2 = \sin^2 \left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right) - \sin^4 \left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right) \tag{50}$$

Because

$$0 < r \leq r_0, \text{ namely } -1 < \frac{2r}{r_0} - 1 \leq 1 \tag{51}$$

so sine function $\sin\alpha \leq 1$ in formula (37), angle α of the function $\leq \pi/2$, that is the angle of the sine function in the formula (37)

$$\alpha = \left(2\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{2\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{2} \right) \right) \leq \frac{\pi}{2} \tag{52}$$

So, sine function angle $\sin(\alpha/2)$ in formula (49) and (50)

$$\frac{\alpha}{2} = \left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right) \leq \frac{\pi}{4} \tag{53}$$

i.e. angle $\alpha/2 \leq \pi/4 < 1$ in formula (53).

The formula (50) sinusoidal function $\sin(\alpha/2)$ is the angle of $\alpha/2 < 1$, the third power and the above term can be discarded when the sine function (50) is expanded into a series:

$$\left(\frac{r}{r_0} - \frac{1}{2} \right)^2 = \left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right)^2 - \left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right)^4 \tag{54}$$

The equation is subtracted from 1/4 of each side for the factorization which can be obtained:

$$\frac{1}{4} - \left(\frac{r}{r_0} - \frac{1}{2} \right)^2 = \left[\left(\sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) \right)^2 - \frac{1}{2} \right]^2 \tag{55}$$

Both sides of formula (55) take the square root and transfer the terms, then take the square root again and shift items again, get:

$$\pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) = \pm \sqrt{\frac{1}{2} \pm \sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2}} - \sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \tag{56}$$

The sign "±" in the left side of formation (56) indicates expansion or contraction respectively, the two "±" signs on the right side is the result of opening square for two times, which is irrelevant to expansion or contraction.

The formula (56) is the simplified algebraic equation for the motion equation of the gas matter at $r < r_0$. Because he expansion scale r spans at least 10^{10} to 10^{20} orders of magnitude, all physical quantities in the formula must have at least 10 exact digits after the decimal point, that is, at least 10 bits after the decimal point, so the formula (56) is not convenient for quantitative calculation, but it is much more convenient and intuitive than (37) for qualitative analysis of matter, energy and temperature distribution.

2.1.2 The growth of the scale at the beginning of the cosmos: If the vacuum is filled with static photons that have neither mass nor size, it can be seen as "empty". Quantum Mechanics holds that static photons in vacuum are undergoing quantum fluctuations, if quantum fluctuations can be regarded as vibrations in the length of positive and negative Planck, then the wavelength of static photon is the length of the Planck $\lambda = \pm 1.616 \times 10^{-35}$ m, each static photon has a "Positive and Negative Self-equilibrium Energy" of $E = ch/\lambda = \pm 1.23 \times 10^{10}$ J. If the quantum fluctuations of the static photon occurs "Resonance" in the vacuum at $\tau = 0$ in the position of $r = 0$, and is stimulated to a state of motion, because "Positive and Negative Energy" is separated from each other, the moving photon releases $E = 1.23 \times 10^{10}$ J of huge energy to the side of the cosmos, and produces an temperature up to $T = E/k_b = 8.91 \times 10^3$ K,

which significantly exceeds the temperature threshold for generating static mass matter, The following mass-energy conversion reaction is about that photon energy E generates static mass cosmic matter M :

$$E = Mc^2 + E^* \quad (57)$$

The cosmos starting point with huge energy and extremely high temperature will be the "Ignition Source", continuously "Ignites" the surrounding static photons into moving photons, and continuously generates the static mass cosmic matter, and the residual energy E^* becomes the total expansion energy of the cosmos in each period after the matter formation period.

Photons move at the speed of light, so the velocity to "Ignite" surrounding static photon is also the speed of light, the cosmos is the equivalent of expanding at the speed of light at the beginning.

Particle physics studies show that the cosmos is an isentropic expansion process in the early period, so it can be described by the isentropic equation of photonic gas as follows [1]:

$$VT^3 = \text{const} \quad (58)$$

The pressure of the photon gas is:

$$p = \frac{\pi^2 k_b^4 T^4}{45 \hbar^3 c^3} \quad (59)$$

The h and \hbar in the formula are the Planck number and the reduced Planck number, respectively, and the k_b is the Boltzmann constant.

The temperature of the static photons after being ignited is as high as $8.91 \times 10^{32} \text{K}$ (probably don't need to be that high), the static mass particles have been generated from the moment of $\tau=0$, and as the surrounding static photons are constantly "Ignited" at the speed of light, the physical cosmos grows at the speed of light. This way of growing up is not "Expansion", but the matter is generated at the speed of light around the cosmos, the distance between the resulting particles did not change. The surrounding static photons are uniform distribution, and the matter that is excited and generated is uniform distribution, so the mass-generated cosmos is isotropic and homogeneous, and the shape must be spherical.

Newton and many researchers have proved that the homogeneous spherical shell has zero gravitation to any mass point in the shell.

In terms of the force and the reaction force, the matter inside the sphere should have zero force on the homogenous spherical shell.

For the matter field of the isotropic homogenization, any layer of matter centered on the geometric center can be regarded as a

homogenous sphere, so that there is no gravitation between all substances. If the elementary matter particle matter field of anisotropic homogenization is considered as a "Many-body Problem" gravitational field with infinite mass points, the combined external force of gravitation on each mass point is zero. During the isotropic and homogeneous matter formation, the inference that there is no gravitation between particles is correct, and will be further confirmed in the follow-up study in this paper. The universe during matter generation should be described in formula (26), namely:

$$\frac{1}{2}w^2 = \frac{p}{\rho} \tag{60}$$

The density ρ of the photon is the energy density of the photons. Substituted $E=k_bT$ into formula (21), get:

$$\rho = \frac{E}{c^2V} = \frac{k_bT}{c^2V} \tag{61}$$

Substitute formula (59) and (61) into formula (60), get:

$$\frac{1}{2}w^2 = \frac{\pi^2k_b^3VT^3}{45\hbar^3c} \tag{62}$$

Since $w=c$ when $\tau=0$, substitute it into (62), get:

$$VT^3 = \frac{45\hbar^3c^3}{2\pi^2k_b^3} = const \tag{63}$$

Substitute formula (63) into formula (62), get:

$$w = \frac{dr}{d\tau} = c \tag{64}$$

Integral formula (64), get:

$$r = c(\tau + C') \tag{65}$$

When $\tau=0$, the cosmos is a point with a scale equal to zero that is, $r=0$, so the integral constant $C'=0$, and substitute it into formula (65), get:

$$r = c\tau \tag{66}$$

The cosmic scale of the matter generation period grows at the speed of light c , the effect is comparable to the cosmic linear "Expansion" at the speed of light, which is consistent with the analysis of the high-energy photons at the starting point of the above-

mentioned cosmos to stimulate nearby static photons and "Ignite" the static photons around the light speed outward. Since the speed of matter generation is the speed of light, relative to the coordinate origin of $\tau=0$ and $r=0$, the formula (64) and the formula (66) are equivalent to the velocity of the movement of matter w and the scale r of the physical cosmos, respectively.

The center of the cosmos first began to produce elementary matter particles, will also be the first to begin generating particles of larger mass, such as nuclei, and entered the plasma gas expansion period before the outer perimeter of the cosmos [2]. The heavier the particles of matter (lepton, baryon, ion mass larger), the more energy is consumed when they are generated, the lower the temperature decrease, so cosmic temperature distribution from outside to the inside is lower and lower in the mass generation period, eventually, because the internal temperature decreases too much, it will affect the excitation of static photons on the periphery, and the cosmos can no longer continue to grow and the matter generation period ends.

If the energy possesses gravitation, when the static photon is excited as the energy of the cosmos, there will be an issue of gravitation increasing to almost infinite at an instant; if the elementary matter particles have gravitation since their generation, there will also be the issue of instant increase in gravitation. Therefore, the theory of the birth of the cosmos in this paper has not found the singularity theory for the time being, which is one of the reasons why the author put forward the hypothesis of "Energy Possesses No Gravitation".

For the convenience of elaboration, the theory that the early cosmos, which is based on quantum fluctuations and which generate elementary matter particles at the speed of light, grows at the speed of light, and is called "LGT (or hypothesis)". From this hypothesis will naturally think of the so-called "Anti Cosmos", "Many-Cosmos Theories" and other issues, but this is beyond the scope of this article, not discussed here.

Contrasting the theory of LGT with the Big Bang Theory. The Big Bang Theory, based on Einstein's gravitational field equation, derived the equation of motion of the early cosmos as a function of the scale r changed by $1/2$ power of time τ , can be expressed as follows:

$$r = (k\tau)^z, z = \frac{1}{2} \tag{67}$$

For convenience, the following may use the formula of different time exponent z (67) to express the relevant motion equation, and the main differences of the equations of motion are explained by the different z of time exponents.

If the LGT, like the Big Bang Theory, also holds that the matter generation possesses gravitation, and expands because the pressure

energy is greater than the gravitational potential energy, then the sign "-" in formula (6) can be taken out for integral, and the following equation can be obtained:

$$\frac{1}{2}w^2 = \frac{p}{\rho} - \frac{GM}{r} \tag{68}$$

The integral constant p/ρ is equivalent to the GR curvature constant K. If, like GR, the curvature constant K i.e. pressure energy p/ρ is changeable, through the photon gas state equation to write the change rule of p/ρ with r and substituted into (68) integral, an equation of motion for the formation of a substance with a time exponent of $z=1/2$ in the form of (67), which is the same as that of the Big Bang Theory is obtained (the solution process is slightly), explain that the physical significance of the (7) integral constant is one of the differences between this paper and GR.

To solve the issues of 1000 times difference between cosmic scale and astronomical observation and how to realize the large-scale isotropic homogenization, there are several versions of the early cosmos's "Inflation" theory, it is thought that in the period $\tau=10^{-35} \sim 10^{-32}$ s of the birth of the cosmos, dimensionless scale factor R grows up according to the following index law:

$$R = \exp\left(\tau\sqrt{\frac{\Lambda}{3}}\right) \tag{69}$$

Moreover, considering that the large numeric value of the cosmic factor Λ at the time of the inflation, so the scale factor R can grow at superluminal speed, and in the period of the inflation of much less than 1 second, the scale of the cosmos given by different inflation theories increases by as much as $20 \sim 10^{30}$ times. After substituting the small-scale gravitational field cosmic factor Λ given later in this paper i.e. (203) into the formula (69), we can obtain:

$$R = \exp\left(\tau\sqrt{-\frac{18GMp}{3c^2\rho r^3}}\right) = \exp\left(\tau\sqrt{\frac{-6GM}{c^2r^3} \times \frac{p}{\rho}}\right) = \exp\left(i\sqrt{\frac{6GM}{c^2w^2r} \times \frac{p}{\rho}}\right) \tag{70}$$

Then substitute the formula (60) into formula (70):

$$R = \exp\left(i\sqrt{\frac{6GM}{c^2w^2r} \times \frac{1}{2}w^2}\right) = \exp\left(i\sqrt{\frac{3GM}{c^2r}}\right) = \cos\left(\sqrt{\frac{3GM}{c^2r}}\right) + i\sin\left(\sqrt{\frac{3GM}{c^2r}}\right) \tag{71}$$

The formula (71) is a wave function of circular motion and cannot express exponential growth. So, the "Inflation" described in formula (69) cannot be achieved.

The question of whether energy possesses gravitation has a significant impact on how to study and understand the cosmos.

2.1.3 Expansion or contraction of the gravitational field of gas matter

1. Expansion or contraction of plasma gas:

a. Maximum Expansion Scale of Plasma Gas: According to formula (44), there is a maximum critical scale r_0 for plasma gas expansion:

$$r_0 = \frac{2\tau_0}{\pi} \sqrt{\frac{2p_0}{\rho_0}} = \frac{2\tau_0}{\pi} \sqrt{\frac{2p_0V_0}{M}} \quad (72)$$

When the gas is completely ionized, and the density is not very high, electrons and ions can be described by the single-atom ideal gas state equation, and the pressure can be described by formula (73) [3]. There is no gravitational binding in the matter generation period, the pressure of the matter and energy system is not high, and the plasma gas expansion after the matter generation period is the pressure release process [4], and the system pressure should be lower, so the establishment condition of formula (73) is satisfied.

$$p = (1+Z)nk_bT \quad (73)$$

The n and Z in the formula are the number density of particles (number of particles per unit volume) and the charge number respectively, k_b is the Boltzmann constant, and T is the temperature of the gas substance. When noting that

$$\frac{M}{nV/N_A} = m \times 10^3, \quad k_b N_A = R \quad (74)$$

simplify the integral constant, i.e. the expansion pressure energy p/ρ according to the formula (73), get:

$$\frac{p}{\rho} = \frac{pV}{M} = \frac{(1+Z)nk_bTV}{M} = \frac{(1+Z)k_bN_AT}{M} \times \frac{nV}{N_A} = \frac{1+Z}{m} RT \quad (75)$$

The m is the molar mass of gas (g/mol), the R and the N_A are the gas constant and the Avogadro constant respectively; each of the relevant expression implies a unit of substance 1 kg, by multiplying by 10^3 to maintain the unit of mass is kg.

Formula (75) shows that during the expansion or contraction of plasma gas, not only the pressure energy p/ρ of matter and energy system unchanged, but also the temperature of matter remains constant [5]. But the average temperature of the matter and energy systems must decrease when expansion and increase when they contraction. During expansion, the thermal expansion pressure energy of the system is p/ρ constant, but the temperature of the system decreases and the temperature of the matter remains unchanged, which inevitably leads to the decrease of the radiation temperature with expansion, which creates conditions for the decoupling of energy (photons and neutrinos) from matter.

Particle physics studies show that the ratio of matter temperature T to radiation temperature T_v increases from $T/T_v=1.0$ to $T/T_v=1.4$ when the early cosmic temperature is $6 \times 10^{10}K \sim 3 \times 10^8K$, that is, the radiation temperature is reduced from the same temperature as the matter to $1/1.4=71.4\%$ of the matter temperature, and at about 10^9K to form a helium nucleus, the disappearance of positive and negative electron pairs at 3×10^8K creates photons, and hydrogen helium plasma gas becomes the only substance in the cosmos (except neutrinos), so 3×10^8K can be regarded as the ionization temperature. The atoms composited by ions are also 300 million degrees Celsius, but the temperature of neutrinos (radiation energy) decreases during expansion.

Since the system pressure is p/ρ and the matter temperature T is unchanged, the plasma gas pressure energy and temperature can be expressed by the parameters corresponding to the critical scale r_0 , according to formula (75), it can be written as:

$$\frac{p}{\rho} = \frac{p_0}{\rho_0} = \frac{1+Z}{m} RT_0 \quad (76)$$

Considering the helium abundance, the ratio of hydrogen to helium atom is 75:25. The average charge number is 1 for hydrogen and 2 for helium, the average charge number is:

$$Z = 1.25 \quad (77)$$

Similarly, the molar mass of hydrogen atom is 1 g/mol, the molar mass of helium atom is 2 g/mol, and the average molar mass is:

$$m = 1.25 \text{ g / mol} \quad (78)$$

Substitute formula (77) and formula (78) into formula (76):

$$\frac{p}{\rho} = \frac{p_0 V_0}{M} = \frac{1+Z}{m} RT_0 = \frac{1+1.25}{1.25} RT_0 = 1.8 RT_0 \quad (79)$$

As the plasma gas expands to maximum critical scale r_0 , Substitute the formula (79) into formula (72):

$$r_0 = \frac{2\tau_0}{\pi} \sqrt{3.6 RT_0} = 1.21 \tau_0 \sqrt{RT_0} \quad (80)$$

Substitute formula (79) into formula (47), when the plasma gas expands to a critical scale r_0 , the resulting inertial rotational motion energy can be:

$$\frac{1}{2} v_{01}^2 = 1.8 RT_0 \quad (81)$$

b. Plasma gas expansion or contraction motion: Substitute formula (48) into formula (27) to obtain the expansion or contraction velocity of the gravitational field of the plasma gas:

$$w = \pm \sqrt{\frac{2GM}{r} - \frac{2p}{\rho}} = \pm \sqrt{\frac{2p_0 r_0}{\rho_0 r} - \frac{2p_0}{\rho_0}} = \pm \sqrt{\frac{2p_0}{\rho_0} \left(\frac{r_0}{r} - 1 \right)} \quad (82)$$

As known by formula (64), at the formation period of matter which is relative to the cosmic center with $\tau=0$ and $r=0$, the cosmos grew at the speed of light, it's the equivalent of an "Expansion" of the cosmos relative to the center of the cosmos in the stationary coordinate system, so the initial velocity of plasma gas expansion can be regarded as the speed of light. By formula (82), the velocity at the end of plasma gas expansion is zero, and according to formula (43), the direction of motion at the end of expansion is known to rotate $\pi/2$ degree. From this we can see that the plasma gas expansion process is the process by which the cosmos reduces the expansion velocity from the speed of light to zero by rotating 90 degree, that is, the process of converting the expansion pressure energy into the rotational energy, the process of converting the pressure energy into the gravitational potential energy according to formula (82).

Substitute formula (79) into formula (82):

$$w = \pm \sqrt{\frac{2p_0}{\rho_0} \left(\frac{r_0}{r} - 1 \right)} = \pm \sqrt{3.6 RT_0 \left(\frac{r_0}{r} - 1 \right)} \quad (83)$$

According to the formula (56), the simplified algebraic equation of plasma gas expansion and contraction motion is:

$$\pm \left(\frac{\tau}{r_0} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) = \pm \sqrt{\frac{1}{2} \pm \sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0} \right)^2}} - \sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0} \right)^2} \quad (84)$$

From the analysis of formula (84), during the plasma expansion process, at the same time, which means the τ is same, the ratio of pressure to density p/ρ of matter and radiation system at different scales r is different. Because neutrinos moving velocity is faster than the velocity of matter particles, expansion leads to the distribution of matter "Inner Dense and External Sparse", namely de-homogenization of anisotropy, while the distribution of neutrinos (radiation energy) is "Inner Sparse and External Dense", and

according to the physics of the particles can know that the radiation temperature is lower than the matter temperature, so the matter temperature distribution is "External Low Inner High".

For the de-homogenization of anisotropy spherical symmetry cosmos, the density of matter at the same r is the same, the density of matter at different r is different, so the gravitation at different r is different, which is represented by the same "Sphere" of each hypothetical "Sphere of Matter" with the center of gravitation as the center of the sphere has the same matter density. Different "Sphere Layer" substances have different generation end times, and the time when they enter the plasma gas state is also different, and the time from plasma gas state to atomic gas state is also different, and gradually develop from the inside to the outside, the anisotropic inhomogeneous matter distribution also changes from the center of the universe began to develop gradually from the inside to the outside.

Substitute the equation (79) into the equation (84), and get:

$$\pm \left(\frac{\tau}{r_0} \sqrt{3.6RT_0} - \frac{\pi}{4} \right) = \pm \sqrt{\frac{1}{2} \pm \sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2}} - \sqrt{\frac{r}{r_0} - \left(\frac{r}{r_0}\right)^2} \tag{85}$$

The upper formula (85) indicates that during the expansion and contraction of plasma gas, at the same time, when the time τ is the same, the matter temperature at the same scale r is the same. Therefore, they can be characterized by critical temperature T_0 .

2.The expansion or contraction of atomic gases

a. Maximum expansion scale of atomic gas: According to the formula (44), like plasma gas, atomic gas expansion also has a maximum critical scale of r_0 :

$$r_0 = \frac{2\tau_0}{\pi} \sqrt{\frac{2p_0}{\rho_0}} = \frac{2\tau_0}{\pi} \sqrt{\frac{2p_0V_0}{M}} \tag{86}$$

After the plasma gas is compounded into atomic gas, the charge number in the equation (73) disappears, that is, $Z=0$, and the pressure of the matter and energy system is:

$$p = nk_bT \tag{87}$$

According to the formula (86), the integral constant, namely the pressure energy p/ρ , can be simplified to obtain:

$$\frac{p}{\rho} = \frac{pV}{M} = \frac{nk_bTV}{M} = \frac{k_bN_A T}{M} \times \frac{nV}{N_A} = \frac{RT}{m} \tag{88}$$

The fresh decoupling atomic gas, photon and undecoupled plasma gas are isothermal, but in the atomic gas expansion, Photonic temperature Tr below matter temperature T , there is a relational formula (88) of $T/Tr=1.4$ indicates that when the atomic gases expand or contract, because the pressure energy of the system remains the same and the temperature of the substance remains the same, but the temperature of the system decreases in expansion and increases in contraction, in essence, the energy (photon) in the system decreases or increases in temperature. The increase in energy temperature during contraction creates conditions for the reionization of atomic gas. The mechanism of pressure and temperature change and temperature of the substance and energy as it is the individual when the atomic gas expands, like the expansion of plasma gas, the difference is only that the energy in the plasma gas system is neutrinos, while the atomic gas system, energy is the photon. But because photons are easily interacted with atoms, that is, they are easily absorbed by matter, long term coexistence leads to thermal equilibrium. Therefore, the strict distinction between atomic matter and energy temperature is only for the convenience of theoretical research and analytical calculation.

If the equation (88) is expressed by the temperature T_0 at the critical scale r_0 , then:

$$\frac{p}{\rho} = \frac{p_0}{\rho_0} = \frac{RT_0}{m} \tag{89}$$

When considering helium abundance and take the ratio of hydrogen to helium atoms at 75:25, the average molar mass is:

$$m = 1.25 \text{ g / mol} \tag{90}$$

Substitute the equation (90) into the equation (89), and get:

$$\frac{p}{\rho} = \frac{p_0 V_0}{M} = \frac{RT_0}{m} = 0.8RT_0 \tag{91}$$

When the atomic gas expands to the maximum scale which is the critical scale r_0 , substitute the equation (91) into the equation (86), and get:

$$r_c = \frac{2\tau_0}{\pi} \sqrt{1.8RT_0} = 0.81\tau_0 \sqrt{RT_0} \tag{92}$$

In case of possible confusion with plasma gas critical scale r_0 , the following atomic gas critical scale is expressed as r_c .

By comparing between the formula (92) and formula (80) can be seen that the critical scale r_0 of plasma gas is 1.5 times that of atomic gas at the same temperature and expansion time.

By substituting Equation (91) into Equation (47), it can be obtained that when atomic gas expands to the critical scale r_c , formed by the rotational motion of inertial rotation energy:

$$\frac{1}{2} v_{02}^2 = 0.8RT_0 \tag{93}$$

b. Atomic gas expansion or contraction equations: By substituting equation (29) and equation (48) into equation (27), and note that the critical scale is r_c , the expansion or contraction rate of atomic gas can be obtained:

$$w = \pm \sqrt{\frac{2GM}{r} - \frac{2GM}{r_c}} = \pm \sqrt{\frac{2GM}{r} - \frac{2p}{\rho}} = \pm \sqrt{\frac{2p_0 r_c}{\rho_0 r} - \frac{2p_0}{\rho_0}} = \pm \sqrt{\frac{2p_0}{\rho_0} \left(\frac{r_c}{r} - 1 \right)} \tag{94}$$

Substitute the equation (91) into the equation (94), and get:

$$w = \pm \sqrt{\frac{2p_0}{\rho_0} \left(\frac{r_c}{r} - 1 \right)} = \pm \sqrt{1.6RT_0 \left(\frac{r_c}{r} - 1 \right)} \tag{95}$$

According to the formula (56), the simplified algebraic equation of expansion and contraction of atomic gas is:

$$\pm \left(\frac{\tau}{r_c} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{4} \right) = \pm \sqrt{\frac{1}{2} \pm \sqrt{\frac{r}{r_c} - \left(\frac{r}{r_c} \right)^2}} - \sqrt{\frac{r}{r_c} - \left(\frac{r}{r_c} \right)^2} \tag{96}$$

The analysis of formula (96) revealed that the ratio of pressure and density p/ρ of the substance and energy system at the same moment τ at different scales r is different. It's similar to plasma gas, the energy (photons) is moving faster than the matter particles in the expansion process, the matter distribution gradually develops to the de-homogenization of anisotropy of "Inner Dense and External Sparse", the energy distribution develops towards "Inner Sparse and External Dense", the temperature distribution develops to "Outside Low and Inside High"; The photon doesn't "Turn Around" and contract back, the motion is just a matter contracting, the result is an increase in the energy temperature of the system, and the center of gravitation is the hottest and starts

"Reionization" process.

The formation of de-homogenization of anisotropy of matter field in the initial cluster of nebulae laid a direct foundation for de-homogenization of anisotropy of matter distribution in the galaxies, and the rotational motion of the sine function in formula (37) must lead to the spin and spin motion of the celestial body in the galaxies.

Substitute the equation (91) into the equation (96), and get:

$$\pm \left(\frac{\tau}{r_c} \sqrt{1.6RT_0} - \frac{\pi}{4} \right) = \pm \sqrt{\frac{1}{2} \pm \sqrt{\frac{r}{r_c} - \left(\frac{r}{r_c} \right)^2}} - \sqrt{\frac{r}{r_c} - \left(\frac{r}{r_c} \right)^2} \quad (97)$$

The above formula (97) indicates that during atomic gas expansion or contraction, at different times, that is, when τ is different, the matter temperature T at the same scale r in the gravitational field was the same, all of which could be characterized by the critical temperature T_0 .

When atomic gas expansion reaches the critical scale of r_c , the sine function $\sin\alpha$ Angle α rotates from 0 to $\pi/2$, and the $\sin\alpha$ reaches its maximum value of $\sin\alpha=1$; As α rotates from $\pi/2$ to larger, the sine function $\sin\alpha$ goes from $\sin\alpha=1$ to $\sin\alpha<1$, expansion automatically transforms to contraction, if you start counting again from $\alpha=\pi/2$, when take $\tau=0$, $r=r_c$, then the formula (37) function is the contraction motion equation after taking the sign of "-":

$$\frac{r}{r_c} = \frac{1}{2} + \frac{1}{2} \sin \left(2n\pi - \left(\frac{2\tau}{r_c} \sqrt{\frac{2p}{\rho}} - \frac{\pi}{2} \right) + 2\sqrt{\frac{r}{r_c} - \left(\frac{r}{r_c} \right)^2} \right) \quad (98)$$

Through the formula (98), when $\tau=0$, $r=r_c$, when $\tau=\tau_0$, $r=0$, it indicates that after passing the critical time of τ_0 again, after the contraction motion turns over an angle of $3\pi/2$ (It takes $2\tau_0$ time to go all the way around, including the expansion process), the matter at the center of the initial cluster of nebulae would shrink to zero on a macroscopic scale, that is, the central matter can form "Black Holes", and a black hole developed from a rotational motion must be spinning at a high speed. The macroscopic motion mechanism of black hole formation should be described by equation (98) instead of equation (8). However, after the formation of the black hole, the gas pressure in the galaxies can be negligible, and the Schwarzschild radius namely equation (19) obtained by equation (8) is valid.

But since there were no singularity theory at the beginning of the cosmos, black hole singularity theory looks even more "Weird". The black holes formed by the contraction motion in equation (98) may not have the same properties as the black holes mentioned at present, and the theory of black holes may need to be reconstructed, which will not be discussed in depth in this paper.

The rotational motion formed by expansion is further strengthened in the contraction motion of equation (98), the angular velocity of the rotational motion is accelerated, and the energy temperature of the atomic gas system rises, until the reionization occurs from the center. After reionization, the pressure energy in equation (98) is no longer equal to that of the previous atomic gas, equation (91) is no longer valid, namely

$$\frac{p}{\rho} \neq 0.8RT_0 \quad (99)$$

It is equal to the pressure energy of the reionization plasma gas, that is

$$\frac{p}{\rho} = 2RT_0 \quad (100)$$

Reionization only ionizes hydrogen atoms while helium atoms do not, therefore, equation (100) is the pressure energy of a plasma

gas system without helium abundance issue (the derivation process is omitted), in the formula, T_0 is the hydrogen ionization temperature of 4000K, instead of the helium ionization temperature of equation (91) of 300 million degrees. The difference between pressure energy before and after reionization, is the same as the difference between Equations (91) and (100), represents the "Reionization Energy" transformed by thermal expansion energy.

In the process of gas reionization in the center of the cluster of nebulae continues to contract according to equation (98), the energy temperature of the gas system increases further, providing conditions for nuclear fusion. After the "Pressure Burst" occurs under the action of high temperature and high pressure of nuclear fusion, the matter that has started nuclear fusion forms star and flies away according to equation (16). The gas pressure $p/\rho \rightarrow 0$ between star, and be substituted into equation (98) to obtain:

$$\frac{r}{r_c} = \frac{1}{2} + \frac{1}{2} \sin \left(2n\pi + \frac{\pi}{2} + 2\sqrt{\frac{r}{r_c} - \left(\frac{r}{r_c}\right)^2} \right) \tag{101}$$

Equation (101) is the motion equation of the star in the galaxies around the center of the galaxies, indicating that in the galaxies with zero gas pressure, objects that has flown into position $r < r_c$ through equation (16), the rotation is repeated in the r radius of the orbit, becoming a stationarity galaxies with no change in time. Equation (101) can also describe the rotation of the planet around the star, the satellite around the planet and the rotational motion of the celestial body.

It can be seen from Equation (94) that the expansion velocity of atomic gas is zero at the end of expansion, according to equation (43), the motion direction of matter rotates by 90° , and it can be seen that atomic gas expansion is a process in which the expansion velocity is reduced from w to zero by rotation of 90° , and the pressure energy is converted into rotational energy, that is, the equivalent gravitational potential energy.

In the process from initial contraction to final stationarity motion in the galaxies, atomic gas pressure energy is first converted to reionization energy, after providing "Ignition" energy for nuclear fusion, the reionization energy is released through "Pressure Burst" to form a r_c critical scale galaxies, the stationarity scale of the galaxies returned to the maximum expansion scale of atomic gas r_c , indicating that the pressure energy consumed by reionization and nuclear fusion "Ignition" was finally released completely through nuclear fusion "Pressure Burst", and the net consumption of gas pressure energy in the whole process was zero.

2.2 Large-scale gravitational field: Astronomical observations have shown that the cosmos is expanding at an accelerated rate at a scale greater than 10Mpc (million seconds gap), distance r increase ($dr > 0$), velocity w increase ($dw > 0$), $dw/dr > 0$. Since the formula (2) is positive, "+" should be taken when the formula (5) is substituted into the formula (2), namely:

$$w \frac{dw}{dr} = \frac{GM}{r^2} \tag{102}$$

By integrating the equation (102), the energy equation of large-scale gravitational field can be obtained:

$$\frac{1}{2} w^2 = -\frac{GM}{r} + C_4 \tag{103}$$

In the formula, the integral constant C_4 represents an expansion energy acting in the opposite direction of gravitational potential energy. The expansion velocity w is:

$$w = \frac{dr}{d\tau} = \sqrt{2C_4 - \frac{2GM}{r}} \tag{104}$$

The analysis of (104) shows that only when

$$C_4 = \frac{GM}{r_0} > \frac{GM}{r} > 0 \tag{105}$$

Equation (104) can be established, that is, equation (105) is the critical condition for the accelerated expansion of the cosmos. Equation (105) indicates that the accelerated expansion can occur only when $r > r_0$, that is, r_0 is the lower limit of the large-scale gravitational field. By comparing Equations (105) and (29), the lower limit scale of the large-scale gravitational field r_0 is equal to the upper limit scale of the small-scale gravitational field, and r_0 is the boundary point of the cosmic small-scale gravitational field and the large-scale gravitational field, namely the critical scale.

Since Equation (104) is the integral result after writing equation (102) according to the astronomical observation fact that "The Cosmos is Accelerating Its Expansion on a Large Scale", and the equation (102) is given according to the Equivalence Principle equation (2), it can only be valid on a large scale if the equation (105) is valid; Since the physical meaning of the equation (105) is that there must be an energy C_4 greater than zero and a minimum scale r_0 , the accelerated expansion of the cosmos on a scale of $r > r_0$ that can be described by the equation (104) and because only expansion pressure can make the cosmos expand, and the cosmos does not have any matter or energy that can produce expansion pressure energy until now, therefore, the C_4 is the "Dark Energy" that astronomy is currently struggling to find.

Substituting the equation (105) into the equation (103) and equation (104) respectively, and get the energy equation and the velocity equation:

$$\frac{1}{2} w^2 = \frac{GM}{r_0} - \frac{GM}{r} \tag{106}$$

$$w = \sqrt{\frac{2GM}{r_0} - \frac{2GM}{r}} \tag{107}$$

2.2.1 Large-scale gravitational field motion equation: After integrating and simplifying the equation (104), it can be obtained as follows:

$$\tau \sqrt{2C_4} = r \sqrt{1 - \frac{GM}{C_4 r}} + \frac{GM}{C_4} \times \frac{1}{2} \ln \left| \frac{\sqrt{C_4 r - GM} - \sqrt{C_4 r}}{\sqrt{C_4 r - GM} + \sqrt{C_4 r}} \right| - \frac{C_5}{C_4} GM \tag{108}$$

The equation (105) is incorporated into (108) and further simplified, we can get:

$$\tau \sqrt{\frac{2GM}{r_0}} = r \sqrt{1 - \frac{r_0}{r}} + \frac{r_0}{2} \ln \frac{\sqrt{r} - \sqrt{r - r_0}}{\sqrt{r} + \sqrt{r - r_0}} - C_5 r_0 \tag{109}$$

If $\tau = 0$, $r = r_0$ is the critical scale for the beginning of accelerated expansion, substitute into the equation (108), and get:

$$C_5 = 0 \tag{110}$$

Substituting the C_5 into the equation (108), the motion equation of large-scale gravitational field is obtained:

$$\tau \sqrt{\frac{2GM}{r_0}} = r \sqrt{1 - \frac{r_0}{r}} - \frac{r_0}{2} \ln \frac{1 + \sqrt{1 - r_0/r}}{1 - \sqrt{1 - r_0/r}} \tag{111}$$

Or:

$$r = \tau \sqrt{\frac{2GM}{r_0(1-r_0/r)}} + \frac{r_0}{2\sqrt{1-r_0/r}} \ln \frac{1+\sqrt{1-r_0/r}}{1-\sqrt{1-r_0/r}} \tag{112}$$

The logarithm term of equation (111) is expanded and simplified according to the first order approximation (i.e., when $r \gg r_0$), we can get:

$$r^2 - \left(\frac{3}{2}r_0 + \tau \sqrt{\frac{2GM}{r_0}} \right) r + \frac{r_0^2}{2} \approx 0 \tag{113}$$

Solution:

$$r \approx \tau \sqrt{\frac{2GM}{r_0}} + r_0 = \tau \sqrt{2C_4} + r_0 \tag{114}$$

It can be seen that when $r \gg r_0$, the change rule of scale r with time T is approximate to the linear relation of time exponent $z=1$ in the formula (67), that is, it tends to be inertial. But where the accelerating expanded dark energy C_4 of the cosmos comes from remains to be investigated.

By solving the formula on a large scale, it can be known that the equivalence principle can only be established when the scale is larger than the critical scale r_0 if dark energy C_4 must be assumed to be greater than zero. However, where dark energy C_4 comes from remains to be seen.

2.2.2 The formation mechanism of dark energy and the cosmological principle: When plasma gas expands to the critical scale r_0 of equation (80), electrons begin to combine with helium ions to form helium atoms and release ionization energy, and then these formed into neutral hydrogen gas ('recombination') and release ionization energy again, finally, all plasma gases are combined into atomic gas, and ionization energy becomes photon that can move independently, the process is called "Photon Decoupling". Neutrino radiation energy will also decouple from matter and release neutrinos that can move freely, which is called "Neutrino Decoupling" or "Matter and Radiation Decoupling". Because the photon decoupling and neutrino decoupling basically occur at the same time. In this paper, they are collectively referred to as "The Decoupling of Matter and Energy Decoupling", "Decoupling" for short.

a. The decoupling process of matter and energy: When you heat a gas to a certain temperature and it starts to ionize, further heat input only increases the share of ionized gas and the gas temperature does not increase, indicating that during the ionization energy of a gas is ionized, atomic and plasma gases are isothermal. Based on inference, the "Reverse Process" of ionization, in which electrons and ions combine to form atomic gases and release ionization energy (photon decoupling energy), the atomic gas and plasma gas should also be isothermal, the theory of particle physics has also proved this inference.

The pressure of gas and energy system is closely related to the particle number density. From the equation (73), it can be seen that the pressure of the plasma gas matter and energy system is:

$$p_{ion} = (1+Z)nk_bT \tag{115}$$

The T in the equation (115) is the matter temperature in the system. It can be seen from the equation (115) that the particle number density of plasma gas is $(1+Z)n$, including the ion number $1 \times n$ and charge number $Z \times n$. After being compounded into atomic gas, the charge is no longer a single particle, and the number density of particles is only n , which is the same as the number of ions before decoupling. Therefore, the pressure of atomic gas substance and energy system is:

$$p_{atom} = nk_b T \quad (116)$$

By comparing equation (115) and equation (116), the pressure difference is generated when the plasma gas is compounded into atomic gas with the same temperature:

$$\Delta p = p_{ion} - p_{atom} = (1 + Z)nk_b T - nk_b T = Zk_b T \quad (117)$$

In the beginning moment of decoupling, decoupling energy has not yet had time to leave the physical system, system of plasma density and atomic gas density ρ can be thought of a system of equal density, the pressure difference energy formed by the pressure difference Δp is:

$$\frac{\Delta p}{\rho} = \frac{Zk_b T}{M/nV} = \frac{Z(k_b N_A)T}{m} = \frac{ZRT}{m} \quad (118)$$

Substitute equation (77) and equation (78) into equation (118), and get:

$$\frac{\Delta p}{\rho} = \frac{ZRT}{m} = RT \text{ Jkg}^{-1} \quad (119)$$

From the equation (82), when the plasma gas expansion ends and the decoupling will begin, the gravitational potential energy is equal to the system pressure energy. In other words, gravitation is in equilibrium with the pressure of the plasma gas system in equation (115):

$$\frac{GM}{r^2} = p_{ion} = (1 + Z)nk_b T = p_{atom} + \Delta p \quad (120)$$

Equation (120) shows that at the beginning of decoupling, the pressure of the gaseous matter system decreases to significantly less than the gravitational force due to ions recombine into atoms, and the atomic gas contracts due to the reduction of pressure, and the decoupling releases ionization energy, which is many photons. From the relationship between equation (117) and equation (118) and the number of particles in equation (119) is the charge Z , it is obvious that equation (119) is the ionization energy released by decoupling.

From the equation (84) and equation (85), plasma gas expansion can realize the anisotropic inhomogeneous distribution of matter "Inner Dense and External Sparse", energy "Internal Sparse and External Dense" and temperature "Internal High and External Low", the outer edge of the gas begins to decouple and develop inward gradually because of the lowest temperature [6]. Decoupling composite atomic gas, after being "Torn" into briquette under the action of differential pressure Δp of equation (117), and under the action of the rotating motion formed by the expansion of plasma gas, "Entrainment" into a series of atomic gas "Clusters" around the undecoupled "Plasma Gas Ball", each of these atomic gas "Clusters" will continue to expand according to equation (37) and develop de-homogenization of anisotropy, eventually, primitive cluster of nebulae and their gravitational centers with the same average density bounded by critical scale r_c were formed, laying the foundation for the development of galaxies. Every atomic gas "Clusters" has the energy and momentum of rotating motion when the plasma gas expands, and these gas "Clusters" will rotate around the "Plasma Gas Ball" that has not been decoupled. After the decoupling is completed, that is, the "Plasma Gas Ball" disappears completely, this swirling motion will develop into a swirling motion among galaxies in the future group of galaxies.

The decoupling energy comes in the form of neutrinos and photons [7]. Neutrinos do not reflect and scatter, and exert almost no force on matter; Photons exert a light pressure on matter when they reflect and scatter, so only the decoupling photon is the only energy that exerts a force on matter. When electrons and ions combine into atoms, the photons released carry energy equivalent to ionization energy. After atomic gases form "Clusters" and develop into initial cluster of nebulae, the decoupling photons with the

isothermal temperature of matter will push the motion of matter through light pressure in the process of expansion and descent temperature. In the inner part of the cluster of nebulae, the pressure of decoupling photons on matter is bound by the rotational motion of matter namely gravitation, and the pressure cannot cause the cluster of nebulae to expand; since the distance between nebula clusters is larger than the critical scale and the gravitational force is weaker, the light pressure of decoupling photons must push the cluster of nebulae recession away from each other. This is the mechanism by which the decoupling photon generates dark energy, that is, the energy of the decoupling photon is the pressure energy of the photon gas. The photon decoupling energy, namely the dark energy, is expressed by E_0 . According to equation (119) and equation (105), it can be written as:

$$E_0 = C_4 = \frac{\Delta p}{\rho} = RT = \frac{GM}{r_0} = RT_0 \tag{121}$$

The distance between the center of the initial cluster of nebulae is $2r_c \geq r_0$, and the decoupling photon pressure p/ρ inevitably cause the scale expansion between the initial cluster of nebulae and reduce the gravitational potential energy between the initial cluster of nebulae during the expansion process. Based on this, the energy equation of large-scale gravitational field can be written as follows:

$$\frac{1}{2} w^2 = \frac{p}{\rho} - \frac{GM}{r} \tag{122}$$

By comparing the equation (122) with the equation (103), the two equations are completely consistent, it can be obtained that:

$$\frac{p}{\rho} = E_0 = C_4 = RT = \frac{GM}{r_0} = RT_0 \tag{123}$$

When accelerating the expansion, always has $C_4 = p/\rho = RT_0$ in value, and when the gravitational potential energy GM/r goes to 0, the equation (122) becomes:

$$\frac{1}{2} w^2 \rightarrow \frac{p}{\rho} \tag{124}$$

Through equations (114) and (122), it can be concluded that the cosmos eventually tends to expand at the same speed as "Ultimate Velocity" w_0 , namely:

$$w \rightarrow \sqrt{\frac{2p}{\rho}} = \sqrt{2RT_0} = w_0 \tag{125}$$

GR studies the gravitational field by coupling matter and energy through Equation (3), the energy issue cannot be studied alone, and when the standard model studies the decoupling issue through particle physics, ignoring the effect of decoupling photon pressure energy, therefore, the photon decoupling energy must be "Lost" and the dark energy cannot be explained.

Substitute the equation (123) into the equation (111), and get the motion equation of large-scale gravitational field:

$$\tau \sqrt{\frac{2p}{\rho}} = \tau \sqrt{2E_0} = \tau w_0 = r \sqrt{1 - \frac{r_0}{r}} - \frac{r_0}{2} \ln \frac{1 + \sqrt{1 - r_0/r}}{1 - \sqrt{1 - r_0/r}} \tag{126}$$

b. Decoupling and CMB: Because the photon distribution in the de-homogenization of anisotropy atomic gas gravitational field is "Inner Sparse and External Dense", after the contraction process ends, it will "Squeeze" most of the photons out of the galaxies, as the only observable cosmic background between the gaseous celestial body (the neutrino background is not visible yet), decoupling photon eventually become the CMB of 2.7K.

When the plasma gas expands to the critical scale r_0 and begins to combine from the periphery into atomic gas, the "Interface" between the atomic and ionic gases can be regarded as an equidistant "Sphere" whose scale is equal to the critical scale r_0 , when the

outer atomic gas of the "Sphere" shrinks into a "Cluster" under the combined action of the pressure differential Δp in equation (117) and the rotational motion, there would be matter "Voids" between the gas "Clusters". The plasma gas inside the "Sphere" will continuously release pressure into the "Voids" through the "Sphere" and continue to be decoupled until the plasma gas in the center of cosmos is finally decoupled and becomes an atomic gas. In the process of the expansion of the outer spherical atomic gas "Clusters" develop into the initial cluster of nebulae of critical scale r_c , under the action of photon decoupling energy, the accelerated expansion will happen between the cluster of nebulae, namely. But according to the equation (46), after the plasma gas expansion ends, it will form the inertial rotation of the tangent velocity v_0 , and the inertial rotation energy carried by the atomic gas "Clusters" and the initial cluster of nebulae will form the local vortex motion, and finally develop into the rotational motion among the galaxies within the group of galaxies. On a scale larger than the group of galaxies, the inertia rotational energy should continue to exist, so all group of galaxies should still perform rotational motion around the center of the cosmos. But because plasma expands only by rotating $\pi/2$, the angular velocity is not high and it is impossible to establish a frame of reference for observing the overall rotation of the cosmos, so astronomical observations can only find that the cosmos is expanding rapidly on a large scale rather than rotating. However, the rotation of a non-rigid circular sphere must develop into an ellipsoidal sphere, the spherical cosmos at the end of the matter formation period will become an ellipsoid cosmos with a small difference between the long and short axes after the rotation of the plasma gas expansion, on this basis, The cosmos developed and evolved should also be ellipsoidal and rotate with its short axis as the axis, and there will be slight deviation between the isotropic homogenization of the short axis direction and the long axis direction and may eventually develop into a circular sheet. If this slight deviation can be detected by careful astronomical observations, it will prove that the cosmos is indeed rotating and that the cosmos is shaped like an ellipsoid that can be approximated as a sphere. By the same token, rotating galaxies, galaxy clusters, etc. will also develop into ellipsoidal or even circular sheets, as confirmed by astronomical observations.

The plasma gas expansion is the continuous process that develop into critical scale r_0 , almost all the plasma gas must be according to the equation (37) expand to the critical scale of equation (80), and "Pass Through" the "Sphere" of critical scale r_0 to become atomic gas. The plasma gas that has not developed to critical scale r_0 cannot undergo contraction movement, and the plasma gas that has developed to critical scale must be compounded into atomic gas. Therefore, undecoupled plasma gas from the early cosmos could not directly form so-called "Initial Black Holes", and only within galaxies are special objects like black holes possible.

The NASA study, based on Cosmic Microwave Background from the Wilkinson Probe (WMAP), shows the distribution of matter in the early cosmos as shown in **FIG. 1**. The distribution of atomic gases on the "Sphere" of critical scale r_0 can be described in this diagram.

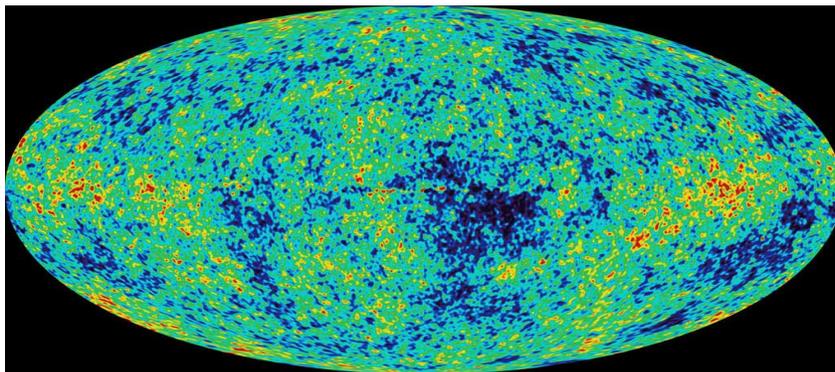


FIG. 1. Distribution of Matter in the Early Cosmos (WMAP).

c. Photon decoupling energy is the numeric value of dark energy: The initial cluster of nebulae with the same average density and critical scale r_c must have the same mass, which is the critical mass M_0 of the initial cluster of nebulae. It can be seen from Equation (121) that when r_c and M_0 are fixed values, the temperature is fixed value T_0 , that is, The photon decoupling energy is a constant determined by T_0 , and the temperature T_0 is the critical temperature at which the decoupling of matter and energy starts, as described in 2.1.3, the temperature can be estimated to be $T_0=3 \times 10^8 K$, and the photon decoupling energy can be obtained by substituting into equation (121):

$$E_0 = \frac{GM_0}{r_0} = RT_0 = 8.314 \times 3 \times 10^8 = 2.49 \times 10^9 Jkg^{-1} \quad (127)$$

By substituting Equation (127) into Equation (125), the ultimate expansion velocity of the cosmos can be obtained:

$$w_0 = \sqrt{\frac{2GM_0}{r_0}} = \sqrt{2E_0} = \sqrt{2RT_0} = \sqrt{2 \times 2.49 \times 10^9} = 7.06 \times 10^4 ms^{-1} = 70.6 kms^{-1} \quad (128)$$

According to Equation (127), the characteristic mass of the initial cluster of nebulae is M_0 :

$$M_0 = \frac{RT_0 r_c}{G} = \frac{E_0}{G} r_c = \frac{2.49 \times 10^9}{6.67 \times 10^{-11}} r_c = 3.73 \times 10^{19} r_c \quad (kg) \quad (129)$$

When the outermost temperature dropped to $3 \times 10^8 K$ in the cosmos started decoupling and compounding the atomic gas, the internal of the plasma is still higher than $3 \times 10^8 K$. Decoupling started in the helium atom compound temperature of $3 \times 10^8 K$, ended in hydrogen atom compound temperature of about 4000K, and decreased as the center of the universe to about 4000K, the average temperature has already dropped to well below 4000K. Until by the end of cosmic dark age and the matter at the cosmos center begins to glow, decoupling process has finished completely [8]. In the absence of other more reasonable basis for reference, this paper temporarily refers to the standard model after the end of the dark age, the average temperature of the cosmos is about 100K, the age is 400 to 500 million years, estimate 500 million years as the completed time of decoupling. Looking forward to the future research of particle physicists to give an accurate completed time of decoupling.

d. "2E" of the cosmos: According to astronomical research, the mass of visible matter in the cosmos is about $8 \times 10^{49} kg$. The critical scales of equation (92) r_c and the critical mass of equation (129) M_0 are the characteristic scales and mass of the initial cluster of nebulae, therefore, after decoupling is completed, there should be about

$$n \approx \frac{8 \times 10^{49}}{M_0} = \frac{8 \times 10^{49}}{3.73 \times 10^{19} r_c} \approx \frac{2.1 \times 10^{30}}{r_c} \quad (130)$$

initial cluster of nebulae in the cosmos. These n (estimated order of magnitude in the billions) "Fundamental Units" of cosmic matter are the "Embryos" of galaxies. If all these billions of initial cluster of nebulae formed and then developed into galaxies at the same time, after all of them are formed, their distribution is isotropic and uniform, and the distance between them is $2r_c$ from each other. If arranged according to the plane-centered cubic structure, the space volume occupied is:

$$n(2r_c)^3 \approx \frac{2.2 \times 10^{30}}{r_c} \times (2r_c)^3 = 1.8 \times 10^{31} r_c^2 \quad (131)$$

The cosmos after decoupling is developed from the spherically symmetric plasma gas gravitational field before decoupling.

Suppose the equivalent radius of the spherically symmetric cosmos after decoupling is r_{0+} , and its volume is equal to equation (131), namely:

$$n(2r_c)^3 \approx 1.8 \times 10^{31} r_c^2 = \frac{4\pi}{3} r_{0+}^3 \tag{132}$$

It can be obtained according to equation (132), the minimum scale r_{0+} of the cosmos formed by the critical scale cluster of nebulae after decoupling is:

$$r_{0+} \geq \sqrt[3]{\frac{1.8 \times 3}{4\pi} \times 10^{31} r_c^2} = 1.63 \times 10^{10} r_c^{2/3} \tag{133}$$

Equation (133) refers to the scale r_{0+} which can realize isotropic homogenization of flat cosmos after decoupling without considering the effect of photon decoupling energy. However, the photon decoupling energy has already caused the universe to expand faster, and the initial cluster of nebulae cannot be completely densely arranged according to the rules of the face-centered cubic structure, under the combined action of the photon decoupling energy and the rotational motion formed during the expansion period of plasma gas, "Groups" of different sizes and slightly looser are formed, these "Clusters" of different sizes and slightly looser shape are the embryonic forms of group of galaxies, galaxy cluster and galaxy supercluster. After considering the effect of photon decoupling energy, the actual scale of the universe is larger than equation (133), so the sign " \geq " is used in the equation.

At the end of the thermal expansion of the plasma, namely the beginning of the decoupling, the cosmic scale is critical scale r_0 of equation (80), and $r_0 = 1.5r_c$; After the complete end of the decoupling period, the cosmic scale at least increases to equation (133), namely r_{0+} , indicating the isotropic homogeneous motion of decoupling process, making the cosmic scale r_{0+} at least:

$$\frac{r_{0+}}{r_0} \geq \frac{1.6 \times 10^{10} r_c^{2/3}}{1.5r_c} = \frac{1.07 \times 10^{10}}{r_c^{1/3}} \tag{134}$$

times larger than the r_0 before the decoupling began. Astronomical observations show that the scale of dark matter halo in the Milky Way is 2×10^{21} m, considering that the maximum diameter of the circle after the galaxy has developed into a circle slice is larger than the initial spherical scale of the galaxy, the critical scale r_c of galaxies should be smaller than the observed scale of dark matter halo in the galaxy. If $r_c \approx 1 \times 10^{21}$ m is estimated and substituted into equation (134), the following equation can be obtained:

$$\frac{r_{0+}}{r_0} \geq \frac{1.07 \times 10^{10}}{r_c^{1/3}} \approx \frac{1.07 \times 10^{10}}{(1 \times 10^{21})^{1/3}} \approx 1000 \tag{135}$$

Thus, the cosmos expanded by at least a thousand times during the process of decoupling to form billions of initial cluster of nebulae! This expansion process may be named "2E" and should be described by large numerical simulations. Think of "2E" as something like this: Imagine using 500 million years, through countless holes on the surface of the "Mother Balloon" with radius

r_0 , billions of "Sub-Balloons" with radius r_c are continuously "Blown Out". These equal diameter "Sub-Balloons" closely arranged around the "Mother Balloon" form a "Big Ball", whose radius is at least 1000 times that of the "Mother Balloon". Considering that the "Mother Balloon" is spinning and the "Sub-Balloons" is recession from each other due to dark energy, this accelerated expansion and rotation of the "Big Ball" is equivalent to the cosmos, and the "Sub-Balloons" is equivalent to the initial cluster of nebulae or galaxies "Embryo".

e. The division of the characteristic periods of the cosmos:

(1) The matter formation period: In the formation period of matter, elementary matter particles are formed at the speed of light, moreover, the cosmic scale grows at the speed of light according to equation (66); The distribution of matter was isotropic homogeneous in the early cosmos, and gravitation had not yet formed. The period of matter formation begins at the birth moment $\tau=0$ of the cosmos and ends with the disappearance of positive and negative electron pairs at a temperature of about 300 million degrees when the positive and negative electron pairs disappear to form photons and the helium core becomes a plasma gas.

(2) Plasma gas expansion period: In the process of expansion according to equation (37), at the same time when the matter distribution changes from isotropic homogenization to de-homogenization of anisotropy, gravitation starts to form gradually, and the rotational motion in equation (37) becomes the origin of the rotational motion in the cosmic group of galaxies.

During the plasma gas expansion period, during the existence of helium ions, the temperature of matter and photon keeps at the ionization temperature of helium at $3 \times 10^8 \text{K}$ constant, while the neutrino temperature drops to $1/1.4$ of the temperature of matter, which is about 210 million degrees; When helium atoms composition is completed and only hydrogen ions are present, the matter and photon temperatures keep at the ionization temperature of hydrogen constant at 4000K , and the neutrino temperature drops to $1/1.4$ of the matter temperature, which is about 2900K .

(3) Decoupling and the "2E" of the cosmos: Shortly after the initial expansion of plasma gas, the outermost layer was first decoupled and compounded into atomic gas and expanded. In most of the time, the three stages of plasma gas expansion, decoupling and atomic gas expansion were superposition and carried out simultaneously.

The combination of plasma gas expansion and decoupled and atomic gas expansion can be called the period of cosmic thermal expansion. During the process of decoupling and atomic gas expansion, the cosmos happened at least 1000 times of "2E" in scale with the formation of initial cluster of nebulae, so this period can also be called the "2E" of the cosmos. From the stable emergence of helium ions to the final recombination of hydrogen ions at the center of the cosmos, the average temperature of the cosmos dropped from $3 \times 10^8 \text{K}$ to 100K orders of magnitude, estimated to span about 500 million years.

(4) The accelerated cold expansion of the cosmos: The photon pressure could make the initial cluster of nebulae and group of galaxies recession by equation (126) and realized isotropic homogeneous among the group of galaxies. Between group of galaxies

and galaxies, as gravitational potential energy infinitely approaches (but does not equal) zero, the ultimate velocity of the expansion of the cosmos will eventually infinitely approach (but does not equal) the ultimate velocity, and the CMB will infinitely approach (but does not equal) absolute zero. Objects outside the critical scale r_c of the galaxies will drift away from the galaxies and become stray objects.

2.2.3 Dark matter is the proof of mass missing: If a substance per unit mass moves in a circle around the gravitational field of mass M in a radius r orbital with the velocity V , if $r \leq r_c$, the centrifugal force of rotational motion is in equilibrium with the gravitation, that is, the relationship between the centripetal acceleration of a unit mass and the strength of the gravitational field is:

$$\frac{V^2}{r} = \frac{GM}{r^2} \tag{136}$$

The left side of equation (136) is the centripetal acceleration, which is to overcome the centrifugal force. According to equation (136):

$$V^2 = 2 \left(\frac{1}{2} V^2 \right) = \frac{GM}{r} \tag{137}$$

Equation (137) shows that the gravitational potential energy in the system is equivalent to the rotational motion inertial rotation energy of 2 times; According to equation (47) it is known that the rotational motion inertial rotation energy is completely transformed by the thermal expansion pressure energy p/ρ . The forming process of gravitational potential energy is: firstly, the thermal expansion pressure energy can be converted into the rotational motion inertial rotation energy, and the inertial rotational energy can be converted into the gravitational potential energy.

If the object rotational motion orbit radius $r > r_c$, the observed rotation velocity is v . Since acceleration expansion occurs when the critical scale is exceeded, there is expansion acceleration a^* in the normal direction. The equilibrium relationship of Equation (136) is broken, and the following equilibrium relationship is established:

$$\frac{v^2}{r} - a^* = \frac{GM}{r^2} \tag{138}$$

Note: a^* is the expansion acceleration of the photon decoupling energy at the $r > r_c$, although contrary to the direction of gravitation, but it's irrelevant to the centrifugal force. The acceleration a^* produces the normal velocity w , but the centrifugal force cannot produce the normal motion. The actual rotation velocity and normal expansion velocity w will form the observed rotation velocity v by velocity composition law, the following formula can be written:

$$v^2 = V^2 + w^2 \tag{139}$$

Substituting equation (137) and Equation (94) into Equation (139), we can get:

$$v = \sqrt{\frac{GM}{r} + \left(\frac{2GM}{r_c} - \frac{2GM}{r}\right)} = \sqrt{\frac{2GM}{r_c} - \frac{GM}{r}} \tag{140}$$

When the expansion velocity w is not large, the included angle between the resultant velocity v and the actual rotation velocity V is very small, so astronomical observation cannot clearly distinguish the resultant velocity v from the actual rotation velocity V , and the observed velocity value will have the following deviation:

$$v - V = \sqrt{\frac{2GM}{r_c} - \frac{GM}{r}} - \sqrt{\frac{GM}{r}} = \left(\sqrt{\frac{2r}{r_c} - 1} - 1\right) \sqrt{\frac{GM}{r}} = \left(\sqrt{\frac{2r}{r_c} - 1} - 1\right) V \tag{141}$$

After velocity v and distance r are obtained through astronomical observation, if we do not know the existence of acceleration a^* and normal velocity w , then it is inevitable that the mass M^* of the matter field will still be calculated according to equation (136). Substituting equation (140) into equation (136), we can get:

$$\frac{GM^*}{r^2} = \frac{v^2}{r} = \frac{1}{r} \left(\frac{2GM}{r_c} - \frac{GM}{r}\right) \tag{142}$$

According to Equation (142), the mass M^* is:

$$M^* = \left(2 \times \frac{r}{r_c} - 1\right) M \tag{143}$$

As you can see, when $r > r_c$, the calculated mass of the matter field M^* in equation (136) is obviously greater than the real mass M , and there seems to be a missing mass of $(M^* - M)$, that is, the so-called "Dark Matter". The ratio of dark matter (only cold dark matter) to the bright matter M is x :

$$x = \frac{M^* - M}{M} = 2 \times \left(\frac{r}{r_c} - 1\right) \tag{144}$$

According to Equation (144), when $r > r_c$, $x > 0$, dark matter begins to appear; when $r > 1.5r_c = r_0$, $x > 1$, there's more dark matter than bright matter. Thus, dark matter is actually an illusion created by the accelerated expansion of dark energy in the rotational motion of orbit radius $r > r_c$.

Through precise astronomical observation, the critical scale r_c and r_0 observation data can be obtained according to equation (144), and the theory is verified.

3. Further Research on the Solution Results of Equivalence Principle

3.1 Gravitational field and gravitational rotational motion

3.1.1 Galaxies formation and rotating centrifugal force

a. Galaxies formation and celestial rotation: Small atomic gas "Clusters" whose mass is less than the critical mass M_0 and the

expansion scale cannot reach the critical scale r_c , will merge with other small atomic gas "Clusters" or be captured as dispersed gas by the initial cluster of nebulae during the contraction process. Most of the initial cluster of nebulae with the characteristic scale of r_c will capture the peripheral dispersed gas during the contraction process, so the mass of the final formed galaxies is greater than the critical mass M_0 and the scale is greater than the critical scale r_c , and there is the so-called "Dark Matter" phenomenon.

When the initial cluster of nebulae contracted, the pressure of the atomic gas system increased (but the pressure energy did not change), and the temperature of the energy (photon) increased. After the hydrogen atom's reionization, the matter and energy realize isothermal again, and the temperature and pressure of the matter and energy increase further, forming a density and temperature gradient gradually increasing from the outside to the inside, until hydrogen ion nuclear fusion starts from the center and the temperature and pressure increase sharply [9]. The central matter of the cluster of nebulae develops towards the black hole due to the large contraction potential (namely gravitation) caused by the rotational motion of the gaseous celestial body; But when a matter at a certain scale away from the center of the cluster of nebulae begins to nuclear fusion, if the contraction potential of the matter at that location is not enough to resist the fusion pressure, the cluster of nebulae will undergo a "Pressure Burst" from that location, "Torn" all the gas outside the location and spreading out in all directions. Under the combined action of contraction potential and explosive force, the plasma gas that has undergone nuclear fusion forms several star that spiral around each other, namely star cluster. The atomic gas that has not undergone nuclear fusion develops into a new generation of small and medium-sized cluster of nebulae and continues to contract and evolve into star, or is captured as dispersed gas by small and medium-sized cluster of nebulae or star.

After the nuclear fusion "Pressure Burst" occurs and form star, the gas pressure energy between star can be $p/\rho \rightarrow 0$, conditions for the establishment of equation (8) are met, therefore, star cluster, star and cluster of nebulae can be described in equation (16). After flying away to a certain scale away from the gravitational center, these matter (celestial bodies) are no longer far away but revolve around the gravitational center of the galaxies in a certain orbit according to equation (101). However, since the maximum stable scale of the galaxies is the critical scale r_c , the celestial body that flies to the $r > r_c$ from the center of gravitation according to equation (16) will gradually move away during galaxies rotation and eventually escape from the galaxies and become the stray celestial body or interstellar gas.

b. The source of centrifugal force in rotary motion: It is known from equation (47) that the gravitational rotational motion is transformed by the pressure energy p/ρ of the gaseous matter system. By comparing equations (37) and (101), the gravitational force is the "Contracting Force" formed after the disappearance of the gas expansion pressure p , but the centrifugal force balanced with the gravitational force is not clear.

It is known in 2.1.3 that the initial velocity of plasma gas expansion can be regarded as the speed of light, and the velocity $w=0$ at

the end of expansion is formed into equation (81), the gravitational rotational motion. It can be said that the process of the disappearance of the expansion motion at the speed of light is the process of the synchronous formation of the rotational motion, and the translational direction of the expansion at the speed of light is completely consistent with the centrifugal force direction. The expansion of atomic gases is similar to plasma gases. The centrifugal force in the rotational motion of the small-scale gravitational field is the result of the transformation of the inertial translational energy of matter. Although the value of centrifugal force and centripetal force are equal, the source and forming mechanism are completely different. Centrifugal force comes from the inertial translational energy of expansion motion, while centripetal force comes from the contraction potential of inertial rotation. In other words, in the small-scale gravitational field, the physical meaning of the equivalence principle formula (2) is that the centrifugal force is equal to the centripetal force (left of equation), that is, gravitation (right of equation).

3.1.2 Transformation and conservation of cosmic energy: For the convenience of expression, in the following, the expansion pressure energy of the matter formation period, the plasma gas thermal expansion period, the atomic gas thermal expansion period and the accelerated cold expansion period were expressed in Terms of E_1 , E_2 , E_3 and E_4 respectively, and the expansion pressure energy of each period was studied and analyzed.

During the formation period of matter, the cosmic scale grows at the speed of light, which is the result of the matter field constantly "growing" new matter outward at the speed of light. The generated basic matter particles remain "Stationary", so there is no matter expansion pressure energy, namely $E_1=0$.

a. Plasma gas expansion period: It is known from Equation (81) that the plasma gas thermal expansion pressure energy can convert all p/ρ into inertial rotation energy, that is:

$$E_2 = \frac{1}{2} v_{01}^2 = \frac{p}{\rho} = 1.8RT_0 = 1.8E_0 \quad (145)$$

Equation (145) is substituted into Equation (22) to obtain the energy conversion relationship during the plasma gas expansion period:

$$\frac{1}{2} w^2 = \frac{GM}{r} - E_2 = \frac{GM}{r} - \frac{1}{2} v_{01}^2 \quad (146)$$

The physical meaning of equation (146) is: with the decrease of translational energy in the expansion motion of plasma gas, all the thermal expansion pressure energy is converted into inertia rotational energy, and an equivalent gravitational potential energy is formed, that is, the increased gravitational potential energy in the expansion process is equal to the thermal expansion pressure energy E_2 .

b. Atomic gas expansion period: Like plasma gas, according to Equation (93), atomic gas thermal expansion pressure energy E_3

can be written:

$$E_3 = \frac{1}{2} v_{02}^2 = \frac{P}{\rho} = 0.8RT_0 = 0.8E_0 \quad (147)$$

Equation (147) is substituted into Equation (22) to obtain the energy conversion relation of atomic gas expansion period:

$$\frac{1}{2} w^2 = \frac{GM}{r} - E_3 = \frac{GM}{r} - \frac{1}{2} v_{02}^2 \quad (148)$$

The physical meaning of equation (148) is: with the decrease of translational energy of atomic gas expansion motion, all the thermal expansion pressure energy is converted into inertial rotational energy, and an equivalent gravitational potential energy is formed, that is, the increased gravitational potential energy in the expansion process is equal to the thermal expansion pressure energy E_3 .

c. Accelerated cold expansion period: According to equation (123), the decoupling photon pressure energy E_4 is:

$$E_4 = \frac{P}{\rho} = RT_0 = E_0 \quad (149)$$

Equation (149) is substituted into equation (122) to obtain the energy conversion relationship during the accelerated cold expansion of the cosmos:

$$\frac{1}{2} w^2 = E_4 - \frac{GM}{r} = \frac{P}{\rho} - \frac{GM}{r} \quad (150)$$

The physical meaning of equation (148) is: in the process of accelerating expansion of the cosmos, as the gravitational potential energy decreases and gradually disappears, all the photon decoupling energy is converted into inertial translational energy, that is, the inertial translational energy increased by accelerating expansion is equal to the photon decoupling energy E_4 . In other words, in the large-scale gravitational field, the physical meaning of equation (2) of equivalence principle is that the reduced gravitation (right of equation) equals to the increase of inertial translational force (left of equation).

d. Energy conservation and mass conservation

1. When neutrinos are not considered: It can be seen from Equations (146) and (148) that the heat expansion period of the cosmos is the gravitational potential energy form, and the gravitational potential energy E_g is the heat expansion energy E_t . that is:

$$E_g = E_t = E_2 + E_3 = 1.8E_0 + 0.8E_0 = 2.6E_0 \quad (151)$$

It can be seen from Equations (81) and (93) that the plasma gas expansion and atomic gas expansion form a total inertial rotation energy is:

$$\frac{1}{2}v^2 = \frac{1}{2}v_{01}^2 + \frac{1}{2}v_{02}^2 = 1.8RT_0 + 0.8RT_0 = 2.6RT_0 \tag{152}$$

It can be seen from equations (151) and (152) that the inertial rotation energy formed by thermal expansion period is equivalent to the thermal expansion energy and is equal to the gravitational potential energy formed in the same period, namely:

$$\frac{1}{2}v^2 = 2.6RT_0 = E_g = E_t \tag{153}$$

During the accelerated cold expansion period, the cosmos "Released" gravitational potential energy equivalent to the photon decoupling energy $E_4=E_0$ outside the galaxies, in addition, the cosmos accelerated accelerates due to the weakening of gravitational constraints, but the gravitational potential energy E_g equivalent to the thermal expansion energy $E_t=2.6E_0$ is still "Bound" in the galaxies. Therefore, in the absence of neutrino mass and energy, equation (57) of mass and energy conservation in the universe can be written as:

$$E = Mc^2 + E^* = Mc^2 + (E_gM + E_4M) = Mc^2 + (2.6E_0M + E_0M) = (c^2 + 3.6E_0)M \tag{154}$$

In the formula, Mc^2 represents matter, E_gM represents thermal expansion energy, i.e. gravitational potential energy, and E_4M represents photon decoupling energy from matter. The energy E^* which is not transformed into matter in the cosmos, which is finally transformed into inertial rotation energy and inertial translational energy, and the photon energy coupled with matter (internal energy of matter) is transformed into inertial rotation energy, and the photon energy decoupled from matter is transformed into inertial translational energy.

2. Analysis of gravitational potential energy in galaxies: Equation (153) shows that the gravitational potential energy in a galaxy is equivalent to the inertial rotation energy; however, equation (137) shows that, the gravitational potential energy is equal to twice the inertial rotation energy. Since equation (137) has been verified by astronomical observation, the deviation should be in equation (153) and related to neutrino energy.

Particle physics research shows that neutrinos can interact with "Gravitons", and the temperature of decoupling neutrinos is as high as 1/1.4 of the matter temperature ($3 \times 10^8 K$). But formula (151) does not include neutrino thermal expansion energy, which is obviously unreasonable. If the neutrino thermal expansion energy is E_v and the gravitational potential energy of the galaxies including neutrino energy is E_G , then formula (153) should be rewritten as:

$$\frac{1}{2}V^2 = E_G = E_g + E_v = E_t + E_v = 2.6RT_0 + E_v \tag{155}$$

Because it is difficult to calculate the energy and mass of neutrinos at present, when we do not consider the neutrino energy for the time being, we can get from equation (153):

$$\frac{1}{2}v^2 = \frac{1}{2}(\omega r)^2 = 2.6E_0 \quad (156)$$

The angular velocity ω of the rotational motion is:

$$\omega = \frac{\sqrt{5.2E_0}}{r} \quad (157)$$

Taking the galaxy as an example, the latest astronomical observation distance from the sun to the galactic center is $r=26600$ light-years= 2.52×10^{20} m, substituting (157), the angular velocity of the sun around the silver center can be obtained [10]:

$$\omega = \frac{\sqrt{5.2E_0}}{r} = \frac{\sqrt{5.2 \times 2.49 \times 10^9}}{2.52 \times 10^{20}} = 4.51 \times 10^{-16} / s \quad (158)$$

The time required for the sun to rotate around the silver center is:

$$t = \frac{2\pi}{\omega} = \frac{2\pi}{4.51 \times 10^{-16}} = 1.39 \times 10^{16} s = 442 \text{ million years} \quad (159)$$

Equation (159) is about twice the period of the sun's rotation around the galactic center $T=212$ million years, which shows that it is not in line with the astronomical observation that the thermal expansion energy of neutrinos is not considered [3].

3. When considering the thermal expansion energy of neutrino: In this paper, we show that the thermal expansion energy of matter is converted into gravitational potential energy, if the thermal expansion energy of neutrinos in matter particles is also converted into gravitational potential energy, then the neutrino thermal expansion energy E_v can be calculated according to the solar revolution period of 212 million years.

According to formula (155), the rewriting formula (153) is:

$$\frac{1}{2}(\omega r)^2 = \frac{1}{2} \left(\frac{2\pi r}{T} \right)^2 = E_G = 2.6RT_0 + E_v \quad (160)$$

By substituting $T=212$ million years = 6.69×10^{15} s and $r=2.52 \times 10^{20}$ m into equation (160), the gravitational potential energy in the galaxy is obtained:

$$E_G = 2.6RT_0 + E_v = \frac{1}{2} \left(\frac{2\pi r}{T} \right)^2 = \frac{1}{2} \left(\frac{2\pi \times 2.52 \times 10^{20}}{6.69 \times 10^{15}} \right)^2 = 2.80 \times 10^{10} = 11.2E_0 \quad (161)$$

The thermal expansion energy of neutrino can be obtained:

$$E_v = E_G - E_t = 11.2E_0 - 2.6E_0 = 8.6E_0 = 8.6 \times 2.49 \times 10^9 = 2.14 \times 10^{10} = 3.3E_t \quad (162)$$

The thermal expansion energy of neutrino is 3.3 times that of visible matter and 8.6 times that of photon decoupling energy. It can even be assumed that the only matter neutrinos with continuous distribution in interstellar space may be the propagation medium of

gravitational waves.

It seems that neutrinos cannot produce pressure energy like light pressure, and photon decoupling energy has achieved balance with the energy of accelerated cold expansion of the cosmos, and can be verified by Hubble constant in the following research, so neutrino energy can only be converted into gravitational potential energy. If the inference is correct, the equation of mass and energy conservation in the universe of equation (57) should be written as:

$$\begin{aligned}
 E &= Mc^2 + E^* = Mc^2 + (E_G M + E_4 M) = Mc^2 + (E_v + E_t) M + E_4 M \\
 &= Mc^2 + (8.6E_0 + 2.6E_0) M + E_0 M = Mc^2 + 11.2E_0 M + E_0 M \\
 &= (c^2 + 12.2E_0) M
 \end{aligned} \tag{163}$$

The inertial rotational energy (i.e. gravitational potential energy) of the cosmos is 11.2 times of the inertial translational energy when the neutrino energy is considered.

If the matter has gravitation in the generation period, it is no longer necessary to convert the thermal expansion pressure energy into the gravitational potential energy through equation (146) and equation (148), which will not only cause the issues that equation (146) and equation (148) cannot explain, but also "Lose" the thermal expansion energy of bright matter and neutrino, and the cosmos energy cannot be conserved at the macro level. The isotropic homogenized matter field has no inference of gravitation, which is not only reasonable and necessary in the period of matter formation, but also can be proved by the isotropic homogenization in the period of accelerated cold expansion, and can be proved by the conservation of cosmic energy, which is also a necessary condition for the complete self-consistency of the theoretical system in this paper.

3.1.3 Re-understanding gravitation and gravitational potential energy: To sum up, we can establish the following new understanding of gravitation and gravitational potential energy:

- a. Gravitational potential energy is the radial contraction potential formed after the thermal expansion pressure energy of cosmic matter is converted into inertial rotation energy. In the process of gas matter forming rotational motion in Galaxies through expansion and contraction, the contraction force formed with the decrease of expansion pressure is the centripetal force of rotational motion, i.e. gravitation, and the centrifugal force in equilibrium with it comes from the translational energy of inertial expansion motion;
- b. The thermal expansion energy, inertial rotation energy and gravitational potential energy of cosmic matter are transformed and equivalent in turn. After the thermal expansion pressure energy is transformed into inertial rotation energy, the gravitational potential energy is equivalent to the inertial rotation energy stored in matter. Therefore, gravitation is the result of the matter movement in the gravitational field, not the cause of the matter movement;
- c. The gravitational potential energy is the inertial rotational energy formed in the process of realizing the de-homogenization of anisotropy motion of matter, so the isotropic homogeneous matter field possesses no gravitation;
- d. Due to the fact that a finite number of particles in a finite scale cannot form an isotropic homogeneous matter field, there is gravitation between the finite number of particles in a finite scale, that is "universal gravitation".

3.2 Hubble's law and main characteristic parameters of the cosmos

3.2.1 Hubble law and hubble constant

1) " Velocity-Distance" law and hubble's law: The cosmological "Velocity-Distance" law can be expressed as: the velocity of recession v between extragalactic galaxies is directly proportional to the recession distance l , farther distance will cause greater velocity of recession. It is expressed by the following formula:

$$H = \frac{v}{l} \tag{164}$$

H is the Hubble constant. Although the velocity of recession and distance described in the Velocity-Distance Law refer to the velocity and distance on the "World Map" of the parallel sphere of the spherical symmetry of the cosmos, but cosmology has proved that the formula (165) expressed by radial velocity w and radial scale r is not limited to the existence of acceleration, which indicates the law of Velocity-Distance expressed by formula (165) is universal in the sphere symmetric cosmos.

$$H = \frac{w}{r} \tag{165}$$

Hubble's law is usually expressed as follows: astronomical observation and discovery, for the extragalactic galaxies far away from us 10 Mpc (30 million light-years), for every increase in the recession distance $\Delta l=1\text{Mpc}$, the velocity of recession increases $\Delta v=70.6\pm 3.0\text{km/s}$ (the observed value at this stage), which is expressed as follows:

$$H = \frac{\Delta v}{\Delta l} = 70.6 \pm 3.0 \text{ km.s}^{-1} . \text{Mpc}^{-1} \tag{166}$$

Hubble's law is only applicable to the accelerated expansion of the cosmos above 10Mpc scale, also Δv and Δl are the velocity of recession difference and scale difference on the "World Map", not the radial velocity difference Δw and scale difference Δr . However, according to the law of Velocity-Distance in equation (165), it can be proved that in the nonconstant expansion of a spherically symmetric cosmos, $\Delta v/\Delta l$ is equivalent to $\Delta w/\Delta r$, that is, equation (166) can be written as follows:

$$H = \frac{\Delta v}{\Delta l} = \frac{\Delta w}{\Delta r} \tag{167}$$

By subtracting the initial velocity and the initial scale, the Hubble's law of equation (167) is completely equivalent to the Velocity-Distance law of equation (165) when the contribution of acceleration or deceleration expansion to velocity and scale is taken into account solely. In addition to the formation period of matter, the cosmos has not yet found the full meaning of isokinetic expansion, so it is generally considered that Hubble's law and Velocity-Distance law are equivalent and collectively referred to as Hubble's law.

From equation (167), we can get:

$$H = \frac{\Delta w}{\Delta r} = \frac{\Delta w/\Delta \tau}{\Delta r/\Delta \tau} = \frac{a}{w} \tag{168}$$

The Hubble constant H is also equal to the ratio of the radial acceleration a to the velocity w , when the expansion velocity is faster and faster, even if the acceleration remains unchanged, the Hubble constant will become smaller and smaller with time the Hubble constant is not a constant of time.

2) Expression of hubble constant and cosmic age: By substituting equation (107), equation (112) and equation (128) into equation (167), the expression of Hubble constant at scale $r>r_0$ is obtained:

$$H = \frac{w}{r - r_0} = \frac{1 - r_0/r}{\tau + \frac{r_0}{2w_0} \ln \frac{1 + \sqrt{1 - r_0/r}}{1 - \sqrt{1 - r_0/r}} - \frac{r_0 \sqrt{1 - r_0/r}}{w_0}} \quad (169)$$

The reciprocal of equation (169) is:

$$\frac{1}{H} = \frac{\tau}{1 - r_0/r} + \left(\ln \frac{1 + \sqrt{1 - r_0/r}}{1 - \sqrt{1 - r_0/r}} - 2\sqrt{1 - r_0/r} \right) \frac{r_0}{2w_0(1 - r_0/r)} \quad (170)$$

By simplifying the logarithm term in the formula by the second order approximation, the expressions of cosmic age and Hubble constant can be obtained:

$$H = \left(1 - \frac{r_0}{r}\right) \times \frac{1}{\tau}, \text{ or } \tau = \left(1 - \frac{r_0}{r}\right) \times \frac{1}{H} \quad (171)$$

The reciprocal of the Hubble constant is directly proportional to the age of the cosmos, and its ratio is obviously related to r_0/r , only when $r \gg r_0$, the age of the cosmos is equal to the reciprocal of the Hubble constant.

If the size of the cosmos is only three times as large as the critical scale, that is, $r = 3r_0$, then the age of the cosmos

$$\tau = \left(1 - \frac{r_0}{r}\right) \times \frac{1}{H} = \frac{2}{3} \times \frac{1}{H} \quad (172)$$

is consistent with the expression of cosmic age which predicted by the Einstein-Desitter model.

3) The velocity of recession and galaxies distance: Equation (166) is multiplied by $\Delta l = 1\text{Mpc}$ at the same time on both sides of the equation, and take the accelerated expansion of the initial velocity of recession is zero, that is, $\Delta v = v$, get:

$$H \times \Delta l = v = 70.6 \pm 3.0 \text{ kms}^{-1} \quad (173)$$

Substituting the sum of $\Delta l = 1\text{Mpc} = 3.0857 \times 10^{19} \text{ km}$ and equation (171) into (173), we can get:

$$v = \frac{\Delta l(1 - r_0/r)}{\tau} = \frac{3.0857 \times 10^{19} (1 - r_0/r)}{\tau} = 70.6 \pm 3.0 \text{ kms}^{-1} \quad (174)$$

When $r \gg r_0$ is equal to the reciprocal of the Hubble constant, equation (174) becomes:

$$v = \frac{\Delta l}{\tau} = \frac{3.0857 \times 10^{19}}{\tau} = 70.6 \pm 3.0 \text{ kms}^{-1} \quad (175)$$

Equation (175) shows that when $r \gg r_0$, the Hubble constant in $\text{km.s}^{-1}.\text{Mpc}^{-1}$ is the velocity of recession in km.s^{-1} . By comparing equation (175) with equation (128), it can be seen that the ultimate expansion velocity $w_0 = 70.6 \text{ km.s}^{-1}$ is calculated from the photon decoupling energy, which is completely equal to the observed value of Hubble's law at the present stage, which proves that the conclusion of the study on dark energy in this paper is correct.

It can be seen from equation (174) that at any time $1\text{Mpc} = 3.0857 \times 10^{19} \text{ km}$, the distance corrected by coefficient $(1 - r_0/r)$ divided by the age of the cosmos, is equal to the velocity of recession of the accelerated expansion of the cosmos, indicating the corrected distance

$$l = \Delta l \left(1 - \frac{r_0}{r}\right) = 3.0857 \times 10^{19} \left(1 - \frac{r_0}{r}\right) \quad (\text{km}) \quad (176)$$

Which is the recession distance between galaxies due to accelerated expansion, when $r \gg r_0$, the recession distance is:

$$l = 3.0857 \times 10^{19} \text{ km} = 3.0857 \times 10^{22} \text{ m} \tag{177}$$

However, the actual distance between galaxies calculated by the distance between the centers of galaxies should also include the largest scale r_c of the formation of the thermal expansion of galaxies, therefore, the distance between the centers of galaxies L is:

$$L = l + 2r_c = 3.0857 \times 10^{22} \left(1 - \frac{r_0}{r} \right) + 2r_c \tag{178}$$

When $r \gg r_0$, the center distance L of the galaxies is:

$$L = 3.0857 \times 10^{22} + 2r_c \tag{179}$$

However, at the scale of $r > r_0$, the vortex motion of galaxies forms group of galaxies, galaxy cluster and galaxy super cluster, so formula (178) and formula (179) represent the average center distance of galaxies.

3.2.2 Estimation of main characteristic parameters of the cosmos: Since the equations of motion of the cosmos in different periods given in this paper are different from that of GR, and the standard model particle physics calculation assumes that there is no overlap between the development and evolution stages of the cosmos, but this kind of assumption is not true, therefore, the early timescale of the cosmos given by the standard model cannot be used in this paper. However, the author's level of particle physics is very limited and cannot calculate and give a reasonable timescale in accordance with the theory of this paper, the timescales used in the following calculations are estimated by the reference standard model, the following relevant calculation may only have reference significance in the order of magnitude, after the accurate timescale is given by particle physics, it should be recalculated.

1. Cosmic scale of matter generation period: According to the division of the development and evolution stages of the cosmos in this paper, the generation period of matter ends at the temperature of $3 \times 10^8 \text{ K}$ in the cosmos. The timescale of $3 \times 10^8 \text{ K}$ in the early cosmos given by the standard model is $\tau_1 = 2.08 \times 10^3 \text{ s} \approx 35 \text{ min}$, if the order of magnitude of the timescale is referential, substituting (66) can get the cosmic scale r_1 at the end of the matter generation period as follows:

$$r_1 = c\tau_1 \approx 3 \times 10^8 \times 2.08 \times 10^3 \approx 6 \times 10^{11} \text{ m} = 6 \times 10^8 \tag{180}$$

2. Expansion of plasma gas and critical scale of cosmos: The age of the reference standard model cosmos is 400-500 million years when the average temperature of the cosmos is about 100 K. It is estimated that $\tau_0 = 500 \text{ million years} = 1.58 \times 10^{16} \text{ s}$ is the reference timescale for the completion of the complete decoupling of the cosmos and the end of the "2E", according to equation (127) and equation (80), the cosmic scale r_2 at the end of the expansion of the plasma gas, namely the cosmic critical scale r_0 , is obtained as follows:

$$\begin{aligned} r_2 = r_0 &= 1.21\tau_0\sqrt{RT_0} \approx 1.21 \times 1.58 \times 10^{16} \times \sqrt{8.314 \times 3 \times 10^8} \\ &= 9.55 \times 10^{20} \text{ m} = 101000 \text{ light years} \end{aligned} \tag{181}$$

The average expansion velocity of plasma gas is:

$$\bar{w} = \frac{r_0}{\tau_0} = \frac{9.55 \times 10^{20}}{1.58 \times 10^{16}} \approx 6.04 \times 10^4 \text{ ms}^{-1} = 60.4 \text{ kms}^{-1} \tag{182}$$

Although the initial expansion velocity of plasma gas is the speed of light, the average expansion velocity is not very high.

3. The critical scale of initial cluster of nebulae and galaxies: Atomic gas and plasma gas have the same temperature and the expansion period is superimposed together, take $\tau_0 = 500 \text{ million years} = 1.58 \times 10^{16} \text{ s}$, $T_0 = 3 \times 10^8 \text{ K}$, substitute equation (92), and get the initial cluster of nebulae scale r_3' , that is, the critical scale r_c of galaxies is:

$$r_3' = r_c = 0.81\tau_0\sqrt{RT_0} = 0.81 \times 1.58 \times 10^{16} \sqrt{8.314 \times 3 \times 10^8} \quad (183)$$

$$= 6.35 \times 10^{20} \text{ m} = 67100 \text{ light years}$$

The average expansion velocity of atomic gas is:

$$\bar{w} = \frac{r_c}{\tau_0} = \frac{6.35 \times 10^{20}}{1.58 \times 10^{16}} \approx 4.02 \times 10^4 \text{ ms}^{-1} = 40.1 \text{ kms}^{-1} \quad (184)$$

The motion equations of atomic gas and plasma gas are the same, and the end velocity of expansion is zero, therefore, according to the same order of magnitude of (184) and (182) and the former is slightly smaller, the "2E" is equivalent to making the initial expansion velocity of atomic gas close to the speed of light.

4. The critical mass of initial cluster of nebulae: Substituting equation (183) into equation (129), we can get the critical mass M_0 of the initial cluster of nebulae:

$$M_0 = \frac{E_0}{G} r_c = 3.75 \times 10^{19} r_c = 3.75 \times 10^{19} \times 6.35 \times 10^{20} = 2.38 \times 10^{40} \text{ kg} \quad (185)$$

Equation (185) is the characteristic mass when the atomic gas expands to the critical scale after decoupling, that is, the critical mass of the initial cluster of nebulae.

5. Estimation of the number of galaxies in the cosmos: Substituting equation (183) into equation (130), we can get:

$$n \approx \frac{2.1 \times 10^{30}}{r_c} = \frac{2.1 \times 10^{30}}{6.35 \times 10^{20}} \approx 3.3 \times 10^9 \text{ (piece)} \quad (186)$$

There are about 3.3 billion Milky Way like galaxies in the cosmos.

6. The cosmic "2E" scale: Equation (135) has clearly shown that during the decoupling period, with the thermal expansion of plasma gas and atomic gas, the cosmic scale has at least 1000 times of "2E". Substituting equation (183) into equation (133), the universe scale after decoupling can be obtained

$$r_3 = r_{0+} \geq 1.63 \times 10^{10} r_c^{2/3} = 1.63 \times 10^{10} \times (6.35 \times 10^{20})^{2/3} = 1.20 \times 10^{24} \text{ m} \quad (187)$$

Equation (187) shows that the expansion of the atomic gas superimposed on the expansion of the plasma gas makes the cosmos expand at least

$$\frac{r_{0+}}{r_0} \geq \frac{1.20 \times 10^{24}}{9.55 \times 10^{20}} \approx 1.3 \times 10^3 \quad (188)$$

times, this result can reasonably explain the issue that cosmology can't explain the difference of cosmic scale by at least 1000 times.

7. The average expansion velocity of the cosmos in the thermal expansion period: The average velocity of cosmic thermal expansion of plasma gas expansion and atomic gas expansion (include "2E") is as follows:

$$w_{2,3} = \frac{r_3}{\tau_3} = \frac{1.20 \times 10^{24}}{1.58 \times 10^{16}} = 7.59 \times 10^7 \text{ ms}^{-1} = 0.25c \quad (189)$$

During the thermal expansion period (include "2E"), the cosmic scale grows up at 25% of the speed of light, which is a subluminal motion.

8. Cosmic age: Obviously, at present, the cosmic scale is significantly larger than the critical scale, i.e. $r \gg r_0$. Substituting (171) for cosmic age:

$$\tau = \left(1 - \frac{r_0}{r}\right) \times \frac{1}{H} = \frac{3.0857 \times 10^{19}}{70.6} = 4.37 \times 10^{17} s = 13.85 \text{ billion years} \quad (190)$$

According to equation (175), the expansion velocity of the cosmos is very close to equation (128) with the ultimate expansion velocity $w_0=70.6\text{kms}^{-1}$.

9. Current scale of the cosmos: Substituting equation (183) into equation (179), it can be concluded that the average center distance of galaxies in the cosmos at present is:

$$L = 3.0857 \times 10^{22} + 2r_c = 3.0857 \times 10^{22} + 2 \times 6.35 \times 10^{20} \approx 3.21 \times 10^{22} m \quad (191)$$

About 3.3 billion initial cluster of nebulae mutual recession $3.0857 \times 10^{22} m$ from a closely arranged state, which is equivalent to the scale after the critical scale r_c in formula (133) changes to $L/2$, therefore, according to formula (133), the minimum scale of the cosmos (the area occupied by matter) is as follows:

$$r \geq 1.63 \times 10^{10} (L/2)^{2/3} = 1.63 \times 10^{10} (3.21 \times 10^{22} / 2)^{2/3} \quad (192)$$

$$\approx 1.04 \times 10^{25} m = 1.1 \text{ billion light years}$$

Equation (192) is the minimum distance between the farthest cosmic matter and the center of the cosmos. At present, the light emitted from the birth of the cosmos has reached 13.85 billion light-years away from the center of the cosmos, the average expansion velocity of cosmic matter is at least $11/138.5=8\%$ of the speed of light.

3.3 Comparative analysis with the standard cosmological model: The Einstein gravitational field equation including the cosmic factor Λ (also known as the cosmic constant) is as follows:

$$R_{uv} - \frac{1}{2} R g_{uv} + \Lambda g_{uv} = -8\pi G T_{uv} \quad (193)$$

The Friedman Lemaitre solution of equation (193) can be written as follows:

$$\frac{d^2 r}{d\tau^2} = -\frac{4\pi G}{3} \left(\rho + \frac{3p}{c^2} \right) r + \frac{\Lambda r}{3} \quad (194)$$

Equation (194) is exactly the meaning of equation (3) that both matter and energy produce gravitation. Since the pressure p and density ρ of the matter and energy system are not constants, but M' is a constant, that is, equation (3) is a constant, for the convenience of integration, equation (3) is substituted into equation (194), It can be concluded that:

$$\frac{d^2 r}{d\tau^2} = -\frac{GM'}{r^2} + \frac{\Lambda r}{3} \quad (195)$$

For the integral of equation (194), we get:

$$\left(\frac{dr}{d\tau} \right)^2 = \frac{2GM'}{r} + \frac{\Lambda r^2}{3} - K \quad (196)$$

Where K is the integral constant. Substituting equation (3) into equation (196), and obtain:

$$\left(\frac{dr}{d\tau} \right)^2 = \frac{8\pi G r^2}{3} \left(\rho + \frac{3p}{c^2} \right) + \frac{\Lambda r^2}{3} - K \quad (197)$$

Equation (197) is equivalent to the Friedman Lemaitre solution of equation (194). Since the GR gravitational field equation is

established in arbitrary coordinate system, that is, curved space conditions, the current cosmology holds that the integral constant K in equation (197) is the space curvature, $K>0$ means that the cosmos is curved with positive curvature, $K=0$ is that the cosmos is straight, $K<0$ is that the cosmos is curved with negative curvature; the cosmological factor Λ represents the effect of an expansion force, which can explain the accelerated cosmic expansion and solve the problem of dark energy. At present, the standard cosmological model cannot give the specific results of curvature constant K and cosmological factor Λ .

By comparing equation (197) with the related energy equation in this paper, the Friedman Lemaitre solution is analyzed and discussed below.

3.3.1 Small-scale gravitational field: When the gravitational field is small-scale, if the pressure p of the matter and energy system cannot be ignored, the equation (197) can be written as follows:

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{2G\rho V}{r} + \frac{8\pi Gpr^2}{c^2} + \frac{\Lambda r^2}{3} - K \tag{198}$$

Where $V=4\pi r^3/3$ is the volume of the sphere, ρ is the density of the system of matter and energy, and the first item on the right is the common gravitation of the system of matter and energy. Since energy possesses no gravitation, ρ is replaced as the density of matter does not affect the magnitude of gravitation, so the following formula is equivalent to formula (198):

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{2GM}{r} + \frac{8\pi Gpr^2}{c^2} + \frac{\Lambda r^2}{3} - K \tag{199}$$

1. Compared with equation (22): We can see that if we use equation (199) to express the small-scale gravitational field with $r<r_0$, we must have

$$\frac{4\pi Gpr^2}{c^2} + \frac{\Lambda r^2}{6} - \frac{K}{2} = -\frac{p}{\rho} = const \tag{200}$$

Moreover, the cosmic factor Λ cannot be a constant, it must be a function of r_2 . When $\Lambda=0$, equation (200) becomes

$$\frac{4\pi Gpr^2}{c^2} + \frac{p}{\rho} = \frac{K}{2} \neq const, \text{ when } p \neq 0 \tag{201}$$

That is, when the pressure $p \neq 0$, K can't maintain the nature of the integral constant, thus must have $\Lambda \neq 0$. Change equation (200) to

$$\left(\frac{4\pi Gp}{c^2} + \frac{\Lambda}{6}\right)r^2 = \frac{K}{2} - \frac{p}{\rho} = const \tag{202}$$

It can be seen from the analysis that only the left bracket of equation (202) is equal to zero, that is, the cosmic factor satisfies

$$\Lambda = -\frac{24\pi Gp}{c^2} \neq const \tag{203}$$

And at the same time, only when

$$K = \frac{2p}{\rho} \tag{204}$$

can keep the integral constant property of K unchanged. Substituting equation (203) and equation (204) into equation (199), we can get:

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{2GM}{r} - \frac{2p}{\rho} \tag{205}$$

When formula (203) and equation (204) are satisfied, equation (199) is equivalent to energy equation (22) of small-scale gravitational field.

2. Compared with equation (60): Compared with equation (199) and (60), if the gravitational potential energy

$$\frac{GM}{r} = 0 \tag{206}$$

And meet the following conditions

$$\frac{4\pi Gpr^2}{c^2} + \frac{\Lambda r^2}{6} - \frac{K}{2} = \frac{p}{\rho} = const \tag{207}$$

From equation (207), we can get:

$$\Lambda = -\frac{24\pi Gp}{c^2}, \quad K = -\frac{2p}{\rho} \tag{208}$$

Substituting formula (208) into formula (199), we can get:

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{2p}{\rho} \tag{209}$$

Equation (209) is the same as equation (26). When $p \neq 0$ and the equation (208) is satisfied, equation (199) is equivalent to the energy equation (60) of matter formation period.

3. Compared with Equation (8): Compared with equation (199) and (8), when

$$p=0, \text{ and } \frac{4\pi Gpr^2}{c^2} + \frac{\Lambda r^2}{6} - \frac{K}{2} = 0 \tag{210}$$

Namely

$$p=0, \quad \Lambda=0, \quad K=0 \tag{211}$$

Equation (199) becomes

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{2GM}{r} \tag{212}$$

Formula (212) is the same as formula (8). The condition of equation (211) is satisfied, equation (199) is equivalent to energy equation (8) (when the pressure energy of gas in gravitational field is negligible in equation (8)), and we can deduce the Einstein de Sitter solution (14).

3.3.2 Large scale gravitational field: When the gravitational field is large-scale, the pressure p of matter and energy system should be ignored, and then formula (197) can be written as follows:

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{8\pi G\rho r^2}{3} + \frac{\Lambda r^2}{3} - K \tag{213}$$

Due to “Energy Possesses No Gravitation”, if ρ is replaced by the matter density, the gravitation will not change. Therefore, the following formula is equivalent to equation (213):

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{2GM}{r} + \frac{\Lambda r^2}{3} - K \tag{214}$$

Comparing equation (214) with equation (106), if equation (214) is used to express the large-scale gravitational field with $r > r_0$, there must be

$$\frac{2GM}{r} + \frac{\Lambda r^2}{3} - K = \frac{2GM}{r_0} - \frac{2GM}{r} \tag{215}$$

And only when

$$\frac{4GM}{r} + \frac{\Lambda r^2}{3} = K + \frac{2GM}{r_0} = const \tag{216}$$

Equation (214) can describe the large-scale gravitational field. And $K \neq const$ in formula (216) when $\Lambda = 0$ the integral constant property of K cannot be guaranteed, so it must be assumed that $\Lambda \neq 0$, and

$$\frac{4GM}{r} + \frac{\Lambda r^2}{3} = 0 \tag{217}$$

And, at the same time, there must be

$$K + \frac{2GM}{r_0} = 0 \tag{218}$$

can keep the property of k-integral constant, formula (216) is established. In other words, only

$$\Lambda = -\frac{12GM}{r^3} = -16\pi G\rho \neq const \tag{219}$$

And, at the same time

$$K = -\frac{2GM}{r_0} \tag{220}$$

Equation (213) is the energy equation of large-scale gravitational field with $r > r_0$ (60). According to formula (123), formula (220) can be written as

$$K = -\frac{2GM}{r_0} = -\frac{2p}{\rho} = -2E_0 \tag{221}$$

When equation (219) and equation (221) are satisfied, equation (197) is equivalent to the large-scale gravitational field energy equation (106).

3.3.3 Curvature constant K and cosmic factor Λ : As can be seen above, by comparing the Friedman-Lemaitre solution with the correlated energy equation in this paper, the following results can be obtained for K and Λ .

1. During the matter formation period:

$$K = -\frac{2p}{\rho}, \Lambda = -\frac{24\pi Gp}{c^2} \frac{GM}{r} = 0, \text{ and } \frac{GM}{r} = 0 \tag{222}$$

2. In the expansion period of plasma gas and atomic gas:

$$K = -\frac{2p}{\rho}, \Lambda = -\frac{24\pi Gp}{c^2} \tag{223}$$

3. In the small-scale gravitational field with gas pressure $p=0$:

$$K = 0, \Lambda = 0 \tag{224}$$

4. During the period of accelerated cold expansion of the cosmos:

$$K = -\frac{2GM}{r_0} = -\frac{2p}{\rho} = -2E_0, \quad \Lambda = -16\pi G\rho \quad (225)$$

The essence of curvature constant K is the pressure energy of thermal expansion of matter and energy system when $r \leq r_0$, and the pressure energy of photon when $r > r_0$, which is irrelevant to spatial curvature; the unit of cosmological factor Λ is s^{-2} , which is the same as the dimension of angular acceleration, when $r \leq r_0$, it is related to the pressure p of matter and energy system, and when $r > r_0$, it is related to the density of matter, the physical meaning is not clear.

3.4 Questions about light bending in flat space: Energy possesses no gravitation means that the gravitational field does not bend the light. When a ray of light from a luminous star to the earth is regarded as a connecting line of one photon after another, if there is no relative motion (or very close distance and relative velocity of motion is very small) between the luminescent star and the earth, the connecting line must be straight (or approximately straight); if there is relative motion, the connecting line must be curved, but this bending is irrelevant to gravitation, It is the result of the particle nature of light and the relative motion of celestial bodies.

"Gravitational Lens Phenomenon" can be explained by the experiment of "Pseudo-gravitational Lens Effect". On the connecting line between the shooting camera and the moon, set a shielding circular plate whose visual size is slightly larger than the moon at a certain position from the camera lens, use the film with slower sensitivity speed to continuously expose and shoot the process of the moon being covered by the circular plate. When the exposure time is longer than the shielding time (it can be achieved by moving the shielding plate at a proper speed), on the film, there will be a light spot of the moon on both sides of the screen, and it may even be the image of two moons. No one should think that this is the gravitational lens effect produced by the shelter plate. This experiment shows that the so-called "Gravitational Lens Effect" is a picture whose exposure time is longer than the time when the luminescent star is covered by the prepositional celestial body, which has nothing to do with gravitation and whether the light is bent or not. When the relative visual size of the luminescent star and the prepositional celestial body is suitable, and the relative motion velocity matches the shutter speed and the film sensitivity speed of the camera, the astronomical camera can take a picture of a post luminescent star or spot on both sides of the prepositional celestial body. A "Gravitational Lens Effect" photo reflects an authentic astronomical phenomenon that is not fundamentally different from a photo of a total solar eclipse.

4. Summary

In order to try to solve the dark energy, dark matter and singularity theory, the basic hypothesis of "Energy Possesses No Gravitation" is put forward, the expression of equivalence principle is solved by integral in the flat space coordinate system, and the energy equation and motion equation of the cosmos in each development and evolution period are obtained, which can not only completely describe the laws of matter motion in the cosmos, but also study the issues of dark energy, dark matter and gravitational potential energy according to the law of conservation of energy, and obtain a series of important conclusions.

- It is found that there is a boundary between the large scale and the small-scale, namely the critical scale r_0 , when the scale $r \leq r_0$, the cosmos can expand or contract; when the scale $r > r_0$, the cosmos can only expand but not contract.
- It is believed that the cosmos was born in a "Resonance" of the quantum fluctuation of static photons in vacuum, and the early cosmos generated basic matter particles around at the speed of light, according to the deduction that isotropic homogeneous matter field possesses no gravitation, and through the energy equation and motion equation during the period of matter generation, the early cosmos "LGT" without Big Bang, inflation and singularity theory is established.

- The equations of expansion or contraction of plasma gas and atomic gas are sinusoidal functions of the same form, the maximum values of the sinusoidal functions are the critical scale r_o of the cosmos and the critical scale r_c of the initial cluster of nebulae or galaxies, respectively. When the plasma gas expands to form the critical scale r_o , it turns around $\pi/2$, which is the origin of the rotational motion in the group of galaxies; when the atomic gas expands to form the critical scale r_c , it turns into the contraction motion automatically after turning around $\pi/2$, which can explain the formation of the galaxies and the rotational motion in the galaxies well. The objects that are $r > r_c$ away from the center of the galaxies will eventually escape the galaxies and become wandering stars.
- By expanding and simplifying the equation of motion of sinusoidal function of gas matter into algebraic equation, the formation mechanism of de-homogenization of anisotropy distribution of matter in gravitational field can be well explained.
- It is found that the pressure energy of decoupling photons is the dark energy by analyzing the gas energy changes in the process of decoupling, the calculated values of the photon decoupling energy and the ultimate velocity of accelerated cold expansion of the cosmos are given, which are in good agreement with the latest observations of Hubble constant.
- It is found that missing mass is the phenomenon of dark matter, which is the false image of accelerating expansion of celestial bodies beyond the critical scale under the action of photon decoupling energy, that is, both dark matter and dark energy are essentially the effect of photon decoupling energy.
- Through the critical mass M_o corresponding to the critical scale, it is estimated that there are about 3.3 billion galaxies in the cosmos that evolved from the initial cluster of nebulae, in the process of decoupling the 3.3 billion initial cluster of nebulae, the cosmic scale is at least 1300 times "2E", and the isotropic homogenization is preliminarily realized.
- Through the analysis of macro conservation of cosmic energy, the viewpoint that isotropic homogeneous matter field possess no gravitation is verified; it is found that the cosmos energy will eventually be converted into the inertial rotational energy and the inertial translational energy, the internal energy of the matter will be converted into the inertial rotational energy, and the energy uncoupled from the matter will be converted into the inertial translational energy; it is concluded that the thermal expansion energy, the inertial rotation energy and the gravitational potential energy of the cosmos matter are transformed in turn and equivalent, it is concluded that gravitation is the result of matter motion rather than the cause of matter motion, and it is predicted that the neutrino thermal expansion energy is an important part of gravitation potential energy.
- According to the equations of motion above the critical scale of the cosmos obtained by integral solution, the expressions of Hubble constant and cosmic age are derived, and the end time of "2E" is roughly inferred according to the end time of the dark age of the cosmos, and the main parameters of the cosmos such as the critical scale of the cosmos, the critical scale of the galaxies and the current minimum scale of the matter universe are estimated by the relevant equations of motion.
- By comparing the Friedman-Lemaitre solution to each period energy equations, the expressions of curvature constant K and cosmic factor Λ of the standard model in each period of the cosmos are given. K represents pressure energy of cosmic expansion, which is irrelevant to spatial curvature; when $r \leq r_o$, The magnitude of Λ is the same as the angular acceleration, and when $r > r_o$, it is related to the density of matter, the physical meaning is not clear.
- In order to explain the "Gravitational Lens Phenomenon" and light bending in a flat space (inertial frame), experiment of

"Pseudo-gravitational Lens Effect" is designed.

According to the basic hypothesis of "Energy Possesses No Gravitation", the core foundation of this paper is to decouple matter and energy and study the conservation of cosmic energy, therefore, this theory can be named "The DCT"; the inference that "Cosmos Grows at the Speed of Light" and "Isotropic Homogenized Matter Field Possesses No Gravitation" are the basic conditions for the complete self-consistency of the theoretical system. Critical scale, photon decoupling energy and cosmic "2E" are the three major discoveries of this theory. This theory can be supported by Hubble's constant and CMB, and can be further verified by precise astronomical observation of isotropy in different directions of the cosmos, dark matter and critical scale in galaxies, thermal expansion energy of neutrinos, and "Pseudo-gravitational Lens Effect" experiment etc.

However, due to the author's limited level of particle physics, the relevant cosmic timescale is estimated according to the current cosmology in this paper, and it is expected that particle physicists can provide accurate timescales based on the "LGT"; in addition, although the existence of black holes can be inferred according to the relevant motion equations, however, due to the different formation mechanism of black holes from the current cosmology, the properties of black holes need further study; in addition, the motion details of "2E" process are also expected to be given by numerical calculation.

In addition, this research work is carried out at home during the COVID-19 virus outbreak. Due to the limited time, it is inevitable that the original manuscript is rough. We sincerely welcome criticism and correction.

Notes

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